MY NEIGHBOURHOOD

Evidence-based Methodology for Sustainable Urban Design

SEPT 2024

UN-HABITAT

Please note, this is a draft copy of the MY Neighbourhood: Evidence-based methodology. We welcome feedback or ideas to create an evolving document.

MY Neighbourhood Evidence-based Methodology for Sustainable Urban Design

Disclaimer
The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers of boundaries. Views expressed in this publication do not necessarily reflect those of the United Nations Human Settlements Programme, the United Nations, or its Member States.

Principle Author
Mario Tavera
Semiha Turgut
Jane Muriuki
Edoardo Forzano

Content Development Group
Herman Pienaar, Pinar Caglin, Maia Smillie

Planning, Finance, Economy Section Chief
Laura Petrella

Design and Layout
Maia Smillie

With Thanks
Stacy Fuende, Yuki Takada, Simon Okoth

https://unhabitat.org/my-neighbourhood

United Nations Human Settlements Programme (UN-Habitat)
P. O. Box 30030, 00100 Nairobi GPO Kenya
Tel: 254-020-7623120 (Central Office)

www.unhabitat.org

WHAT IS THIS PUBLICATION ABOUT?

PURPOSE

This publication provides a guide to Evidence-Based Urban Planning. It shows how spatial analysis can inform urban planning and design, ensuring that transformation in our cities and neighbourhoods leads us toward a more sustainable future.

A large proportion of cities around the world find themselves in the challenging position of formulating policies and action plans without clear evidence and information. Due to constraints, such as budget and resource limitations, GIS capabilities within planning departments, or lacking or unreliable data bases, many cities struggle to collect timely data about their urban areas, making it difficult for them to understand where certain issues are. This limits their ability to address evolving urban needs and challenges and hinders the formulation of responsive and tailored policies or development projects.

UN-Habitat, the United Nations Human Settlements Programme, is strongly committed to supporting cities in overcoming the challenge of rapid urbanization and address its impacts by innovating and promoting evidence-based approaches and practices that facilitate the decision-making process. We believe that this approach can assist cities to reach the SDGs.

IN THE FACE OF COMPLEX URBAN ISSUES, AND PARTICULARLY IN CONTEXTS WHERE GOVERNMENTS HAVE LIMITED FINANCIAL RESOURCES, EVIDENCE-BASED DECISION-MAKING BECOMES INCREASINGLY CRITICAL

WHO IS THIS FOR?

This document has been created to help urban practitioners and decision makers – both within government and private sectors - to implement evidence-based planning.

In order to be inclusive and applicable in contexts with a lack of available data, this document provides the key and basic spatial analysis examples to get decision makers started in understanding, diagnosing and transforming their cities through an evidence-based process.

Given that evidence, spatial analysis, physical development, and policy outcomes are integral to various aspects of urban life, this document seeks to present evidence-based planning to practitioners across multiple disciplines. Anthropologists, transport planners, landscape architects, community leaders, housing developers, and anyone interested in the urban environment may leverage evidence-based methods in their work and decision-making processes to effect meaningful transformations in urban settings.

OBJECTIVES

Therefore, the objectives of this document are to:

1. **Encourage Evidence-Based Planning Culture**
2. **Provide the minimum, easy-to-access and open-source spatial analysis resources**
3. **Clarify complex and general principles of sustainability to specific and implementable actions**
4. **Bridge the gap between data and decisions**
5. **Assist Cities to shift toward achieving SDGs**

WHY EVIDENCE-BASED PLANNING?

It is becoming increasingly urgent for our society to have efficient and effective responses to complex problems such as climate change, poverty, and urbanization.

In settings where governments have limited financial resources or existing or current databases, planning authorities struggle to establish strong monitoring mechanisms and also miss out on the opportunity to measure the effectiveness of their interventions, identify areas for improvement and capitalize on successful strategies. Planning without an evidence-based process leads to development that can be driven by arbitrary needs or political lobbying. With a lack of analysis to support new development projects or policies, this approach can lack transparency, and also lack integration to support one development project to resolve multiple challenges, leading to financial inefficiencies.

Now more than ever, rapid advances in technology and data sources provide us with the tools to make better decisions. The evidence-based approach systematizes and maintains the rigour of this activity, making it possible to understand the root causes, evaluate the efficacy of interventions, and find the most effective strategies.

The application of an evidence-based approach offers several advantages, including:

1. Increased reliability: Provides quantitative and qualitative data to inform the decision-making process.
2. Improved decision objectivity: Reduces the element of individual interest and bias supported by data-driven decision making.
3. Enhanced efficiency: Supports the optimization of resources contributing to a more efficient and cost-effective decision-making process and interventions implementation.
4. Accountability and Transparency: Ensures transparency and accountability by requiring decision-makers to justify their choices based on objective and verifiable evidence
5. Alignment with institutional objectives: Ensures that decisions and interventions are aligned with stakeholder needs and preferences.

WHAT IS EVIDENCE-BASED PLANNING?

Evidence-Based Planning is the process of collecting spatial and non-spatial data and using it to inform decision making in urban planning.

Through the collection, processing, analysis, and visualization of quantitative and qualitative data, spatial data science plays a vital role in identifying spatial urban trends and patterns. These insights serve as a valuable guide in the planning process, facilitating the determination of specific locations requiring interventions and informing effective strategies to address urban challenges.

To explain how it works, below are three main parts that make up Evidence Based Planning **I. DATA BASE, II. SPATIAL ANALYSIS, and III. DECISION MAKING.**

HOW DOES IT WORK?

I. DATA BASE

Often, city officials have a database with spatial and non-spatial data. Examples of non-spatial data may be population statistics relating to the city as a whole, or sub-categorized by administrative boundaries (districts or boroughs).

An example of a spatial data file could be a map file that shows population density (with 'hot spots' of more densely populated areas). An example of a non-spatial file may be a census list of the demographics for the whole city.

Evidence can be found through open-source data bases such as census, or satellite imagery. Non-spatial information contained in reports (regulations and policies that guide land use, zoning, infrastructure, services and governance of the urban area) can be drawn onto a map and digitized (using programs such as GIS or Adobe illustrator). If official sources are lacking, evidence can be gathered in, for example through stakeholder and community consultation or field visits.

An example of this could be counting the number of bus stops along a road, or the number of apartments within a residential block.

The quality of data is important to assess before using it – how current it is, the level of detail it provides, whether it is 'complete' will all impact how useful the outcome is. Spatial analysis based on unreliable data will not accurately support the urban planning process.

A summary of data that is considered to be necessary for this approach is listed in the next page.

This guide does not provide detailed methodology to use analytical tools such as GIS, however, cleaning data is necessary so that data from various sources are compatible and can be combined in the spatial analysis.

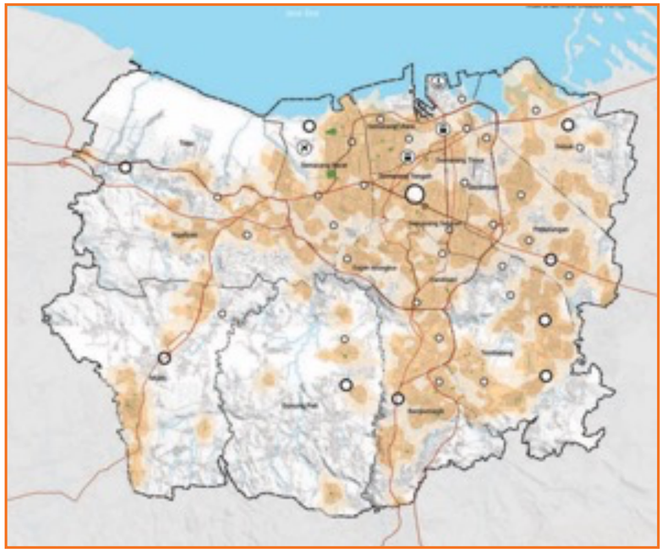
To move from a sectoral to integrated planning approach it is useful at the evidence collecting stage to not focus on the dataset itself, but on how usefulness it will be to understand questions you have about the city and to support urban objectives.

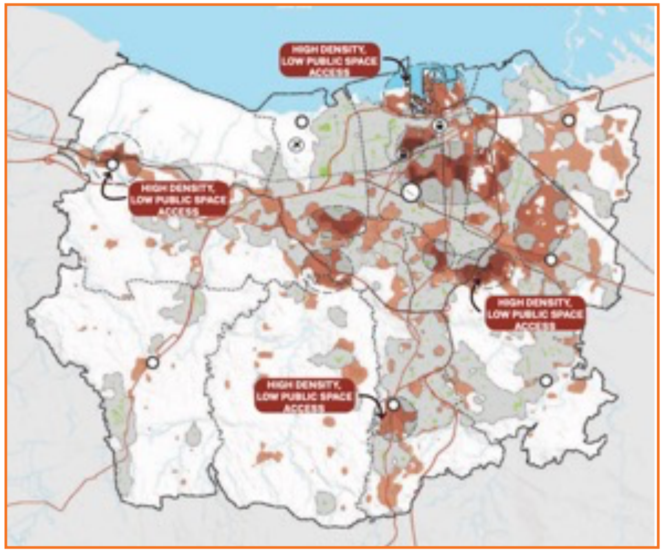
II. SPATIAL ANALYSIS

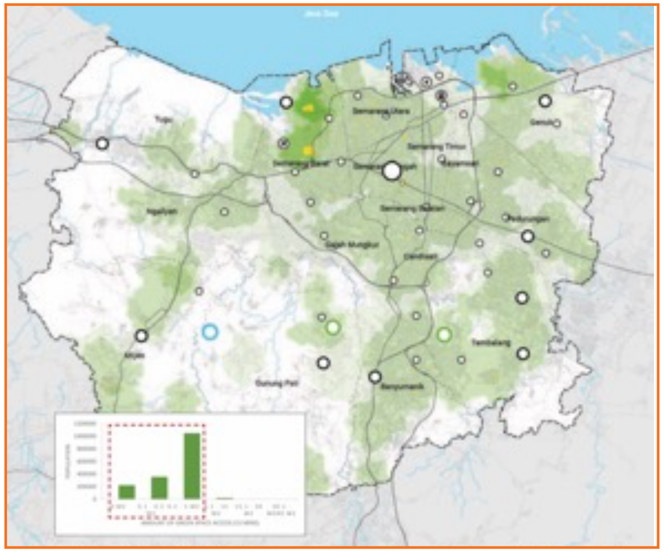
Looking at individual datasets provides very limited information to the urban planning process. Spatial analysis tools combine and overlay spatial datasets to stimulate the complexity of built-environment systems. They also generate additional spatial layers of information and allows various sectors - such as transport and mobility, housing, green space, utilities networks, public and social services - to be assessed together. This ensures that the planning process is integrated.

The outcome of the analysis provides information to both diagnose the challenges or deficiencies the city may be facing, as well as to test out what the most effective solutions could be.

To perform the different spatial calculations a number of software application (commercial and open source) can be used. Open-source software such as QGIS combined with available plug-ins and libraries are recommended for analysis whereas commercial products like ESRI's products such as ArcGIS Pro and ArcGIS Online are suitable for analysis as well as data visualization and cartography. An example of this application is shown below.







These maps highlight a few analyses in relation to population density distribution and access to public space. This example shows how a few datasets, applied to a spatial analysis can provide answers for the following questions:

What public spaces are there (type, size)?
Where are they located?
Which areas are well serviced? Which are 'deficit' areas? Where might a new public space be best located to service the most population? Or to create a network of public space? Which type of public space is currently lacking?
Which social groups are excluded? What type of public spaces would include these groups?
Does the city currently meet national public space benchmarks or policies?
Which public spaces have reached capacity? And which could be used more? What management or programming strategies need to be introduced to support this?

III. INFORMING PLANNING DECISIONS

The outcome of the spatial analysis supports more informed decisions about where development could be incentivised or limited, where there is an existing deficit in access and need for new education, health, water, electricity, sewage or waste networks and facilities. It can highlight where new roads or paths are needed and where residents are vulnerable to future natural hazards. It can provide an indication of the most effective location of a new bus stop, or where road safety measures are most effective by revealing where children are most likely to walk within the city. It can highlight locations for new pocket parks and help to identify how existing facilities can be better used.

Some ways that spatial analysis directly impacts urban planning outcomes are summarised in the table.

Some examples of planning implications include:

SPATIAL ANALYSIS **What kind of spatial analysis is applied?**	PLANNING IMPLICATION **How might the analysis impact urban planning decisions?**
Population Density Distribution *Depending on availability of data, understanding the distribution of population by residential units can assist in understanding stresses on infrastructure, competition for public services, poor air quality and transport congestion and the concentration of marginalised communities.*	When combined with layers of spatial information such as building density, this may have an impact on the identification of an **Urban Growth Boundary**.
Accessibility to Facilities *Assessing the walking distance between public facilities in relation to the distribution of people living in the city can help to identify the dependency or over-burdening of certain facilities, or the need for increased public transport or permeability.*	This type of analysis directly informs **Infrastructure and Facilities Planning**. It can also inform **Mobility and Transport Planning**.
Natural Conservation *Understanding the spatial distribution and proportion of terrestrial and freshwater biodiversity that is covered by protected natural areas can assist in understanding the impact of climate change, direction for urban expansion and the need for new green and blue networks.*	**Zoning & Land Use Planning** is impacted by this analysis due the importance of locating non-polluting functions adjacent to protected areas, as well as incentivising densification in other areas.
Building Quality *Understanding the spatial distribution of households with inadequate structure can assist in understanding the most immediate threats from natural hazards, density of vulnerable households in relation to emergency services, access routes and access to economic activities.*	**Building Codes and Regulations** and **Emergency Preparedness and Response Plans** are directly impacted by this analysis.

AN INTEGRATED APPROACH

As described, the evidence based planning methodology encourages an integrated and holistic approach to urban planning.

This approach ensures that development projects respond to a number of challenges at once. It addresses the intersectionality of challenges that a city faces, and the need for spatially and sectorally integrated responses.

Therefore, when considering what spatial analysis to undertake, using **objectives** can assist to ensure this integrated approach.

UN-Habitat use the **5 objectives** as criteria of evaluation to determine the degree of sustainability of an urban structure is based on its level of alignment with **compactness, connectedness, inclusiveness, vibrancy, and resilience.** Within each objective, there are a series of spatial analyses that can be applied to diverse urban contexts.

The objectives, and the spatial analyses that contribute to each objective, are derived from, but not limited to, the Sustainable Development Goals and New Urban Agenda using indicators from official UN monitoring frameworks.

LINKS TO GLOBAL INDICATORS

The evidence based planning methodology, by spatialising and localising global sustainable indicators, bridges the gap between global goals and local implementation.

The spatial analysis incorporates spatial indicators from official frameworks such as the SDGs, Urban Monitoring Framework, City Prosperity Index, Sendai Framework for Disaster Risk Reduction, and others designed by UN Habitat for assessing urban structure and function.

This guide serves as a valuable complement to the **Global Urban Monitoring Framework** and other monitoring frameworks indicators, aiding in the integration of their spatial dimension.

LINKS TO DESIGN GUIDELINES

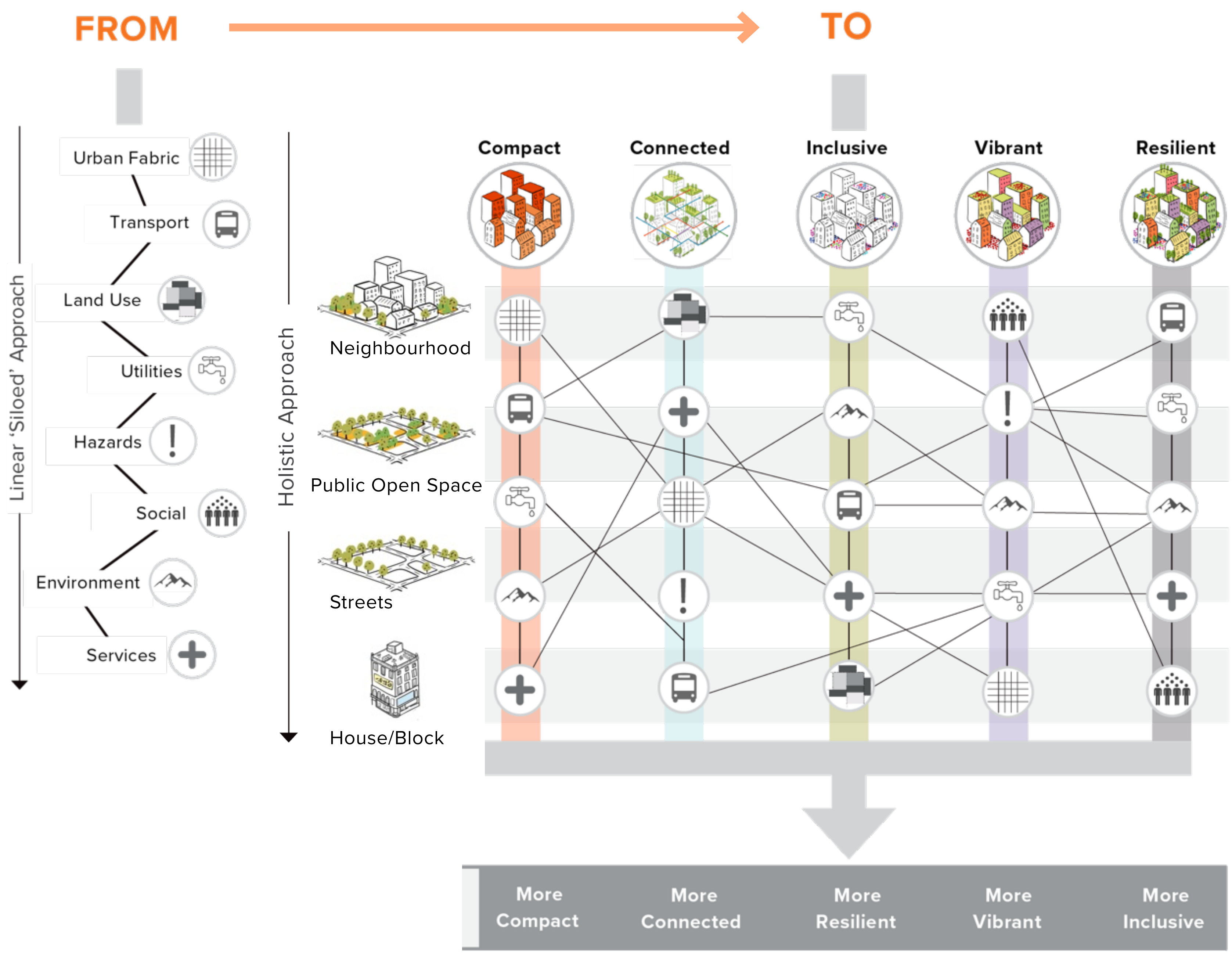
UN-Habitat's **MY Neighbourhood** publication provides a checklist of urban design principles and tips that can be applied at various scales and in a diversity of urban contexts.[1]

This evidence based planning methodology directly aligns with that - the analysis outlined in the following chapters provide benchmarks and indicators to assess the current status of the city and neighbourhoods, and the future shift.

The urban design principles provide specific intervention(s) to achieve that shift. Organised within the same objectives, these principles and tips similarly ensure that development interventions are considered in a multi-scalar and multi-sectoral way. Both of these publications, therefore, can be used side-by-side.

The diagram on the next page illustrates how the five objectives assists in achieving this integrated approach to urban planning and design.

1 Click here to access the MY Neighbourhood publication



FROM
TO
Linear 'Siloed' Approach
Urban Fabric
Transport
Land Use
Utilities
Hazards
Social
Environment
Services
Holistic Approach
Neighbourhood
Public Open Space
Streets
House/Block
Compact
Connected
Inclusive
Vibrant
Resilient
More Compact
More Connected
More Resilient
More Vibrant
More Inclusive

OBJECTIVES

To guide a multi-sectoral and multi-scalar analysis and solutions approach

1. COMPACT CITY

2. CONNECTED CITY

3. INCLUSIVE CITY

4. VIBRANT CITY

5. RESILIENT CITY

SPATIAL ANALYSIS

How well does the city function for its citizens?

- How accessible are key facilities?
- How efficient is the infrastructure provision?

- How permeable is the street network?
- How accessible is the public transport system?

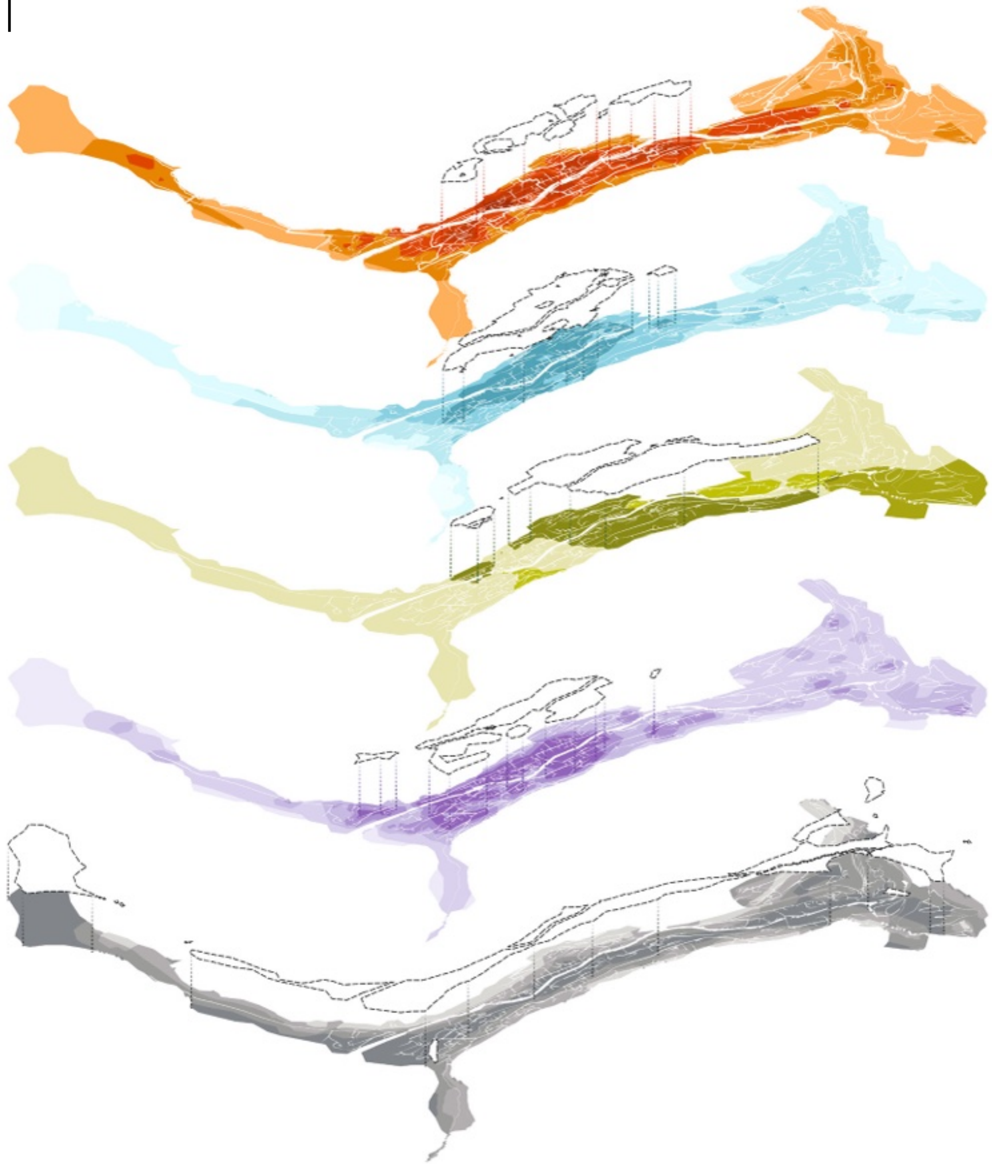
- How equitable is the service provision?
- How are communities distributed (by age, income, gender etc.)?

- How diverse is the land use?
- How is movement distributed?

- How vulnerable is the urban structure (risk area, population or assets at risk)?
- How responsive is the urban structure to risks?

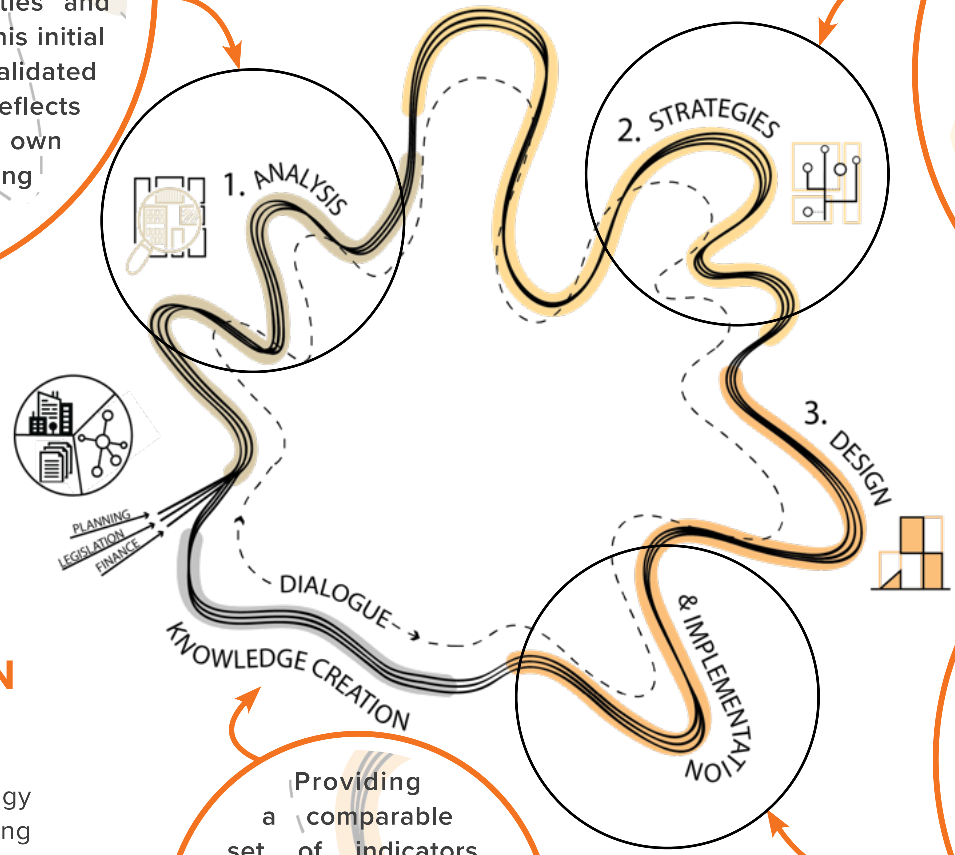
EVIDENCE-BASE

Visualising spatial analysis to understand the dynamics of the urban area and to better identify, test, and monitor integrated solutions



WHERE DOES THIS COME IN THE PLANNING PROCESS?

The evidence based planning methodology is threaded throughout the urban planning processes. It is useful for understanding and diagnosing, testing strategies and contributing to global monitoring of shifts towards more sustainable urban environments.



In this part of the process, the data collection and cleaning is necessary. A data base is formed and from this set of available data, the type of spatial analysis is identified. A diagnosis of the current context, opportunities and challenges can be developed. This initial data set, and analysis can be validated by local actors, asking if this reflects their understanding of their own city, and if there is anything missing they can add.

The spatial analysis and diagnostic outcomes directly inform the strategies - what intervention is needed to resolve deficits or guide the city toward a more sustainable growth. The use of spatial analysis software (GIS) can show the impact that a development project will have. It can provide a benchmark, or 'current scenario' to compare to a potential future scenario.

This data-driven planning process supports the implementation of new development projects by providing transparency to investors. It facilitates discussion and collaboration with non-practitioners. It also provides a starting point to monitor a city's progress - both within the context of the city itself, as well as across cities and globally, by aligning methodologies and outcomes in a diversity of contexts.

Providing a comparable set of indicators, analyses and outcomes allows cities to contribute to global best practices and implement global targets at the local level.

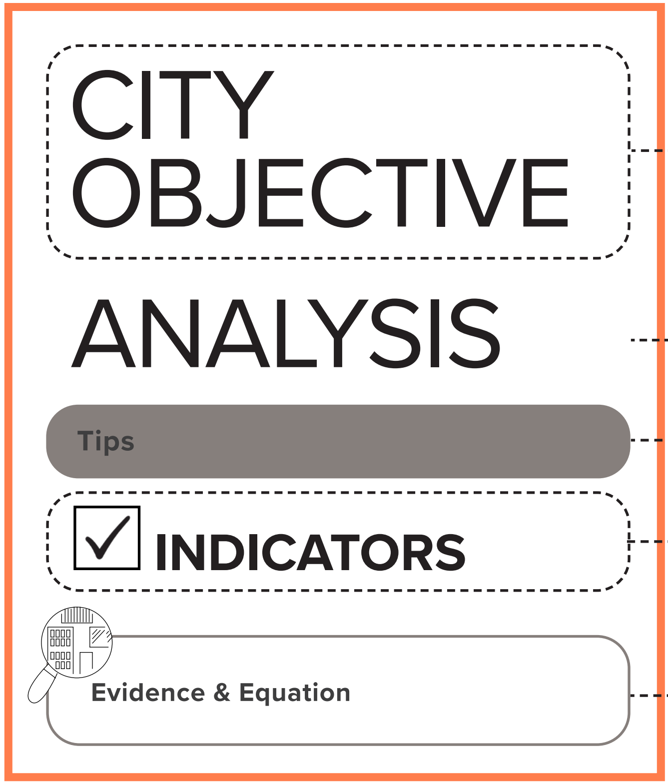
WHAT THIS DOCUMENT DOES DO

- Provides indicators for urban monitoring against SDG and NUA targets
- Provide indicators that support the design tips in MY Neighbourhood
- A starting point to identify additional spatial indicators and benchmarks
- Ensure that urban assessment, urban interventions and outcomes are multi-scalar and integrated (rather than sectorally siloed or spatially fragmented)
- Show the link between local transformation with global goals
- Enhance strategic urban planning capacity of municipal governments;
- Provide an entry point to identify strategic projects within a sustainable urban development framework;
- Harness and share knowledge of urban planning and design
- Link policy to evidence-based and un-siloed approach to urban transformation

WHAT THIS DOCUMENT DOESN'T DO

- Provide a full list of spatial analyses for decision making about every sector of urban life
- Suggest the applicability of spatial analyses in different global contexts or provide categories of analyses for specific countries or regions
- Provide spatial analyses that are specifically applicable on a regional scale

INSTRUCTIONS



City Objectives
These objectives are: Compact City, Connected City, Inclusive City, Vibrant City, Resilient City.

Analysis
These are topics of analysis that are considered key to assess each objective.

Tips
This section provides GIS analysis tips or important things to consider when running the analysis. Not all analyses have one methodology, and some have multiple.

Indicators
These are indicators that are components of the analysis topics.

Evidence & Equation
All indicators have a list of datasets that are required. Often, a few variations of an indicator will be given to provide options for contexts with less or more data availability. An equation is sometimes given to help illustrate the analysis.

COMPACT CITY

Residents of the compact city enjoy a highly efficient urban form characterized by close proximity to services, reduced travel times, and variety of uses and functions. A highly walkable environment that is supported by the urban layout encourages walking and cycling, providing opportunities for people to interact and businesses to emerge. An efficient public transport system provides affordable and better accessibility for all, bringing multiple economic and environmental benefits. Achieving a compact city implies creating an efficient urban space that is safe, comfortable and attractive for all its residents.

The Compact City relates to the New Urban Agenda transformative commitments: 34, 36, 37, 39, 43, 62, 67, 68, 69, 70

The following are the recommended spatial analyses to run to help you understand what obstacles or opportunities there are for your neighbourhood in relation to the compact city:

POPULATION & BUILDING DENSITY

- Ratio of Buildings and Open Space
- Building Volume
- Population Density

PROXIMITY AND WALKABILITY

- Access to Open Public Space
- Access to Health Services
- Access to Education Services
- Access to Public Transport
- Proximity to Diverse Land Uses

POPULATION & BUILDING DENSITY

One of the most significant challenges for urban development worldwide is maximizing the efficient utilization of urban land resources. This task demands accommodating rapidly growing urban populations and related functions within limited land, while ensuring dignified and healthy living conditions for residents. Achieving an efficient and balanced density also helps environmental protection by limiting the sprawl and help accommodating adequate infrastructure and social facility investments.

Evaluating efficient density involves assessing the distribution of certain elements within a surface unit, such as one hectare or a square kilometre. To achieve this, analytical tools such as intersect (using a grid) and summarize (to aggregate units of measurement) are very useful.

☑ RATIO OF BUILDINGS TO OPEN SPACE

It is important to assess the ratio between land that is open space in a city, and land that is built upon. An 'inefficient' use of land may look like sprawl, where there is a low building to open space ratio. This can sometimes lead to a dependency on cars and lack of pedestrian flow, which can lead to a less vibrant urban environment and in some cases a lack of sense of safety. Similarly to sprawl, if there is an empty plot of land within a dense city or neighbourhood this can cause fragmentation of the urban fabric, and can lead to similar outcomes, less pedestrians or land uses and a sense of lack of safety.

What data do I need to assess building to open space ratio?

A. Building Footprints

B. The size of the 'urban area' you are assessing

What equation helps me assess building density?

Building to Land Ratio (%) = [Building Area (m^2) / Surface Area (m^2)] / 100

Efficient building occupancy can be measured using the building-to-land ratio, which is typically expressed as the percentage of area covered by built-up space within a given surface unit. According to UN-Habitat, an efficient use of land involves allocating 50-55% of it to buildings, maximizing utilization while leaving space for essential uses such as streets, sidewalks, and public open spaces, thus ensuring liveability.

It is important to consider the scales of the building site (meaning how much should one plot of land be built up?) as well as the neighbourhood (where is the denser and more vibrant neighbourhood centre, where are quieter residential areas or parks?), and city as a whole (is there a consistency in how built-up the city is, or are there fragmented areas that need integration?).

☑ BUILDING VOLUME

Vertical growth in urban areas reduces land consumption but comes with trade-offs. Tall buildings, though space-efficient, demand significant materials and energy, raising greenhouse gas emissions. They can also diminish urban liveability by overshadowing public spaces, limiting natural light, and disrupting the human-scale experience essential for community interaction. Therefore, it is important to assess building scale and form as this is vital for both environmental sustainability and residents' quality of life.

What data do I need to assess building volume?

A. Building Footprints and

B. Building Heights or

C. Building Volumes

What equation helps me assess building volume?

Building Volume Density = Built Volume (m^3) / Surface Area (m^2)

What equation helps me assess openness?

Building Volume Density = Built Volume (m^3) / Open Space (m^2)

UN-Habitat strongly advocates for a human-scale approach to urban planning that promotes the use and enjoyment of urban areas. Various studies suggest low-rise, high-density developments as the ideal urban layout, in particular for residential neighbourhoods arguing that they offer optimal environmental efficiency while ensuring functionality and urban organization.

Although certain land uses may require and benefit from specific building volumes, or there may be building codes relating to contextual requirements (such as earthquake mitigation etc.) it is generally recommended that the average building height throughout an area be between 5 and 10 stories.

Complementary to the building volume, openness provides insight on the relationship of the building volume and the open space for human scale

It is recommended that the ratio of built-up space to open space be maintained between 10 to 50 meters.

☑ POPULATION DENSITY

A higher concentration of people in a city can mean that utilities and public services are more efficiently used and less energy is consumed. Utility networks, for example, do not have to cover such a large distance and maintenance costs are reduced. Higher densities of people can leave more space for public and open spaces within an urban area, and it can create a more lively and vibrant environment which leads to safer and more cohesive communities. More people within a smaller area can also lead to a higher diversity of activities and functions, which assists in create a dynamic urban area. However, over population can lead to overcrowding, transport congestion, poor air pollution and a greater challenge of managing waste and consumption levels.

What data do I need to assess population density?

A. Population Dataset

B. Residential Land-use Footprint

C. The size of the 'urban area' you are assessing

What equation helps me assess population density?

Population Density = Population Number / Residential Urban Footprint (m^2)

Understanding the distribution of population in an urban area can assist in many ways. It can help to direct new facilities in areas with a higher population, or identify areas that have a potential to densify. Although an ideal population density varies in diverse contexts, UN-Habitat recommends a minimum concentration of 150 people per hectare (within the built-up area) as a guideline to promote an active environment without overcrowding or sprawl. A comprehensive analysis, including field studies and consultation with local experts, is essential to determining the most appropriate population density for urban areas.[1]

1 This analysis uses residential population mainly. According to the availability of data more information such as students in schools or patients in hospital, daily or seasonal workers and out-migration or seasonal university student population can build a better picture of the city's population.

PROXIMITY AND WALKABILITY

A sustainable city ensures residents have quick access to key facilities, and a diverse mix of land uses preferably without using private vehicles.

Key facilities may vary in diverse contexts, however there are a few examples that are included below. Walkability and proximity to services and mixed land uses fosters a community where daily needs are met within walking distance, reducing commuting time, lowering energy consumption and transport costs and enhancing both quality of life and environmental resilience.

Evaluating proximity and walkability involves assessing the existing relationship between the population distribution and the location various elements through the road network. To achieve this, analytical tools from the network analysis toolset such as service area and closes facility (using a grid) are of great help.

Evaluating the mix use degree involves assessing the existing proximity between multiple land use categories. To achieve this, analytical tools from the network analysis toolset such as the origin-destination matrix is appropriate for this complex technical process.

☑ ACCESS TO OPEN PUBLIC SPACE

Public spaces are vital for quality of life, physical and mental well-being, air, soil and water quality. Open public spaces can enable community integration and cohesion, can be necessary to reduce the impacts of natural hazards, urban heat effects, and can be essential in cases of natural disasters. They can be a place of safety, rest, commemoration and demonstration. They can be temporary, planted or programmed. Ensuring universal access to a diversity of good quality open public spaces, within walking distance, regardless of socioeconomic status, is essential.

What data do I need to assess access to open public space?

A. Population Dataset

B. Open Public Space

C. Road Network

What equation helps me assess access to open public space?

Access to Open Public Space = Surface Unit Access Time ≤ 5 minutes

Population with access in a walking distance = Σ Population within surface units access time ≤ 5 minutes

The UN Habitat Global Public Space Programme (GPSP) suggests that all residents within a city should be able to reach a public space in ideally no more than 5 minutes by walking, to fully benefit from its amenities. This benchmark serves as a useful reference when assessing access to open public spaces. However, it's crucial to adapt this standard based on the size and typology of the public spaces, as these factors significantly influence both their impact and accessibility.

This analysis can help to see which areas lack open public spaces, what type or function of the open public space is needed and how the road network assists or obstructs access to this key part of urban life.[2]

2 The UN-Habitat Global Public Space Programme (GPSP) offers a valuable tool, the City Wide Public Space Assessment - CWPSA, for identifying and categorizing public spaces through a spatial catalogue.

☑ ACCESS TO HEALTH SERVICES

Health centres must be within easy and convenient reach of the population of a city or urban area, including emergency and preventive care services, regardless of socioeconomic status, vulnerability, or access to private transportation. A sustainable city integrates health and equity into urban planning. This is crucial for ensuring quick response times for health emergencies and promotes regular preventive check-ups, which are vital for the functioning and reducing burden on a health system.

What data do I need to assess access to health services?

A. Population Dataset,

B. Health Facilities, and

C. Road Network

What equation helps me assess access to health services?

Access to Health Services = Surface unit access time ≤ 5 minutes

Population with access in a walking distance = Σ Population within surface units access time ≤ 5 minutes

UN-Habitat recommends that all residents of a city should ideally be able to reach a regular health clinic within 5 minutes' walk to promote equity and efficient care. Including a public transport assessment can help to build a better understanding of the kinds of strategies needed to tackle accessibility issues. Assessing the type of facilities that are available, and the specialities of the health facility should also be taken into account. However, overall this assessment can be useful to see if there are disparities in the healthcare service provision across various neighbourhoods.

☑ ACCESS TO EDUCATION SERVICES

Achieving sustainable development depends on creating a just society, which requires an equitable spatial distribution of public educational institutions, ideally within walking distance of all children. Poor access to education can impact whether parents are able to work, and is a direct cause of and can exacerbate disparities in the opportunities and prosperity of children and their families. Unsafe or lengthy travel times to school can inhibit learning and is particularly impactful on girls and children with disabilities or special needs.

What data do I need to assess access to education services?

A. Population Dataset,

B. Education Facilities, and

C. Road Network

What equation helps me assess access to health services?

Access to Education Services = Surface unit access time ≤ 5 minutes

Population with access in a walking distance = Σ Population within surface units access time ≤ 5 minutes

The proportion of the population outside of a convenient access to primary education facilities can help to show where there are disparities in primary education provision. UN-Habitat recommends an ideal benchmark of all children under the age of 11 accessing a primary school within a 5 minute walk. When assessing education facilities such as universities or secondary schools, the time to access can be extended based on the context.

☑ ACCESS TO PUBLIC TRANSPORT

Poor public transport services can lead to a higher dependency on private vehicles, traffic congestion, poorer air quality, safety challenges, and exacerbates inequality and access to key services. It also creates a higher demand for road infrastructure, which fragments free flowing pedestrian movement within a city. An integrated public transport system is the most effective way to reduce congestion even in densely populated areas of a city and promotes rational, sustainable, and equitable mobility across a neighbourhood.

What data do I need to assess access to public transport?

A. Population Dataset,

B. Public Transport Stops

C. Road Network

What equation helps me assess access to public transport?

Access to Public Transport System =

Surface unit access time ≤ 5 minutes

Population with access in a walking distance = Σ Population within surface units access time ≤ 5 minutes

UN-Habitat recommends providing access to both low-capacity (e.g., bus, BRT) within a 5-minute walking distance and high-capacity (e.g. trains) public transport systems within a 1-kilometre radius. This assessment shows areas where transportation services are inadequate, allowing for targeted improvements such as new transport stations, extensions to transport routes or identification of new routes or modes of transport. This dataset may also be looked at alongside frequency or regularity of public transport (hourly and seasonally) as well as other factors associated with access, such as cost or design.

☑ PROXIMITY TO DIVERSE LAND USES

Cities that have a diversity of businesses, services, and amenities stimulate innovation, creativity, and entrepreneurship and support a more economically sustainable and resilient urban area for its residents. Ensuring a spatial distribution of economic activities in a city enables more equitable access to income and employment.

What data do I need to assess access to diverse land uses?

A. Building footprint (containing heights and use category) and

B. Road network

Land-use categories could include

- Administrative

- Commercial
- Mixed-Use
- Cultural Facilities
- Industrial Units
- Recreational Areas

What equation helps me assess diverse land uses?

Proximity to diverse land-uses = $\sum_{i=1}^{5}$ Individual proximity layers

A diverse land use can encourage diverse groups of people to use the same space, encouraging social interactions and community cohesion. Some analyses give an understanding of the distribution of mixed-use areas across neighbourhoods (for example balance, entropy, and Herfindahl-Hirschman indices). However, it is recommended to include population in the equation, to better understand where diverse land uses and economic opportunities are in relation to where people live. Therefore, the 15 minute city principle may be a useful guide in this instance.

Creating individual proximity layers for each land use category and overlaying them to assess overall accessibility can be a useful approach. It is also recommended to categorise each layer into five classes based on walking access time, allocating the lowest value to most remote areas.

REFERENCES

POPULATION & BUILDING DENSITY

General References:

Angel, S., Blei, A., Parent, J., Lamson-Hall, P., Galarza Sánchez, N., Civco, D. L., Lei, R. Q., & Thom, K. (2016). Atlas of Urban Expansion—2016 Edition, Volume 1: Areas and Densities. New York University, UN-Habitat, and Lincoln Institute of Land Policy.

Berghauser Pont, M., & Haupt, P. (2021). Spacematrix: Space, density and urban form (Revised and expanded edition). nai010 publishers.

Carruthers, J. I., & Ulfarsson, G. F. (2003). Urban sprawl and the cost of public services. Environment and Planning B: Planning and Design, 30(4), 503-522.

Güneralp, B., Zhou, Y., Ürge-Vorsatz, D., Gupta, M., Yu, S., Patel, P. L., Fragkias, M., Li, X., & Seto, K. C. (2017). Global scenarios of urban density and its impacts on building energy use through 2050. Proceedings of the National Academy of Sciences, 114(34), 8945-8950. https://doi.org/10.1073/pnas.1606035114

Iungman, T., Khomenko, S., Barboza, E. P., Cirach, M., Gonçalves, K., Petrone, P., Khreis, H., Ortigoza, A. F., Nieuwenhuijsen, M., & Mueller, N. (2024). The impact of urban configuration types on urban heat islands, air pollution, CO2 emissions, and mortality in Europe: a data science approach. The Lancet Planetary Health, 8(7), e489-e505. https://doi.org/10.1016/S2542-5196(23)00161-8

McGarigal K., SA Cushman, and E Ene. 2023. FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors; available at the following web site: https://www.fragstats.org

Pomponi, F., Saint, R., Arehart, J. H., Gharavi, N., & D'Amico, B. (2021). Decoupling density from tallness in analysing the life cycle greenhouse gas emissions of cities. Npj Urban Sustainability, 1(1), 33.

Ståhle, A. (2008). Compact sprawl: Exploring public open space and contradictions in urban density [Doctoral dissertation, KTH Royal Institute of Technology]. DiVA. http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A37326

Benchmark:

UN-Habitat. (2014). A New Strategy of Sustainable Neighbourhood Planning: Five Principles. United Nations Human Settlements Programme.

Urban Ecology Agency of Barcelona. (2012). Ecosystemic urbanism certification: Methodological guide for auditing, certification or accreditation systems of quality and sustainability

in the urban environment. Spanish Ministry of Development.

PROXIMITY AND WALKABILITY

General:

Chang, Y. S., Jo, S. J., Lee, Y. T., & Lee, Y. (2021). Population Density or Populations Size. Which Factor Determines Urban Traffic Congestion? Sustainability, 13(8), 4280. https://doi.org/10.3390/su13084280

Grisé, E., Boisjoly, G., Maguire, M., & El-Geneidy, A. (2022). Qualifying accessibility to education to investigate spatial equity. Journal of Transport Geography, 98, 103254. https://doi.org/10.1016/j.jtrangeo.2021.103254

Lindelöw, D., Svensson, Å., Sternudd, C., & Johansson, M. (2021). The Walkable city and the importance of the proximity environments for sustainable mobility. Frontiers in Built Environment, 7, 721218. https://doi.org/10.3389/fbuil.2021.721218

Nieuwenhuijsen, M. J. (2020). Urban and transport planning pathways to carbon neutral, liveable and healthy cities; A review of the current evidence. Environment international, 140, 105661.

Ren, Y., Guo, Y., & Xiong, Y. (2023). The Equity of Basic Educational Facilities from the Perspective of Space. Sustainability, 15(14), 11121. https://doi.org/10.3390/su151411121

Rojas-Rueda, D., Norberciak, M., & Morales-Zamora, E. (2024). Advancing Health Equity through 15-min Cities and Chrono-urbanism. Journal of Urban Health, 101, 483–496. https://doi.org/10.1007/s11524-024-00850-2

Suárez-Lastra, M., Delgado-Campos, J., & Peralta-Higuera, A. (2023). Determinants and metropolitan patterns of school travel time. Is location associated with average years of schooling?: The case of Mexico City. Cities, 140, 104394. https://doi.org/10.1016/j.cities.2023.104394

UN-Habitat. (2015). Global Public Space Toolkit: From Global Principles to Local Policies and Practice. United Nations Human Settlements Programme.

Vuchic, V. R. (2017). Transportation for Livable Cities. Routledge.

https://doi.org/10.4324/9781351318167

World Health Organization & UN-Habitat. (2020). Integrating health in urban and territorial planning: A sourcebook for urban leaders, health and planning professionals. https://www.who.int/publications/i/item/9789240003170

Zuniga-Teran, A. A., & Gerlak, A. K. (2023). Walkability and Its Relationships With Health, Sustainability, and Livability: Elements of Physical Environment and Evaluation Frameworks. Sustainable Cities and Society, 103955. https://doi.org/10.1016/j.scs.2023.103955

Benchmark:

UN-Habitat. (2018). SDG Indicator 11.7.1 Training Module: Public Space. United Nations Human Settlement Programme.

UN-Habitat. (2020). City-wide public space assessment toolkit: A guide to community-led digital inventory and assessment of public spaces. United Nations Human Settlements Programme (UN-Habitat). https://unhabitat.org/city-wide-public-space-assessment-toolkit-a-guide-to-community-led-digital-inventory-and-assessment

UN-Habitat. (2022). Global Urban Monitoring Framework: A Guide for urban monitoring of SDGs and NUA and other urban-related thematic or local, national and global frameworks. https://unhabitat.org/sites/default/files/2022/08/the_global_urban_monitoring_framework_metadata.pdf

MIX LANDUSE

General:

Liu, S., Gu, C., & Chen, Y. (2023). Analysis of Coupling Relation between Urban Spatial Compactness and Degree of Land Use Mix Based on Compact City Theory: The Case of Downtown Shenyang, China. Sustainability, 15(2), 1202. https://doi.org/10.3390/su15021202

Song, Y., Merlin, L., & Rodriguez, D. (2013). Comparing measures of urban land use mix. Computers, Environment and Urban Systems, 42, 1-13. https://doi.org/10.1016/j.compenvurbsys.2013.08.001

Yue, Y., Zhuang, Y., Yeh, A. G. O., Xie, J. Y., Ma, C. L., & Li, Q. Q. (2017). Measurements of POI-based mixed use and their relationships with neighbourhood vibrancy. International Journal of Geographical Information Science, 31(4), 658-675. https://doi.org/10.1080/15481603.2014.993854

Zagorskas, J. (2016). Mixed-Use Development, Compact City, and Urban Sustainability. International Journal of Environmental Science, 1, 284-293

GENERAL COMPACT CITY REFERENCES

Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. Developments in the built environment, 4, 100021.

Duranton, G., & Puga, D. (2020). The Economics of Urban Density. Journal of Economic Perspectives, 34(3), 3-26.

Gehl, J. (2010). Cities for people. Island Press.

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the “15-Minute City”: Sustainability, resilience and place identity in future post-pandemic cities. Smart Cities, 4(1), 93-111.

UN-Habitat. (2014). A New Strategy of Sustainable Neighbourhood Planning: Five Principles. United Nations Human Settlements Programme.

CONNECTED CITY

Residents of the connected city leverage from permeable and efficient street network with walkable and cyclable distances to close destinations while having access to multi-modal transport systems to connect with the opportunities of the wider city. Streets in the connected city function as public spaces and cornerstones for Transit Oriented Development and give priority to people and transit over cars. The urban environment of the connected city considers streets as vibrant, safe and attractive open public spaces accessible for all. A grid road network that is well connected supports rapid evacuation by offering alternative routes and provides health benefits to pedestrians less dependent on private vehicles.

The Connected City relates to the New Urban Agenda transformative commitments: 34, 36, 37, 39, 54, 62, 67

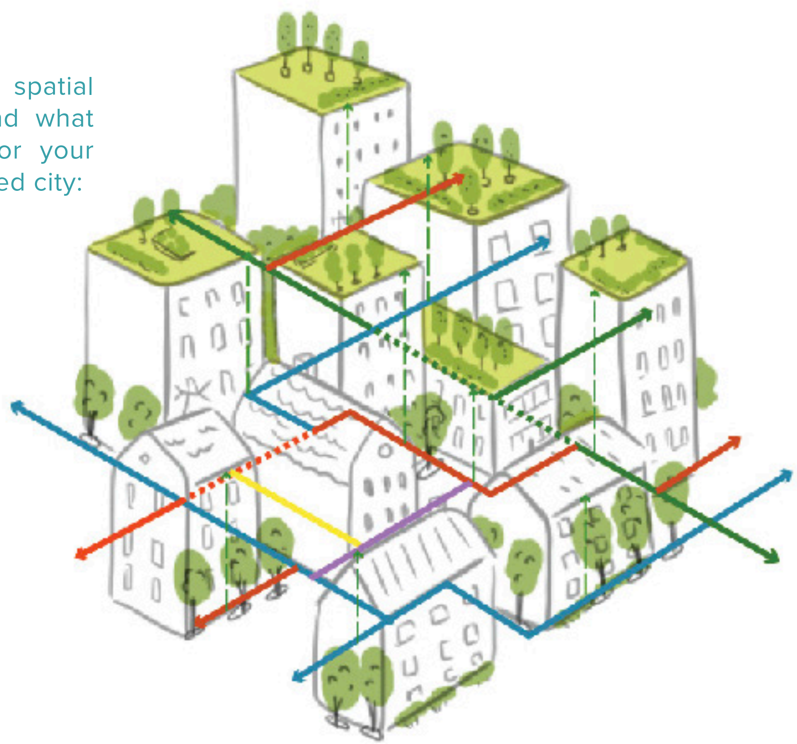
The following are the recommended spatial analyses to run to help you understand what obstacles or opportunities there are for your neighbourhood in relation to the connected city:

STREET NETWORK

- Street Density
- Street Permeability
- Street Network Efficiency
- Street Network Population/Land Use
- Street Network Functionality

TRANSPORT SYSTEM

- Public Transport Lanes Provision
- Diverse Choice of Public Transport Modes
- Transit Network Global Centrality



STREET NETWORK

The transit street network is the lifeblood of a city, facilitating the exchange of goods, services, labour, and information, all of which are crucial for driving economic activity. Its efficiency relies how pedestrian-friendly and navigable the network is. A well-designed street network not only enhances economic performance but also improves quality of life by reducing travel times and fostering more seamless mobility for residents and visitors alike. Avoiding clusters of road far from denser core areas, and 'closing the gap' in the road network (otherwise called, 'consolidating' the network) can be a way to improve the movement of residents and services.

Assessing how efficient is the road network involves analysing the spatial distribution of its key components, especially segment (sections of the road between intersections) and nodes (intersections). This evaluation is greatly facilitated by tools like intersection (based on a grid) and field calculators to apply simple mathematical formulas that assess the relationship between both elements. For a more comprehensive understanding, reviewing literature on graph theory is recommended.

☑ STREET DENSITY

The growing concentration of traffic in urban areas necessitates robust road networks capable of handling increased loads effectively. Conflicting movement patterns and insufficient road infrastructure exacerbates congestion, reduces accessibility and increases air pollution. On the other hand, too much road infrastructure, a prioritisation of private car use can also lead to a loss of vibrant, street life and pedestrian movement in a city. The cost of road maintenance is also high, and therefore, the road network must be assessed by its area (width and length) and also in relation to population concentrations across a neighbourhood or city.

What data do I need to assess street network density?

A. Road network - lines

B. Urban morphological/functional classification

Street network density is often quantified by length of roads per square kilometre. This metric helps us to understand the degree and extent of street network development. UN Habitat (CPI[3]) suggests to provide from 20 to 40 kilometres of street per square kilometre to establish a basis for sustainable, compact development and efficient movement.

It is suggested to use this benchmark as a reference, considering, among other things, the city's size. Since it's challenging to set a benchmark suitable for all city morphological and functional types (e.g., high-density central areas, low-density peri-urban zones), a solution is to define local or multiple standards based on typology classification. These standards could be derived from empirical studies or the median value for each city/typology, allowing for an assessment of how other parts of the city deviate from that standard.

This assessment allows an understanding of how to reduce congestion, where new roads are needed, and when compared with population density analysis, where there might be roads that are not being used.

3 The City Prosperity Index is an Urban Indicators Database and can be found here.

☑ STREET PERMEABILITY

Avoiding congestion on road networks is an increasing challenge in urban areas. The concentration of street intersections plays a critical role in increasing efficiency of movement in a neighbourhood both for cars and pedestrians. A higher intersection density promotes navigability and permeability. Road intersections and permeability also reflects on building unit size and massing. More permeable streets can assist in a fine grain and dynamic urban environment through the opportunity for smaller and more diverse building units. Creating easily navigable, permeable urban grids reduces travel distances, congestion and also can reduce car speeds, enhancing the overall efficiency of the transportation system and the quality of the pedestrian environment.

What data do I need to assess permeable street network?

A. Road network - nodes

A common way to measure the permeability of a road network is by calculating the number of intersections within a specific unit of measurement, such as a hectare or square kilometre. UN-Habitat recommends using the hectare as the standard unit and suggests that there should be more than one intersection per hectare to achieve a degree of permeability that facilitates efficient navigability. This analysis helps to provide an understanding about how well the road network facilitates movement, in relation to more or less permeable areas, where the construction of a road could close the network and increase route options and the efficiency of movement in a certain neighbourhood.

☑ STREET NETWORK CIRCUITY

As explored in the two assessments above, understanding the efficiency of the street network includes both the presence of sufficient road infrastructure, as well as the number of intersections and route options. Therefore, a combined assessment can come in useful to see which areas provides more route choices.

What data do I need to assess an efficient street network?

A. Road network - lines and nodes

A network consists of a framework of routes connecting locations, known as nodes. A route is a single link between two nodes within a larger network. The efficiency of this relationship, reflected in the number of alternative routes to a destination, can be measured by the Beta Index.

An efficient street network features well-connected routes that reduce travel distances and improve accessibility. A connected network with one cycle has a Beta Index of 1, while more complex networks score higher. According to graph theory applied to urban network studies, a Beta Index of 1.4 is recommended as the minimum for a walkable community.

STREET NETWORK LOCAL CENTRALITY

The previous assessments provide indicators to help an understanding of the extent and layout of the streets in a neighbourhood or city, and whether it may be enhancing or inhibiting a connected urban environment.

The following assessment includes land use datasets to provide an understanding not only of connection routes and road infrastructure, but also how well it works for the people that live there.

It answers the question, how many different buildings, people, amenities or job places can be reached by a given portion of the road network? Understanding how nodes and the road network complement each other can highlight which areas of the city may be disconnected or serves as a 'hub' or 'centrality' of activities and services.

What data do I need to assess street network functionality?

A. Road network - lines and nodes

This assessment uses the Closeness Index, which indicates how close an origin is to all destinations within a given area. Lower closeness values indicate more central, well-connected hub nodes.

It is recommended to use the city's 15-minute parameter for the radius (considering walking and cycling speeds), considered the optimal time for reaching essential services and amenities.

If this indicator is combined with additional indicators such as population density or density of economic activities, it helps to promote short-range interactions, supporting sub-nodes of activity like neighbourhood markets and local services that drive the local economy.

NETWORK OF CENTRALITIES

In addition to this, it is important to assess how well the street network functions for broader interactions. Such interactions are large-scale interactions via motorized transport, ensuring no area is isolated from key economic and social opportunities.

A well established network of centralities enables efficient travel, reduces travel times, and promotes equitable access to urban resources. Balancing local and network of centralities through effective road design reduces congestion, prevents the over-concentration of resources, and promotes a more polycentric urban structure.

What data do I need to assess street network functionality in relation to public transport?

A. Road network - lines and nodes

Using the same Closeness Index, but using a 30 minute radius and a different mode of transportation, assists in identifying network design interventions that reduce congestion, prevent the over-concentration of resources, and promote a more poly-centric urban structure.

Additional ways to assess transport and its role in creating a connected city are in the next chapter.

TRANSPORT SYSTEM

Cities around the world face the challenge of providing integrated public transport systems, which are essential for strengthening urban connectivity and reducing inequalities in access to services and opportunities. Achieving this requires thoughtful urban planning that designs well-connected transit networks, prioritizes accessibility, and minimizes reliance on private vehicles. A well-executed multi-modal system fosters inclusivity, mitigates congestion, lowers environmental impacts, and improves the overall quality of life by ensuring equitable, sustainable mobility options for all residents. A multi-modal transportation system offers its citizens the chance to choose from different types of transportation and distributes the demand among a variety of options. Thus, it also ensures the continuity of urban mobility in case of disruption in one of modes. By this, multi-modality contributes to urban resilience.

Evaluating the degree of multi-modal public transport access involves assessing the diversity of access to different transport modes within a specific time distance. Analytical tools from the network analysis toolset, such as the origin-destination matrix, are appropriate for this complex technical process.

☑ LOCATION OF PUBLIC TRANSPORT ROUTES

Dedicated public transport lanes (e.g., for buses or trams) ensure efficient transit, reduce congestion, and improve reliability. These lanes help mitigate traffic delays and encourage more residents to choose public transport over private cars, fostering a more sustainable and accessible urban mobility system.

What data do I need to assess how effectively is the location of public transport routes?

A. Road network - lines and nodes

B. Public Transport Lines

An analysis of which routes in the city are likely to be the most used can show where public transport may be most depended upon for connectivity in a city or neighbourhood. Therefore, it is useful to overlay this with where existing public transport lines are.

This can highlight where new public transport lines would be most effective to connect people to areas that are

☑ LOCATION OF PUBLIC TRANSPORT STOPS

Residents' travel needs vary depending on distance, time constraints, and personal preferences. Providing a range of transportation options—including walking, cycling, buses, and trains, depending on the context—ensures that mobility is inclusive and adaptable to these diverse needs.

What data do I need to assess if there are sufficient public transport options?

A. Road network - lines and nodes

B. All Public Transport Stops

C. Population Density

D. Transport Types

The Reachability Index is an effective tool to measure where there is a higher number of transport options. UN-Habitat recommends ensuring access to both low-capacity (e.g., buses, BRT) and high-capacity public transport systems within a 5-minute walk or 1-kilometre radius. It is advised that these benchmarks be applied during the assessment to measure connectivity effectively.

A vibrant city provides diversity of activities, services and economic opportunities to its inhabitants. By vibrancy, a city can enhance its attractiveness and be able to offer spaces for social interaction, cohesion and thus enables social and human capital development.

One of the main components of the vibrant city is the variety of functions and the distribution of the mixed land. Mixed land-use is also found to be one of the components that encourages walking behaviour of inhabitants. Economic activities can benefit from cross-industry spillovers and attract a diverse labour force, providing space for interaction.

In GIS, the count of uses and/or volume of uses summarized within the defined area (hexagon, grid or any other equally defined polygon). For a better visual, polygons can be transformed to points, followed by the application of Natural Neighbour technique.

REFERENCES

STREET NETWORK

General:

Boeing, G. (2019). Urban spatial order: Street network orientation, configuration, and entropy. Applied Network Science, 4(1), 1-19.

Ewing, R., & Cervero, R. (2010). Travel and the built environment: A meta-analysis. Journal of the American Planning Association, 76(3), 265-294.

Marshall, S. (2005). Streets and patterns. Spon Press.

Southworth, M., & Ben-Joseph, E. (2003). Streets and the shaping of towns and cities. Island Press.

Porta, S., Crucitti, P., & Latora, V. (2006). The network analysis of urban streets: A primal approach. Environment and Planning B: Planning and Design, 33(5), 705-725.

Benchmark:

UN-Habitat. (2013). Streets as Public Spaces and Drivers of Urban Prosperity. Nairobi: UN-Habitat.

UN-Habitat. (2016). Measurement of city prosperity: Methodology and metadata. United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/2019/02/CPI-METADATA.2016.pdf

URBAN CENTRALITY

General:

Crucitti, P., Latora, V., & Porta, S. (2006). Centrality measures in spatial networks of urban streets. Physical Review E, 73(3), 036125.

Hillier, B. (2007). Space is the machine: A configurational theory of architecture. Space Syntax

Jiang, B. (2009). Ranking spaces for predicting human movement in an urban environment. International Journal of Geographical Information Science, 23(7), 823-837.

Porta, S., Latora, V., Wang, F., Rueda, S., Strano, E., Scellato, S., ... & Latora, L. (2012). Street centrality and the location of economic activities in Barcelona. Urban Studies, 49(7), 1471-1488.

Scheurer, J., & Porta, S. (2006). Centrality and connectivity in public transport networks and their significance for transport sustainability in cities. World Planning Schools Congress, Global Planning Association Education Network.

Sevtsuk, A., & Mekonnen, M. (2012). Urban network analysis. Revue internationale de géomatique–n, 287, 305.

Benchmark:

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the “15-Minute City”: Sustainability, resilience and place identity in future post-pandemic cities. Smart Cities, 4(1), 93-111.

UN-Habitat. (2016). Measurement of city prosperity: Methodology and metadata. United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/2019/02/CPI-METADATA.2016.pdf

MULTIMODAL TRANSPORT SYSTEM

General:

Altshuler, Y., Puzis, R., Elovici, Y., Bekhor, S., & Pentland, A. (2011). Augmented Betweenness Centrality for Mobility Prediction in Transportation Networks. In J. Salerno, S. Yang, D. Nau, & S. Chai (Eds.), Social Computing, Behavioral-Cultural Modeling and Prediction (pp. 1-8). Springer.

Derrible, S. (2012). Network Centrality of Metro Systems. PLOS ONE, 7(7), e40575. https://doi.org/10.1371/journal.pone.0040575

Haas, A. R. N. (2019). Key considerations for integrated multi-modal transport planning. International Growth Centre. https://www.theigc.org/sites/default/files/2019/02/Integrated-multi-modal-transport-planning-FINAL-Jan2019.pdf

Kazerani, A., & Winter, S. (2009). Can Betweenness Centrality Explain Traffic Flow? In B. Gottfried & H. Aghajan (Eds.), Behaviour Monitoring and Interpretation – BMI: Smart Environments (pp. 308-322). IOS Press.

Vuchic, V. R. (2007). Urban transit systems and technology. John Wiley & Sons.

Zhang, X., Xu, Y., Tu, W., Xu, C., Yin, J., & Zhou, C. (2023). Interconnectedness enhances network resilience of multimodal public transportation systems for Safe-to-Fail urban mobility. Nature Communications, 14(1), 4245. https://doi.org/10.1038/s41467-023-39999-w

Benchmark:

Institute for Transportation and Development Policy. (2023). The BRT Standard https://www.itdp.org/publication/the-brt-standard/

UN-Habitat. (2018). SDG Indicator 11.2.1 Training Module: Public Transport System. United Nations Human Settlement Programme.

UN-Habitat. (2016). Measurement of city prosperity: Methodology and metadata. United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/2019/02/CPI-METADATA.2016.pdf

GENERAL CONNECTED CITY REFERENCES

Rodrigue, J. P. (2020). The geography of transport systems (5th ed.). Routledge. https://doi.org/10.4324/9780429346323

Van Nes, A., & Yamu, C. (2021). Introduction to space syntax in urban studies. Springer Nature. https://doi.org/10.1007/978-3-030-59140-3

INCLUSIVE CITY

The residents of an inclusive city have equitable right to the city, access to services, employment, open public space, public transportation, and other opportunities the city provides. The urban environment of an inclusive city supports physical, economic, cultural and social needs of all people of all abilities, of all backgrounds and income levels. Open public spaces of an inclusive city are welcoming to all visitors, housing is affordable and attracts a diverse range of residents.

The Inclusive City relates to the New Urban Agenda transformative commitments: 25, 26, 27, 31, 32, 33, 34, 36, 37, 39, 40, 43, 62

The following are the recommended spatial analyses to run to help you understand what obstacles or opportunities there are for your neighbourhood in relation to the vibrant city:

MIXED LAND USE

- Affordable housing
- Housing Price
- Rent to Income Ratio
- Subsidized Housing

SOCIAL MIXTURE

- Housing Tenure Diversity
- Income Diversity
- Demographic Diversity

EQUITABLE ACCESS TO BASIC SERVICES

- Sufficient Living space
- Clean Water and Sanitation
- Electricity
- Waste Collection Points

EQUITABLE ACCESS TO SOCIAL SERVICES

- Open Public Space Provision
- Green Area Provision
- Health Facilities Provision
- Education Facilities Provision

AFFORDABLE HOUSING

Rising housing costs driven by rapid urbanization, insufficient housing supply, or policies which allow housing units to remain empty, can lead to economic and social inequalities that are manifested in spatial segregation between the city's centre and outskirts. This exacerbates inequitable access to key services and employment in cities, and, if not addressed, undermines the Universal Declaration of Human Rights, which includes the right to housing.

☑ HOUSING PRICE

Housing sales prices in urban areas have become a significant challenge, particularly as demand for housing outstrips supply in rapidly growing cities. Home-ownership is becoming increasingly unattainable for many, particularly for lower-income households, young professionals, and vulnerable groups such as single-parent families or migrants. High housing prices are contributing to socioeconomic segregation and displacement, reducing the potential for building inclusive cities where all residents have equal access to opportunities and resources.

What data do I need to assess what housing prices are spatially in an urban area?

A. Housing price

B. Neighbourhood boundary

A valuable metric for evaluating housing distribution and affordability is the Median Home Price. To evaluate this, data from real estate platforms or databases that track sales costs can be used. It is advisable to aggregate this information at the neighbourhood level to gain more localized insights. Visualizing the results through appropriate categorization methods in GIS, such as natural breaks, can help highlight areas of concern as it identifies natural groupings in the data, making it easier to detect where housing prices significantly differ across the city.

This analysis can provide an understanding of house prices in a certain neighbourhood and assist in identifying where income and social segregation may be as an outcome of house prices.

☑ RENT TO INCOME RATIO

Rapid urbanization, population growth, and the growing inability to afford home-ownership have pushed more residents into renting, driving up rental prices while wages stagnate. This widening rent-to-income gap strains residents, particularly in lower-income brackets, displacing vulnerable populations to the urban periphery with limited access to services and opportunities. This undermines the social mix and inclusivity of urban environments, creating divided cities with concentrations of wealth and poverty.

What data do I need to assess the affordability of rent for residents in an urban area?

A. Rental price

B. Average income

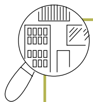
C. Neighbourhood boundary

The Rent to Income Ratio is a widely used metric for assessing housing affordability, representing the percentage of a household's income that goes toward rent. This ratio is crucial for determining whether residents can afford housing without sacrificing their ability to meet other basic needs. According to UN Habitat, a ratio above 30% typically indicates a housing cost burden, where households may face financial strain.

Data from real estate platforms or databases can be used to calculate average rent values, while income data can be sourced from census surveys. It is recommended to conduct the analysis at the neighbourhood statistical block level, comparing rent and income figures. The natural breaks classification method is advisable to visualize areas in GIS where affordability issues are most pronounced.

☑ SUBSIDISED HOUSING

Subsidized housing programs, which include rent-controlled units, housing vouchers, and public housing developments, are designed to bridge the existing gap between supply and demand. However, many cities struggle with limited resources, bureaucratic delays, and a lack of available land, resulting in long waiting lists and inadequate supply. Planning for subsidized housing must be proactive, ensuring that such housing is integrated into well-connected areas rather than concentrated in marginalized zones, which can lead to social segregation. Achieving a balanced provision of subsidized housing is vital for fostering inclusive and equitable cities.



What data do I need to assess where and how much subsidised housing there is in an urban area?

A. Rental price

B. Average income

C. Neighbourhood boundary

Subsidized housing is government-supported housing made available to low-income individuals and families. It plays a crucial role in reducing housing costs and preventing homelessness, ensuring that vulnerable populations have access to adequate shelter.

There is a strong international emphasis, supported by organizations like UN-Habitat, on ensuring a substantial portion of urban housing is affordable, though specific targets like 20% to 50% are often set by national or local policies, depending on housing needs and market conditions.

A key metric for assessing the provision of subsidized housing includes the percentage of total housing units that are subsidized. Government Housing Agencies or Housing Program Databases are useful sources containing information on the number and distribution of subsidized housing units across a city. Such information is usually aggregated at the neighbourhood level. In such cases, the natural breaks classification method is useful to the gaps.

SOCIAL MIXTURE

Cities often face the challenge of socioeconomic segregation, where different income groups live in separate areas, leading to disparities in access to services, employment, and opportunities. Promoting social mix through urban planning involves encouraging diverse housing options, integrating different income groups, and avoiding the concentration of wealth or poverty in specific areas. By designing mixed-income, mixed-use neighbourhoods, cities can ensure that residents from various backgrounds interact, share resources, and contribute to more equitable urban environments.

☑ HOUSING TENURE DIVERSITY

A balanced mix of housing tenures, such as public housing, private rental, owner-occupied housing units, Co-op housing, and home-ownership is an indicator of social integration due to the neighbourhood capacity to respond to varying financial situations and stages of life, attracting a diverse range of income groups and lifestyles. Ensuring mixed tenure enables daily encounters with others, favouring better coexistence and mitigating location-based stigma. It also contributes to the reduction of the territorial concentration of poverty, strengthening the levels of inclusiveness of urban areas.

What data do I need to assess housing tenure diversity across an urban area?

A. Land parcels, Land Ownership and Housing Type – Census Data

Housing tenure diversity refers to the variety of housing tenure types within a neighbourhood, including renters, homeowners, and residents in subsidized or social housing.

The Shannon Diversity Index is a useful metric to assess it, capturing whether multiple housing tenure types exist and whether they are evenly distributed within the neighbourhood. The index produces a value between 0 and 1, with values closer to 0 indicating a lack of diversity (domination by a single tenure type) and values closer to 1 suggesting a more balanced distribution of tenure types, reflecting greater housing tenure diversity.

UN-Habitat recommends that no single tenure type should occupy more than 50% of the residential floor area at the neighbourhood scale. Translating this into the Shannon Diversity Index, neighbourhoods with values above 0.5 demonstrate the recommended level of tenure diversity.

When interpreting the results, it is essential to focus on areas where diversity is lacking, identifying regions where one housing tenure dominates the landscape. Census data should be used as a primary source for tenure information. For a more comprehensive analysis, field validation is also advised to ensure that tenure diversity aligns with broader goals of social inclusion and equity in urban planning.

☑ INCOME DIVERSITY

Income diversity within a city or neighbourhood is crucial for fostering social cohesion, social capital, and economic inclusivity. Neighbourhoods that encompass a range of income levels tend to be more resilient, as they prevent socio-economic segregation and create environments where different income groups can live together and share access to public services, amenities, and employment opportunities. On the contrary, income segregation can lead to pockets of concentrated poverty or wealth, limiting upward mobility for lower-income residents and restricting their access to opportunities.

Income diversity can be a consequence of housing price and availability. Assessing this is one layer of information that can inform planning decisions to encourage economic diversity across a neighbourhood and city.

What data do I need to assess income diversity?

A. Household income

B. Neighbourhood boundary

Several metrics can be used to evaluate the economic diversity of neighbourhoods and assess income segregation across different areas. One highly recommended tool for this is the Theil Index, which measures how local incomes compare to the broader region, helping to identify whether wealth is concentrated in specific areas or if income levels are more evenly distributed. A low Theil Index value (closer to 0) indicates income equality, meaning that residents across neighbourhoods have similar income levels. In contrast, higher values reflect increased economic segregation, where a small portion of the population controls a larger share of total income.

Census data or Housing surveys are recommended as primary sources for household income data. It is important that the results are interpreted within the specific local context and validated through field studies to ensure an accurate understanding of income distribution patterns and their potential impact on urban planning decisions.

☑ SOCIAL DIVERSITY

Social diversity, including age, gender, ethnicity and more (based on available demographic data), is a key factor in creating socially inclusive and vibrant urban environments. A balanced mix of demographics helps promote social cohesion, reduce segregation, and foster cross-cultural interactions that enhance the overall quality of urban life.

Diverse communities are often more resilient, economically dynamic, and culturally rich. Planning for diversity at the neighbourhood level ensures that different groups, regardless of background or age, have equitable access to services, employment opportunities, and public spaces.

What data do I need to assess social diversity?

A. Demographic characteristics

B. Neighbourhood boundary

Evaluating demographic diversity, particularly, for example, ethnic and age groups, requires a metric that captures whether one group is dominant over others. The Simpson Diversity Index is commonly used for this purpose, as it measures the probability that two randomly selected individuals will belong to different demographic groups. The index ranges from 0 to 1, with values closer to 0 indicating homogeneity (dominance of one group), and values closer to 1 reflecting greater diversity.

To apply this index effectively, it is important to group individuals appropriately based on the context. For ethnic diversity, for example, this may involve classifying residents into relevant ethnic categories, while for age diversity, standard groupings such as children (0-14 years), working-age adults (15-64 years), and the elderly (65+ years) could be used. Census data and demographic surveys are key data sources for calculating ethnic and age diversity at the neighbourhood level. The results should be analysed to identify areas with high levels of homogeneity, which may require targeted interventions to promote social integration and prevent the exclusion or segregation of specific groups.

EQUITABLE ACCESS TO BASIC SERVICES

Including Housing & Utilities

In an inclusive city, all residents must have access to adequate living conditions that support a dignified life, regardless of their location or socioeconomic status. Achieving this requires addressing gaps in the provision of essential services, particularly in densely populated or marginalized areas, to prevent the rise of under served communities. A well-planned, inclusive city ensures that no group is disproportionately impacted by inadequate services, fostering healthier, more equitable, and resilient communities while promoting sustainable urban development.

☑ LIVING SPACE

Housing is a fundamental need that must be adequately provided. The rapid urbanization occurring in cities worldwide has outpaced the ability to provide sufficient housing, leading to widespread shortages. As a result, many people are forced to live in overcrowded conditions, facing poor sanitation, heightened risk of disease, and social tensions. Ensuring adequate living space is crucial for promoting a healthy and dignified life, while reducing the negative effects of overcrowding.

What data do I need to assess adequate living space in an urban area?

A. Household number,

B. Number of rooms,

C. Population data,

D. Floor area

Various studies propose different parameters for evaluating housing adequacy, such as the number of persons per room, the ratio of persons per square meter, and others. International housing standards, including those set by the United Nations, generally classify a household as overcrowded when there are more than three persons per room, with an ideal standard being fewer than two persons per room. This data is typically gathered through census data or housing surveys, either at the statistical area or building level. Another common metric sets a minimum of 10 square meters per room per person or 15 square meters of floor area per person, which can be calculated using spatial data layers to assess housing conditions comprehensively.

Note that the benchmarks provided serve as general guidelines and should be adapted to the local context. Factors such as population density, cultural practices, and available land may influence what constitutes adequate housing in different regions. It is advisable to conduct thorough local assessments and engage with relevant stakeholders to tailor these standards to the specific needs and realities of each city or neighbourhood.

☑ CLEAN WATER & SANITATION

Access to safe water and sanitation is a fundamental right, and urban planning must ensure equitable provision of these services. Many cities, however, struggle to provide reliable access to all, often neglecting marginalized communities and worsening health risks and social inequalities. Ensuring equitable access to clean water and sanitation promotes healthier communities, prevents water-borne diseases, and supports environmental sustainability through efficient resource management, while improving overall living conditions.

What data do I need to assess the population's access to clean water and sanitation?

A. Population connected to pipelines (statistical block)

B. Population

C. Water sources

D. Sanitation facilities

E. Street network

The Sustainable Development Goal (SDG) 6 aims to achieve universal access to clean drinking water and adequate sanitation by 2030, setting a benchmark of 100% coverage. Given the challenges posed by rapid urbanization, it is recommended that the analysis include both direct pipeline access and proximity-based access to services sources.

Direct access is typically assessed through census or household survey data aggregated at the statistical block level, reflecting the percentage of the population served connected to pipeline systems. To highlight areas needing intervention, a natural breaks classification method can be employed, which groups data into categories based on significant gaps in service provision.

For proximity-based access, a network analysis with a 10-minute walking parameter is suggested to evaluate how accessible water sources are to residents through the street network.

☑ ELECTRICITY

Residents need electricity to carry out daily and productive activities, making a consistent and reliable supply essential. While providing electricity is generally easier than services that rely on pipelines, such as water and sewage, the rapid urbanization the world is experiencing continues to present significant challenges. Expanding the grid to under served areas, ensuring reliability, and transitioning to renewable energy sources are crucial components of meeting the growing demand in a sustainable way.

What data do I need to assess the population's access to electricity?

A. Population connected to pipelines (statistical block)

B. Population

C. Night-time lights

The Sustainable Development Goal (SDG) 7 aims to achieve universal access to affordable, reliable, and modern energy services by 2030, setting a benchmark of 100% coverage. Common data sources for assessing electricity access include census data or household surveys, which provide aggregated information at the statistical block level, indicating the percentage of households connected to the electricity grid. It is recommended to use the natural breaks classification method to identify areas that require intervention. When such data is unavailable, satellite imagery can be utilized to conduct night-time light assessments, offering insights into electrified versus non-electrified areas . Regions with little to no night-time light typically correlate with limited access to electricity. Additional information about electricity source or national supply can build a bigger picture about access.

WASTE COLLECTION POINTS

Waste management is a growing challenge in the context of rapid global urbanization. The increasing volumes of waste generated require well-designed and evenly distributed collection systems, ensuring that all citizens can dispose of their waste safely and in an environmentally responsible manner.

An uneven distribution of waste collection points can lead to dirty streets, litter, and environmental degradation, which often exacerbates existing inequalities, disproportionately affecting marginalized communities. The consequence of poorly managed waste can also lead to the spread of disease or stray or wild animals entering into urban areas.

What data do I need to assess the access to waste collection points?

A. Waste collection points

B. Population

An important factor in the efficiency of waste management systems is the proper disposal of waste by residents, which depends largely on the provision and proximity of waste collection points for different types of waste. To ensure ease of access and encourage proper disposal, various design guidelines recommend that collection points for different waste fractions be located within 150 meters (in a straight line) from all residences. This proximity supports more effective waste segregation and disposal, contributing to a cleaner and more efficient urban environment.

EQUITABLE ACCESS TO SOCIAL SERVICES

Incuding Health, Education and Open Public Space

Addressing inequality in cities requires equitable access to key public services that enhance liveability and promote resilience. Ensuring these services are adequately provided based on population demand is crucial, to benefit the population and also ensure the investment in infrastructure is most efficiently used.

Many marginalized communities face insufficient per capita provision, leading to overcrowded services and reduced quality. Urban planning should, therefore, focus on both access and balanced distribution to ensure all residents benefit from a well-functioning, equitable urban environment (please see the 'Connected' chapter to learn about how to assess the access of facilities through transport and road networks alongside these analyses).

☑ OPEN PUBLIC SPACE PROVISION

Open public spaces—such as parks, plazas, and recreational areas—provide essential opportunities for social interaction, leisure, and civic engagement, which are vital for fostering both physical and mental health. These benefits are most effective when the provision of public space is proportionate to the population it serves.

However, in many cities, these spaces are unevenly distributed, often concentrated in wealthier neighbourhoods, leaving under served areas with limited access. This imbalance deepens social inequality and denies marginalized communities the benefits of public spaces.

What data do I need to assess the sufficient provision of open public space?

A. Open Public Space Network

B. Population

C. Street Network

UN-Habitat research highlights that well-functioning cities allocate about 50% of their surface area to public spaces . However, this figure alone does not ensure equitable distribution, as these spaces are often concentrated in certain areas. To enhance urban liveability, it is essential to provide a minimum reserve of open public space per inhabitant. Design guidelines recommend between 10 and 15 square meters of public space per person within a walkable radius, with higher provisions in residential areas compared to central urban fabrics.

When computing this analysis, it is recommended to use a parameter reflecting short-distance access, ideally within a 15-minute walk.

Assessing the quality of public spaces is equally important in evaluating equitable provision. The Public Space City-Wide Assessment, developed by the Global Public Space Programme, provides a comprehensive methodology for data collection and analysis.

☑ GREEN SPACE PROVISION

Living in urban areas demands spaces that offer psychological relief, foster social cohesion, promote physical activity, and reduce exposure to air and noise pollution. (Please see the 'Resilience' chapter which explores how integrating green and natural areas into urban areas is also important for biodiversity and ecology). However, poor planning and rapid urbanization lead many cities worldwide to lose valuable natural assets, often limiting access to specific socio-economic groups. To promote a healthy and just society, the provision of urban nature must be equitable, ensuring that all residents benefit without perpetuating inequalities.

What data do I need to assess the sufficient provision of green space?

A. Open Public Space Network

B. Population

C. Street Network

Numerous studies highlight the benefits of urban greenery for city dwellers. The World Health Organization (WHO) recommends that urban residents should be surrounded by a green area of at least 0.5 to 1 hectare with - in a 400-meter linear distance, or roughly a 5-minute walk, from their homes. It's important to note that green spaces typically feature non-seasonal vegetation and can include both planned and unplanned areas. These spaces span public and private realms and should be managed as an integrated system to maximize their range of environmental, social, and health benefits.

It is worth mentioning that models like the Urban Nature Access proposed by InVEST are available for open use, allowing for the assessment of the territorial distribution of the benefits provided by urban nature networks. This tool helps planners and decision-makers understand how green spaces contribute to well-being by distinguishing between passive and active green spaces, allowing them to identify areas where access to nature may be lacking and where interventions are needed to improve equitable distribution and functionality of these spaces.

HEALTH FACILITIES PROVISION

Access to healthcare is a human right, and a fundamental aspect of promoting well-being in urban areas. Ensuring an equitable distribution of healthcare facilities across a city is crucial for enabling residents to access timely medical attention, regardless of socioeconomic status or location. This prevents overcrowding in certain facilities while ensuring vulnerable communities are not left without adequate healthcare resources. A well-distributed healthcare system fosters public health and helps address inequalities.

What data do I need to assess the provision of health facilities?

A. Health Facility (supply data)

B. Population

C. Street Network

Several metrics are used to assess the efficiency of healthcare facility provision, focusing on key aspects like human resources, equipment, and infrastructure. One widely recognized indicator related to equipment is the number of hospital beds per 1,000 residents, which offers valuable insight into the system's capacity to meet healthcare demand. Acquiring accurate data on hospital beds and other healthcare resources often requires targeted studies, surveys, or health facility assessments, especially when disaggregating data for planning purposes.

In relation to the metric mentioned above, the World Health Organization (WHO) recommends a range of 3–5 hospital beds per 1,000 people as a minimum standard for adequate health equipment. While WHO does not establish a global norm for hospital bed density relative to population, this and other metrics estimate serves as a guideline for health system planning. It is important to consider local contexts, population density, and specific health care needs when establishing benchmarks that facilitate decision making.

For spatial analysis, the Closest Facility Network Analysis tool is highly recommended as it evaluates the geographic distribution of healthcare facilities and identifies the population for which these facilities are most accessible.

By comparing this information with available service supply data, such as human resources, equipment, and infrastructure, it can help identify gaps in healthcare provision. Although this tool primarily accounts for spatial factors and does not include variables like patient preferences or service quality, it remains a valuable method for assessing the spatial distribution and accessibility of healthcare services across urban areas.

☑ EDUCATION FACILITIES PROVISION

Equitable access to education is a key driver of social mobility and human development. Cities must ensure that educational institutions are evenly distributed, providing all children with the opportunity to receive quality education close to their homes. This includes primary, secondary, and tertiary institutions, each catering to different levels of education. Equitable provision reduces disparities in learning outcomes and fosters community engagement, paving the way for a more inclusive urban environment.

> **What data do I need to assess the provision of health facilities?**
>
> A. Education (supply data)
>
> B. Population
>
> C. Street Network

Like the health sector, the education sector relies on several key metrics to assess the effectiveness of educational facility provision, focusing on factors such as human resources, infrastructure, and equipment. One essential metric related to human resources is the pupil-to-teacher ratio, which helps evaluate the system's capacity to deliver quality education. Collecting accurate data on this requires targeted studies, surveys, or assessments of educational facilities, especially when granular data is needed for planning and resource allocation

Although UNESCO may not provide specific global benchmarks for this ratio, studies consistently demonstrate that lower pupil-to-teacher ratios improve student outcomes and teaching effectiveness. For context, OECD countries average approximately 15 students per teacher in primary schools, offering a benchmark that can guide local planning efforts, with adjustments to reflect specific needs and conditions.

For spatial analysis, tools like the Closest Facility Network Analysis can assess the geographic distribution of schools, estimate demand, and identify imbalances. While the tool primarily considers spatial factors, it provides valuable insights into the accessibility of educational services across urban areas and supports more equitable planning.

UNESCO recommends one primary school for every 1,500 to 2,500 inhabitants in urban areas, with adjustments based on population density and accessibility. For secondary schools, the guideline is one school for every 7,000 to 10,000 residents.

REFERENCES

AFFORDABLE HOUSING

General

Asian Development Bank. (2017). Housing challenge in emerging Asia: Options and solutions. https://www.adb.org/publications/housing-challenge-emerging-asia

Bamberger, M., & Majale, M. (2023). Impact evaluation of UN-Habitat's housing approach to adequate and affordable housing and poverty reduction 2008-2019: Synthesis report. UN-Habitat. https://unhabitat.org/sites/default/files/2023/12/synthesis_report_affordable_housing_dec_2023_final.pdf

Inter-American Development Bank. (2018). Urban development in Latin America. https://publications.iadb.org/en/urban-development-latin-america

International Monetary Fund. (2021). Affordable rental housing: Making it part of Europe's recovery. https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2021/05/24/Affordable-Rental-Housing-Making-It-Part-of-Europes-Recovery-50116

Organisation for Economic Co-operation and Development. (2020). Housing and inclusive growth. https://www.oecd.org/publications/housing-and-inclusive-growth-6ef36f4b-en.htm

Rosa Luxemburg Stiftung. (2020). Displacement and evictions: Human rights and the struggle for housing justice. https://rosalux.nyc/wp-content/uploads/2020/11/RLS-NYC_displacement_and_evictions.pdf

The Role of Land in Achieving Adequate and Affordable Housing. (2021). UNHabitat. https://unhabitat.org/sites/default/files/2021/09/the_role_of_land_in_adequate_housing_final.pdf

United Nations Economic Commission for Europe. (2021). #Housing2030: Effective policies for affordable housing in the UNECE region. https://unece.org/sites/default/files/2021-10/Housing2030%20study_E_web.pdf

World Bank. (2015). Housing matters. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/586981468178728596/housing-matters

World Resources Institute. (2017). Towards a more equal city: Confronting the urban housing crisis in the global south. https://www.wri.org/research/towards-more-equal-city-confronting-urban-housing-crisis-global-south

Benchmark:

UN-Habitat. (2021). The role of land in achieving adequate and affordable housing. https://unhabitat.org/sites/default/files/2021/09/the_role_of_land_in_adequate_housing_final.pdf

SOCIAL MIX

General:

Arthurson, K., Levin, I., & Ziersch, A. (2015). What is the meaning of 'social mix'? Shifting perspectives in planning and implementing public housing estate redevelopment. Australian Geographer, 46(4), 491-505. https://doi.org/10.1080/00049182.2015.1075270

Fainstein, S. S. (2005). Cities and diversity: Should we want it? Can we plan for it? Urban Affairs Review, 41(1), 3-19. https://doi.org/10.1177/1078087405278968

Galster, G. C. (2013). Neighborhood social mix: Theory, evidence, and implications for policy and planning. In N. Carmon & S. S. Fainstein (Eds.), Policy, planning, and people: Promoting justice in urban development (pp. 307-336). University of Pennsylvania Press.

Lees, L., Slater, T., & Wyly, E. (2008). Gentrification. Routledge.

Phang, S. Y., & Helble, M. (2016). Housing policies in Singapore. ADBI Working Paper Series, No. 559. Asian Development Bank Institute. https://www.adb.org/publications/housing-policies-singapore

Reardon, S. F., & Firebaugh, G. (2002). Measures of multigroup segregation. Sociological Methodology, 32(1), 33-67. https://doi.org/10.1111/1467-9531.00110

Turok, I. (2016). Housing and the urban premium. Habitat International, 54, 234-240. https://doi.org/10.1016/j.habitatint.2015.11.018

Benchmark:

UN-Habitat. (2014). A new strategy of sustainable neighbourhood planning: Five principles. United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/download-manager-files/A%20New%20Strategy%20of%20Sustainable%20Neighbourhood%20Planning%20Five%20principles.pdf

ADEQUATE HOUSING

General:

Cities Alliance. (2019). Adequate housing for all: Analysis of urban housing. https://www.citiesalliance.org/resources/publications/cities-alliance-knowledge/adequate-housing-all-analysis-urban-housing

Habitat for Humanity. (2021). The need for adequate housing. https://www.habitat.org/about/advocacy/resources/shelter-report-2021

UN-Habitat. (2016). Slum almanac 2015-2016: Tracking improvement in the lives of slum dwellers. https://unhabitat.org/slum-almanac-2015-2016

UN-Habitat. (2019). The right to adequate housing fact sheet. https://www.ohchr.org/sites/default/files/Documents/Publications/FS21_rev_1_Housing_en.pdf

WHO/UNICEF. (2021). Progress on household drinking water, sanitation and hygiene 2000-2020: Five years into the SDGs. https://www.who.int/publications/i/item/9789240030848

World Health Organization. (2018). WHO housing and health guidelines. https://www.who.int/publications/i/item/9789241550376

Benchmark:

Schwab, K., & Zahidi, S. (2020). Measuring overcrowding in housing. U.S. Department of Housing and Urban Development, Office of Policy Development and Research. https://www.huduser.gov/portal/publications/pdf/measuring_overcrowding_in_hsg.pdf

United Nations. (n.d.). Goal 6: Ensure availability and sustainable management of water and sanitation for all. https://sdgs.un.org/goals/goal6

United Nations. (n.d.). Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all. https://sdgs.un.org/goals/goal7

United Nations Development Programme. (n.d.). Achieving universal electricity access. https://data.undp.org/insights/achieving-universal-electricity-access/electricity-access-from-space

UN-Habitat. (2018). SDG Indicator 11.1.1 Training Module: Adequate Housing and Slum Upgrading. United Nations Human Settlement Programme (UN-Habitat). https://unhabitat.org/sites/default/files/2020/06/indicator_11.1.1_training_module_adequate_housing_and_slum_upgrading.pdf

UN-Habitat. (2018). Indicator 11.6.1 training module: Solid waste in cities. https://unhabitat.org/sites/default/files/2019/02/Indicator-11.6.1-Training-Module_Solid-waste-in-cities_23-03-2018.pdf

KEY URBAN SERVICES EQUITABLE PROVISION

General:

Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban green space and its impact on human health. International Journal of Environmental Research and Public Health, 15(3), 445. https://doi.org/10.3390/ijerph15030445

Organisation for Economic Co-operation and Development. (2023). Hospital beds and occupancy. In Health at a Glance 2023: OECD Indicators. OECD Publishing. https://doi.org/10.1787/bdd23022-en

Organisation for Economic Co-operation and Development. (2023). Education at a glance 2023: OECD indicators. OECD Publishing. https://www.oecd-ilibrary.org/education/education-at-a-glance-2023_315d95e6-en

Rigolon, A., Browning, M., Lee, K., & Shin, S. (2018). Access to urban green space in cities of the Global South: A systematic literature review. Urban Science, 2(3), 67. https://doi.org/10.3390/urbansci2030067

UN-Habitat. (2015). Global Public Space Toolkit: From Global Principles to Local Policies and Practice. United Nations Human Settlements Programme.

Urban Ecology Agency of Barcelona. (2012). Ecosystemic urbanism certification: Methodological guide for auditing, certification or accreditation systems of quality and sustainability in the urban environment. Spanish Ministry of Development.

World Health Organization. (2017). Urban Green Spaces: A Brief for Action. WHO Regional Office for Europe. https://www.who.int/europe/publications/i/item/urban-green-spaces-a-brief-for-action

Benchmark:

International Task Force on Teachers for Education 2030. (2021). Closing the gap - Ensuring there are enough qualified and supported teachers. UNESCO. https://teachertaskforce.org/knowledge-hub/closing-gap-ensuring-there-are-enough-qualified-and-supported-teachers

Sharp, R., Douglass, J., Wolny, S., Arkema, K., Bernhardt, J., Bierbower, W., Chaumont, N., Denu, D., Fisher, D., Glowinski, K., Griffin, R., Guannel, G., Guerry, A., Johnson, J., Hamel, P., Kennedy, C., Kim, C.K., Lacayo, M., Lonsdorf, E., ... Wyatt, K. (2020). InVEST 3.9.0 User's Guide. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund.

UN-Habitat. (2020). City-Wide Public Space Assessment Toolkit: A Guide to Community-Led Digital Inventory and Assessment of Public Spaces. United Nations Human Settlements Programme.

World Health Organization. (2016). Urban green spaces and health. WHO Regional Office for Europe. https://www.who.int/europe/publications/i/item/urban-green-spaces-and-health

World Health Organization. (n.d.). Global Health Observatory. Retrieved 2024-08-18, from https://www.who.int/data/gho

GENERAL INCLUSIVE CITY REFERENCES

Addison, Douglas; Stewart, Benjamin. 2015. Nighttime Lights Revisited: The Use of Nighttime Lights Data as a Proxy for Economic Variables. Policy Research Working Paper;No. 7496. © World Bank, Washington, DC. http://hdl.handle.net/10986/2346

UN-Habitat. (2022). World cities report 2022: Envisioning the future of cities. https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf

VIBRANT CITY

Residents of the vibrant city have access to the diversity of activities, urban services, and economic opportunities. A vibrant urban environment forms place identity, facilitates social interaction, communication, physical and learning activities and attracts people to live, work and spend time in the vibrant neighbourhood. A vibrant city provides an enabling environment for building social, cultural, and economic capital, where urban character is emphasized.

The Vibrant City relates to the New Urban Agenda transformative commitments: 26, 27, 34, 36, 37, 38, 39, 40, 45, 53, 62, 68

IMPLEMENTING THE NEW URBAN AGENDA

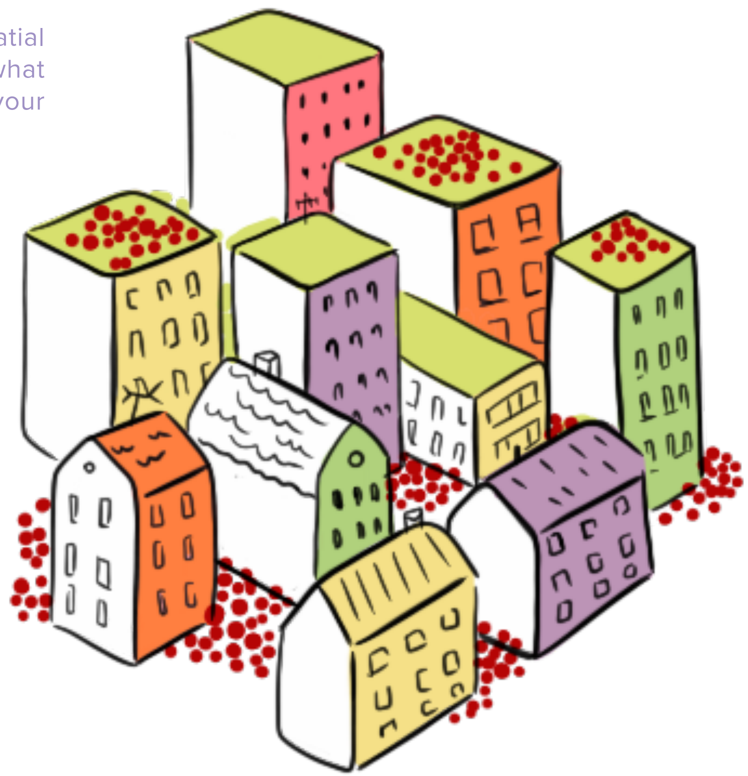
The following are the recommended spatial analyses to run to help you understand what obstacles or opportunities there are for your neighbourhood in relation to the vibrant city:

MIXED LAND USE

- Variety of Land uses
- Volume of Mixed Use Areas
- Variety of Economic Activities
- Concentration of Economic Activities

ACTIVE STREETS

- Elements of Street Design
- Streets with High Non-Motorised Traffic
- Permeability



MIXED LAND USE

☑ VARIETY OF LAND USES

Residential development without appropriate allocation of public space and commercial creates monotonous, unproductive and unsafe zones within an urban area. This is a common challenge in rapidly urbanising areas.

A variety of land uses and their spatial distribution affects inhabitants' equal access to services, employment opportunities and other functions. For example, an agglomeration of a single function (a mono-functional area), such as commercial, industrial or military zones, may affect a day-night population difference, pose security challenges or discourage citizens mobility choices.

On the other hand, a balanced distribution of related land uses (such as a public space next to an education or residential and commercial centre) can enhance each of their uses, create more attractive, busy areas and encourage social interactions across diverse groups of people.

What data do I need to assess the variety of land uses?

A. Land-use

B. Hexagon, grid or any other equally defined area type

The appropriate mix of uses varies between contexts, and varies within an urban area. In some areas, promoting a low land use mix can support a healthier urban environment (such as with industrial or polluting uses). In residential areas, it is recommended to encourage economic activities to support a more vibrant urban environment. UN Habitat recommends at least 40% of an urban area to be allocated to economic uses at a neighbourhood scale.

Calculating the degree and location of mixed land uses is often quantified by the proportion of non-residential use in a certain space such as floor area or total area. Several calculation methods offer different ranges of benchmarks defining sufficiency. For example, The Entropy Index suggests the values above and equal to 0.25 as sufficient.

Understanding the distribution of mixed use areas can give an indication of where a vibrant neighbourhood centre may be that may encourage densification, where there may be a mono-functional residential area in need of more diverse land uses or economic activities.

☑ VOLUME OF MIXED USE AREAS

Mono-centric development can create challenges such as accessibility, affordability of housing and traffic congestion. A poly-centric urban form ensures equal access of citizens to various services and benefits.

As explored above, the mix of land uses can enable a vibrant area within a city. An area with a high diversity of land uses and also a high volume may be representative of a city centre with large scale shopping units. An area with a high diversity but low volume may be representative of a small market or residential neighbourhood centre.

It is also useful to understand mono-functional areas (those with a low diversity of land uses and a high volume), to see if certain interventions are needed. For example, a large area with a high concentration of education buildings may benefit from improved public transport routes, street lighting, or public spaces in response to an expected high student population.

Therefore it is useful to look at the volume of mixed land uses in an urban area.

What data do I need to assess the volume of mixed use areas?

A. Land-use

B. Building floor area

C. Building heights

D. Hexagon, grid or any other equally defined area type

Land use concentration can be measured by several methods. One of the most preferred and easy to apply method is the location quotient (LQ), which is the proportion of a ratio of a measurement in a specific area to the ratio of the same measurement in the greater area. Such measurement can be count of points or the volume of a specific land use. I.e. the concentration of administrative use (by points within hexagons) can be calculated as:

$$LQ=(CP_{ah}/CP_{th}) / (CP_{ac}/CP_{tc})$$

Where CP: Count of points, a: administrative, h: hexagon, t: total and c: city. While the LQ values often varies between 0 and 1, the value closer to 1 means a higher concentration and values greater than 1 can be interpreted as concentration.

This can guide the overall form of a city, where the central area is, and where there are smaller 'secondary' centres. This can assist in transport planning (considering regional or local traffic routes), the placement of new facilities (e.g. a regional hospital vs. a local clinic) and so on.

☑ VARIETY OF ECONOMIC ACTIVITIES

In addition to assessing the mix of land uses in a neighbourhood, as an indicator of vibrancy, the variety of economic activities within a city or region is also a useful measure, as it can provide diverse livelihood opportunities for its inhabitants and can attract diverse socio-economic groups and firms to invest. This, in turn, can provide an environment of interaction for citizens if supporting infrastructure and social facilities such as micro-mobility and public open spaces are provided. The economic activities that create vibrant areas can be in a related (for example, fashion and manufacture of textiles, or agriculture and manufacture of food products) or unrelated activities.

What data do I need to assess the variety of economic activities?

A. Points or Polygons of economic activity

B. Types of economic activities

C. Employment (although this is not a necessary data set, it can enhance the analysis)

The outcome of this analysis is that it provides an indication of where a neighbourhood centre could be enhanced through a diversity of economic activities. Understanding where there is economic activity, and what types currently exist, can provide an insight into an area that may be currently unsafe or unused, or what types of economic activities are lacking. This can be particularly relevant in contexts with diverse social groups.

CONCENTRATION OF ECONOMIC ACTIVITIES

Understanding the diversity of economic activities explored above, can assist in identifying vibrant nodes of activity. Similarly, and alongside that analysis, the concentration of economic activities can also give an insight into the functioning of a city or urban area.

For example, this analysis can highlight where in the city large infrastructure projects will or already have created a cluster of economic activities. An example of this is a large airport development, with associated economic activities and functions such as warehousing or storage facilities.

Other pre-determined areas of economic activity, such as free-trade zones, or industrial zones have similar distribution and concentration of economic activities.

Other forms that can be highlighted in this analysis are main axes of economic activity (along a transport corridor), or historical centres (which includes accommodation, restaurants, tourism and other diverse economic activities).

This analysis can assist in identifying sites to encourage types of economic activities and the kind of urban forms that will be created as a consequence.

What data do I need to assess the concentration of economic activities?

- Points or Polygons of economic activity
- Types of economic activities
- Employment and Road network can enhance this analysis but are not crucial

In GIS, this analysis uses a benchmark, measured within the spatial statistics such as the LQ value being greater than 1 or in the case of using a Kernel Density, the density value may be interpreted differently based on the population field. Combined with the POIs, the outcome of Kernel Density can highlight the clusters or outliers of economic activity. If the type of economic activity is known, related or unrelated variety of economic activity types and clusters can be identified by further descriptive statistics.

Streets are the lifeblood of urban life, serving as the primary spaces where social interaction, economic activity, and cultural exchange occur. The design and functionality of streets greatly influence a city's vibrancy and dynamism by either encouraging or hindering walking, cycling, and public gatherings.

Streets must not only be considered as connectors or ways of moving between places. Instead, streets should be considered as public spaces in their own right. 'Streets as public spaces' promote more careful design, stimulate local businesses, foster a sense of community, and enhance safety, making them essential to the overall vitality and sustainability of urban areas.

In GIS, the count or sum of specific metrics such as street nodes, intersections or aspects of street segments can be summarized within a defined area (hexagon, grid or any other equally defined polygon).

ACTIVE STREETS

ELEMENTS OF STREET DESIGN

Numerous studies have shown that well-maintained pedestrian pathways and cycling infrastructure significantly increase the likelihood of people choosing active and non-motorized modes of transportation. Non-motorized infrastructure not only encourages walking and cycling but also supports safer, more inclusive streets by accommodating people with different mobility needs.

Elements such as pedestrian crossings, street furniture, and universal design features make walking more enjoyable and accessible, inviting greater pedestrian activity, reducing air pollution and providing health benefits.

Higher foot traffic and a more stable pedestrian flow makes areas more attractive for businesses, economic as well as social activities.

What data do I need to assess the presence of elements of street design?

A. Road network

B. Cycle lanes

C. Pedestrian pathways

D. Pedestrian crossing

E. Street furniture

F. Universal design features

This analysis uses points to locate areas with a number of specific interventions or elements of street design (listed above). When deciding where to build a new school, where may be developing a new neighbourhood centre, or which streets may need new interventions to increase the flow of people, this analysis can support these decisions.

It is therefore recommended to conduct an analysis that groups all of these elements together, to identify streets or areas where these elements are most or least concentrated.

STREETS WITH HIGH NON-MOTORISED TRAFFIC

In a street network, pedestrians generally choose the straightest or shortest route to save time. This optimal route can be found by identifying the streets that are most often used as a connection between places. These ‘transit’ routes are most commonly selected by people, even when they are travelling to or from different places.

Sometimes, these sections of streets are those that are able to support more economic activity and can create a vibrant urban environment if appropriately designed, as businesses can thrive in areas with a high pedestrian flow. Decisions such as increasing mixed-use, smaller commercial ground floor land uses, shop fronts that encourage slower pedestrian movement (those with more textured façades or entry points), increasing street lighting, waste collecting, seating furniture or maintenance staff are all considerations that may be affected by this analysis. Therefore, it is useful to analyse and have an understanding of where these high pedestrian traffic streets are in an urban area, and adjust planning and design interventions accordingly.

What data do I need to assess where the streets are with a high non-motorised traffic flow?

A. Road Network

It is recommended to use centrality metrics (the centrality of a street segment being how often it is used as a connection between other segments in the network), to predict movement patterns in the road network. For spatial analysis, straightness and betweenness metrics are particularly recommended, as they provide valuable insights into the most commonly used routes and the overall accessibility of the network.[4]

4 Validation Advice: If data on pedestrian traffic is available, it is highly recommended to use it to validate the results obtained from the spatial analysis. By comparing the predicted pedestrian flows—based on centrality metrics, block granularity, and non-motorized infrastructure—with actual pedestrian traffic data, you can increase the confidence in your findings. This validation process allows for the refinement of the model, ensuring that the identified high-activity areas genuinely correspond to where pedestrian movement is most concentrated. Incorporating real-world data not only strengthens the accuracy of the analysis but also provides valuable insights for further urban planning and decision-making.

☑ PERMEABILITY

Finally, as mentioned in the 'Connected City' chapter, city permeability also plays an important role in how likely it is for pedestrians to pick that street to travel on, and how vibrant that street may be. Permeability can be created by the size and structure of urban blocks, plots of land and building massing. Smaller blocks with a finer grain allow for more frequent intersections and route options, promoting pedestrian activity and enhancing the overall walkability of an area.

Large blocks, especially those with dead frontages (e.g., industrial lots or logistics centres), can inhibit pedestrian flow, reduce the sense of safety, and detract from the vibrancy of an area. The interaction of buildings with the streets - how many openings, windows and doors there are along the street frontage, whether the building use is one that people can interact with, and how much texture there is on the building facade - open space uses, historical or culturally significant buildings also help increase pedestrian activity.

What data do I need to assess permeability?

A. Road Network

Therefore, as well as efficient routes between places, as in the previous analysis, assessing street permeability can support an understanding of how walkable an area is. Smaller blocks are optimal for promoting walkability, as they directly influence the movement and influx of people. Block sizes with a perimeter length of 400-600 meters, or approximately 1 to 2 hectares in area, are generally considered ideal for enhancing pedestrian activity.

REFERENCES

MIXED LAND USE

Kang, C. D. (2015). The effects of spatial accessibility and centrality to land use on walking in Seoul, Korea. Cities, 46, 94-103.

Esri. (n.d.). Natural neighbor interpolation (Spatial Analyst). Esri. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/natural-neighbor.htm

Variety of Land Uses

Song, Y., Merlin, L., & Rodriguez, D. (2013). Comparing measures of urban land use mix. Computers, environment and urban systems, 42, 1-13.

Iannillo, A., & Fasolino, I. (2021). Land-use mix and urban sustainability: Benefits and indicators analysis. Sustainability, 13(23), 13460.

Habitat, U. N. (2014). A new strategy of sustainable neighbourhood planning: Five principles. Nairobi, Kenya: United Nations Human Settlements Programme.

Volume of Mixed Use Areas

Gerike, Regine & Carlow, Vanessa & Görner, Hendrik & Hantschel, Sebastian & Koszowski, Caroline & Medicus, Matthias & Krieg, Michael. (2023). Vibrant streets: characteristics, success factors and contributions to sustainable development.

Variety of Economic Activities

Content, J., & Frenken, K. (2016). Related variety and economic development: a literature review. European Planning Studies, 24(12), 2097-2112.

ACTIVE STREETS

Permeability

Ewing, R., & Cervero, R. (2010). Travel and the built environment: A meta-analysis. Journal of the American planning association, 76(3), 265-294.

Park, K., Ewing, R., Sabouri, S., & Larsen, J. (2019). Street life and the built environment in an auto-oriented US region. Cities, 88, 243-251., Chicago,

Stangl, P. (2015). Block size-based measures of street connectivity: A critical assessment and new approach. Urban Design International, 20, 44-55.

Calthorpe, P. (2022). Ending Global Sprawl: Urban Standards for Sustainable Resilient Development. The World Bank.

Streets with High Non-Motorised Traffic

Sevtsuk, A., & Kalvo, R. (2024). Modeling pedestrian activity in cities with urban network analysis. Environment and Planning B: Urban Analytics and City Science, 23998083241261766.

Pearce, D. M., Matsunaka, R., & Oba, T. (2021). Analysing the Impact of Pedestrian Network Centrality on Segment-Level Pedestrian Density. Journal of advanced transportation, 2021(1), 3061567.

Crucitti, P., Latora, V., & Porta, S. (2006). Centrality in networks of urban streets. Chaos: an interdisciplinary journal of nonlinear science, 16(1).

RESILIENT CITY

A resilient city supports and protects its physical assets and citizens to withstand acute shocks and chronic stresses. These can be physical, financial or social, for example. They can occur from natural hazards such as earthquakes, or effects of climate change such storms, floods (rapid onset events), drought or sea level rise (slow onset events). Some stresses and shocks can occur from disruptions to urban systems and services (such as energy supply shortages).

Determining the hazards, identifying the exposure and estimating the existing potential vulnerability are the critical steps for preventing risk and damage. By reducing the impact that these shocks have on a city's networks and systems, a resilient city can maintain the population's access to basic and public services and protect them from risk. The adaptive capacity of a city and its response mechanism in the face of urban risks defines its urban resilience.

The Resilient City relates to the New Urban Agenda transformative commitments: 25, 31, 32, 34, 36, 37, 38, 39, 43, 44, 62, 65, 67, 68, 69, 70, 73, 77

The following are the recommended spatial analyses to run to help you understand what obstacles or opportunities there are for your neighbourhood in relation to the Resilient City:

CITY EXPOSURE

- Exposure of Population
- Exposure of Buildings and Infrastructure
- Exposure of Natural Environment

EXISTING VULNERABILITY

- Vulnerability of Population
- Vulnerability of Buildings and Infrastructure
- Vulnerability of Natural Environment
- Vulnerability of Economy

CITY ADAPTABILITY

- Critical Facilities
- Utility Services
- Blue & Green Infrastructure

EMERGENCY RESPONSE

- Early Warning System
- Evacuation Routes
- Safe Havens

RISK =

Hazard X Exposure X Vulnerability

URBAN RESILIENCE =

(Adaptive Capacity X Response mechanisms) - (Hazard X Exposure X Vulnerability)

CITY EXPOSURE

Cities across the world face the threat of natural hazards. The degree and frequency of which greatly vary, and are becoming even more intense and unpredictable with the effects of climate change. Analysing the current risk of natural hazards is necessary to plan for city growth, and ensure that there are adequate measures in place to reduce the risk of existing hazards on the current population, infrastructure and natural assets. Hazards can cause risk to life and infrastructure, creating disruption in service provision and access to key facilities.

Urban areas can prevent risk by adapting and mitigating natural hazards. There are many methods to adapt and mitigate natural hazards in cities. Mitigation strategies, such as nature-based solutions (NBS) and blue-green infrastructure (BGI), can help reduce exposure by creating natural buffers that absorb or divert hazard impacts. For instance, urban parks and green corridors can mitigate the effects of heat islands, while permeable surfaces and rainwater retention systems reduce flood exposure. Assessing hazard risk is vital, and informs all design, planning, legislation and investment decisions.

As hazard analyses are critical but complex, the use of open access hazard data sources is recommended.[5] The pairwise intersect of hazard zones and assets (such as buildings, roads, social facilities or natural areas) and their specific functions (such as residential buildings, health facilities) provides the first glance of exposure.

☑ POPULATION EXPOSED

One way of doing this analysis, outlined in this chapter, is by mapping areas, where people are at risk of hazards. The spatial distribution of risk can show which areas may need investment to mitigate the impact of hazards. Exposure of population refers to the number and density of people present in areas prone to hazards.

Understanding how many people are at risk varies across time and space. Examining day-night population differences and population density in urban areas is therefore a first step.

5 Please see the Reference List and United Nations Office for Outer Space Affairs (n.d.). Recommended practices. UN-SPIDER. https://www.un-spider.org/advisory-support/recommended-practices for further sources and practices.

Population exposure is usually measured by the overlapping area highlighted in a map, of hazard zones and the distribution of population data. The higher the population density in a hazard-prone area, the greater the exposure and risk is.

What data do I need to assess the density of people exposed to hazards?

A. Hazard prone areas (by type of hazard, polygons)

B. Building footprint

C. Population

D. Land-use (for estimation of day/night population shifts)

The outcome of this assessment highlights which areas may require regulations to reduce new housing from being developed in land at risk as well as where new or expanded mitigation measures should be implemented. It also can provide a degree of prioritisation, by showing the areas in the city that have the highest density of people at risk.

☑ BUILDINGS AND INFRASTRUCTURE EXPOSED

The exposure of physical assets refers to the extent to which critical infrastructure, buildings, and other urban systems are located in hazard-prone areas. These physical assets include residential and commercial buildings, transportation networks, utility systems, and social facilities such as hospitals and schools. The exposure of these assets to hazards, such as earthquakes, floods, or extreme weather events, can lead to significant economic losses, disruptions in urban functions, and threats to human life.

In this analysis, intersecting hazard zones with the locations and land uses, highlights key assets that are at risk. Assets in densely populated areas or along key transportation corridors, may have a greater impact on urban resilience if exposed to hazards or disrupted. Key services, for example failure of a power grid during a flood that can disrupt emergency response services, result in compounded losses.

What data do I need to assess which buildings or key infrastructure is at risk from hazards?

A. Hazard prone areas (by type of hazard, polygons)

B. Building footprints and heights

C. Infrastructure network (e.g., roads, bridges, utility lines)

D. Land-use and asset types (e.g., residential, commercial, health facilities)

This analysis highlights ‘hotspots’ of infrastructure at risk, for example where are the greatest sections of road or railway lines that are likely to be impacted by a flood, or landslide. It helps to provide evidence to assist in decision making related to the identification and prioritisation of investment into retrofitting or mitigation, as well as relocating. This analysis can assist in investing in projects now, but also in understanding the future city and how it can evolve with existing hazards.

☑ NATURAL ASSETS EXPOSED

Natural environments, including forests, rivers, wetlands, and coastal areas, play a critical role in supporting biodiversity, regulating climate, and providing essential ecosystem services, such as water filtration and carbon sequestration.

Similar to the previous two analyses, this one highlights which natural assets are at risk from being damaged or affected by hazards. However, this analysis looks at natural assets in contact with hazards such as floods, droughts, storms, as well as the long-term effects of climate change or human-induced hazards such as pollution.

What data do I need to assess natural assets that are at risk of hazards and human induced pollution?

A. Natural (protection) zones

B. Watersheds, river systems

C. Hazard-prone areas (by type of hazard, polygons)

D. Climate change projections (Variations of rainfall, drought, temperature variations)

E. Land cover (time series), vegetation cover and type

F. Land-use (to identify pollution hotspots)

This analysis highlights the density of the natural asset at risk (in m^2 or m^3). This can provide information to inform what areas are experiencing hazards - for example, which natural areas may be experiencing rising water levels, or which slopes are most likely to have land slides. If available, the climate change prediction data can add to this understanding of potential changes or threats, such as drought-prone land. De-forestation will also be shown in this analysis and, it can highlight which land uses may be causing pollution of water systems or soil. This information can inform decisions about investments into infrastructure, nature based solutions, or planning for green and blue infrastructure changes over time. It can inform urban or 'grey' infrastructure expansion or relocation and help to mitigate against future challenges.

Not only is it important to understand the current and potential exposure to threats, but also the existing condition of a city or neighbourhood to highlight the vulnerabilities that may be most affected, or exacerbated by natural or man-made hazards. Examples of this include the demographics of the population, as well as income levels, and the quality of buildings or how resistant they are. This information helps to provide an estimation of risk and helps locate necessary interventions.

EXISTING VULNERABILITY

☑ VULNERABLE POPULATION

Vulnerability of the population can be related to a number of factors such as age, gender, income or income reliability, disability, social dependencies and more. In some cases, it may be more difficult for certain groups to recover from hazards than others. For example, groups that reside in informal settlements are usually more prone to hazards. Building an understanding of where these groups are located can be supplemented by an income or poverty index distribution dataset. Although this provides one layer of information amongst others, it is vital to the ability for the city or urban area to be able to prepared and recover as efficiently as possible to a hazard.

What data do I need to assess the distribution of vulnerable groups?

A. Population by age groups

B. Population by gender

C. Population by income level or poverty

D. Population by disability

E. Land-use (for estimation of day/night population shifts)

As demographic data is one of the most common datasets that are shared by governments, the scale of data is often at city level. For precise examination of vulnerable population, the data should be at the most detailed scale, if possible, at the building scale. An alternative approach to identifying vulnerable groups and their spatial distribution, interviews or data of civil society organizations and related secondary data can be utilized.

This analysis highlights the spatial distribution of vulnerable population or high-risk demographic groups, including day-night variations of vulnerability. From this analysis, customised emergency plans for evacuation can be tailored and priority areas for supporting facilities identified.

☑ VULNERABLE BUILDINGS & INFRASTRUCTURE

Physical assets include residential and commercial buildings, transportation networks, utility systems (water, power, communications), and critical infrastructure such as hospitals, schools, and emergency services. Vulnerable buildings and infrastructure can amplify the impact of hazards, causing cascading failures that affect wider urban systems. For example, poorly maintained health facilities can mean that even small floods can damage key water or electricity supply and reduce necessary functions. Light structure buildings (wood etc.) tend to be less vulnerable in terms of earthquakes but more vulnerable in terms of fire, flood or mud flows, therefore, this analysis is useful to assess the likelihood of risk.

What data do I need to assess the location and type of vulnerability to buildings and infrastructure?

A. Hazard prone areas (by type of hazard, polygons)

B. Building footprint (by types, height, construction materials)

C. Infrastructure network

This analysis provides the locations of infrastructure and buildings that are most vulnerable to damage. It shows if and where buildings and infrastructure that are poor quality or have low resilience against certain hazards are in hazard risk zones. Using hazard scenarios (different earthquake magnitudes, 75-year flood) can also assist in estimations of future vulnerabilities.

This analysis, alongside others, can create an understanding of how failure in one system can lead to cascading failure in others (for example, road closures can impact emergency service access).

☑ VULNERABLE NATURAL ENVIRONMENT

The encroachment or degradation of natural areas can cause a number of challenges to urban areas. Natural areas provide protection for urban areas from hazards such as floods, land slides, erosion and earthquakes. Natural areas may be adjacent to urban areas, or embedded within it. Therefore, it is necessary to consider the ‘quality’ of these natural areas, and assist in decision making relating to legislative protective measures, development boundaries, or planting schemes. Human pollution of natural areas may be greatly linked to deficiencies within the existing systems of the city - for example, a city that has an insufficient supply of electricity to the population, may find that people must use forest wood for energy. Another example, is that poor waste management can lead to pollution of rivers, streams or soil, that can mean that drinking water becomes contaminated.

What data do I need to assess the vulnerability of natural assets?

A. Protection zones

B. Degradation indicators (e.g., deforestation rates, soil erosion data)

C. Ecosystem health data (biodiversity, water quality)

Assessing the vulnerability of the environment involves both the natural areas (and changes within those areas) and the causes of vulnerability. Degradation ratios and habitat health assessments are key indicators of vulnerability.

☑ VULNERABLE ECONOMY

The vulnerability of the economy to hazards is a complex and multi-dimensional issue, influenced by various factors including the nature of economic activities and dependence on specific industries.

Economic sectors with a high concentration of employment or those heavily reliant on specific resources are particularly susceptible to disruptions. For instance, areas with a strong agricultural focus are highly vulnerable if they depend on a narrow range of crops, making them sensitive to climate change impacts such as droughts or floods. Similarly, urban areas dependent on single industries, such as tourism, can experience severe economic shocks following disruptions, as evidenced by the substantial impact of the Covid-19 pandemic on global tourism.

What data do I need to assess the vulnerability of the urban area’s economy?

A. Economic activity (type, n. of people employed, type of risk such as pollution or explosion)

B. Agricultural production (type, quantity of crops)

C. Hazard prone areas (by type of hazard, polygons)

D. Land-use or land cover (to identify industrial zones, agricultural lands)

This analysis can highlight the proportion of GDP or employment, related to key economic sectors, particularly those vulnerable to hazards. This helps identify sectors that are critical to economic stability and may require targeted resilience measures.

An assessment of the variety of crops or agricultural products in rural areas can also help to determine the resilience of the agricultural sector to climate-related risks. A more diverse portfolio can reduce vulnerability to adverse environmental conditions.

High-risk economic density, for example hotels exposed to avalanche in a tourism dominated urban economy, identification of spatially targeted diversification strategies or projects (such as increasing diversity of crops) and prioritising interventions that reduce hazard impacts are provided in this analysis.

CITY ADAPTABILITY

A city or neighbourhood's ability to maintain its functions is one of the core values of being resilient. The adaptability of the city is how well it can continue to function whilst experiencing the impacts of hazards. The following analyses look at how well the city's critical facilities (hospitals, emergency services etc.), utilities (source of energy) and blue and green networks (prevalence of nature based solutions) are set up, to understand how well the city is set up to deal with natural hazards.

Analysing this can help to identify ways in which the city or neighbourhood can provide 'back ups' or multiple options in case of disruption. An example of this is, in terms of transportation, is the integration of transportation systems to provide alternative choices in terms of a disruption in a specific transportation mode. Such as in case of heavy rain, micro-mobility choices such as cycling can be restricted, the integration of cycling paths to public transportation routes reduces disruption in accessibility. Techniques such as network analysis, spatial overlays, and buffer analysis can be applied to determine the adequacy and effectiveness of critical facilities, utilities and blue and green networks.

☑ CRITICAL FACILITIES

Critical facilities, including hospitals, emergency services, and power stations, must maintain their functionality during and after a hazard or in case of a disruption in services. Ensuring redundancy in these facilities—such as backup power sources and alternative operational protocols—enhances the city's adaptive capacity.

What data do I need to assess the adaptability of critical services?

A. Hazard prone areas (by type of hazard, polygons)

B. Capacity of critical facilities (N. of beds in hospitals etc.)

C. Aspects of critical facilities (Presence of back-up utility sources, building type)

The assessment of critical facilities adaptive capacity requires exposure and vulnerability assessment, proximity and capacity analysis. This includes and exposure and vulnerability analysis of critical facilities as addressed within 'Exposure of Buildings and Infrastructure' and 'Vulnerability of Buildings and Infrastructure' in the previous sections. It also includes the number of people that the facility services (which is outlined in the Compact City chapter). Finally, it includes a capacity analysis of the facility, which can be considered as the benchmark of number of beds, or specialised personnel per capita (please see the Inclusive City chapter for reference of these benchmarks). Overlays of these analyses provides a comprehensive understanding of adaptive capacity.[6]

This analysis can highlight those facilities that are most crucial for relocation, reinforcement or renovation.

☑ UTILITIES

The diversity and flexibility of utility services such as water and electricity ensure continuity of daily activities of citizens and economic activities. Diversity in the resources of utilities increases the capacity in provision of services. For example, adding renewable energy resources to the portfolio of energy supply can prevent shortages (that are caused by supply system). Diversifying the energy resources also help reduce demand on fossil fuels, thus reducing air pollution and impact on climate change.

6 For overlay, Suitability Model or Weighted Overlay tools can be used.

What data do I need to assess the adaptability of the utilities networks?

A. Utility sources (type, capacity)

B. Utility infrastructure and coverage (lines)

C. Exposure and vulnerability of utility (as explained in the 'Exposure and Vulnerability of Buildings and Infrastructure' chapters above)

D. Household survey

Assessment of utility services adaptive capacity should be applied separately for each utility service. The scale of the analysis can be at the administrative level of districts or neighbourhood for more area-based approach. As coverage or utility services or buildings connection to these networks can be challenging in terms of data availability, additional data sources such as household surveys or expert interviews of local officials should be considered. The spatial analysis should consider the number of energy or water sources within the defined area (hexagon, grid or the administrative unit) or the share of renewable energy sources in use.

For assessment of adaptive capacity of utilities, a household survey should contain questions of utility network connections, presence of additional power sources (electric generators, solar power), additional water systems (such as rainwater or storm water collection systems) in the resident or building. The geocoded results of a survey can be computed by Natural Neighbours tool. In several countries, building registration data contains such information.

This analysis can inform policy recommendations for the sustainable use of sources (such as energy transition and water efficiency).

☑ BLUE & GREEN INFRASTRUCTURE

Blue & green infrastructures (BGI) help mitigation of variety of hazards. As BGI helps mitigation of floods and heat island effects, in the long term it can help reduce pollution and support biodiversity. The BGI elements such as rain or stormwater collection systems, bioretention areas, permeable surfaces help decreasing surface run-offs and thus urban floods. As collection and reuse of water helps decrease the demand on water, it also helps create a spare capacity for water sources. Additional benefits of BGI include increased quality of life and human well-being by transforming urban landscapes.

Assessment of BGI in the context of adaptive capacity consist of several approaches depending on data availability. This includes assessing the carbon absorption capacity, assessing the heat islands (UHI) and estimation of water absorption capacity. Please see the references section for suggested sources and more information about these approaches.

What data do I need to assess the quality of the blue and green infrastructure in relation to hazard mitigation?

A. Hazard prone areas (by type of hazard, polygons)

B. Green network (parks, green corridors, permeable surfaces)

C. Land cover (by vegetation type)

D. Land surface temperature (LST)

This analysis helps to identify the effectiveness or gaps in existing mitigation measures as well as existing carbon sink and pollution reduction capacity.

EMERGENCY RESPONSE

Effective response to hazards requires improved governance structure to ensure comprehensive emergency management. On the spatial context, coverage or early warning systems, determination of evacuation routes and presence of safe havens ensure a solid infrastructural basis for effective response. As citizens knowledge on emergency response and their compliance to emergencies are vital, supplementary non-formal education on hazards and emergency response is also key.

Use of the closest facility analysis in network analysis toolbox for estimation of routes between hazard exposed areas and safe havens is sufficient enough for the preliminary identification in data limited environments. This analysis also helps identify the provision of safe havens. Depending on the data availability more advanced models may be preferred.

EARLY WARNING SYSTEMS

Early warning systems (EWS) can be a vital tool to minimize human-life losses in cases of hazard mitigation measures that are limited or ineffective. Early warning is a complex system that utilizes knowledge on previous hazards, monitoring services and risk estimation. As common early warning system is meteorological, more advanced systems provide multi-hazard warnings such as rainfall triggered floods and landslides or earthquake triggered rockfalls, landslides or tsunami. In the absence of multi-hazard EWS, use of single-hazard systems is vital, especially in local contexts such as Flood EWS, which can be a simple system of sensors that transmits water levels.

What data do I need to assess areas lacking EWS?

A. Hazard prone areas (by type of hazard, polygons)

B. Existing EWS networks (sensors, coverage)

The effectiveness of an EWS depends on its spatial coverage, especially in communities identified as highly vulnerable to hazards. Spatial analysis techniques, such as overlaying hazard zones with the spatial distribution of EWS networks, can identify gaps in coverage. For example, areas prone to floods should be monitored through a network of water-level sensors, which can be mapped against hazard-prone zones to ensure maximum coverage of vulnerable populations.

This analysis highlights the areas in the city or neighbourhood that lack EWS and provides an indication of where new infrastructure is needed to close the gap in coverage.

EVACUATION ROUTES

Regardless of the presence of EWS, identification of evacuation routes is critical for minimizing human-life losses. Evacuation routes should identify the route between hazard exposed areas to safe havens and from safe havens to temporary shelters in cases of destruction of residential units. If available, building collapse estimations should also be included in the analysis.

What data do I need to assess the availability of evacuation routes?

A. Hazard prone areas (by type of hazard, polygons)

B. Road network

C. Existing safe havens (If N/A, please see next section)

The identification of evacuation routes should include the roads that are not exposed to any hazards. The access time and specification of routes vary between national policies and hazard types. For example, in Turkey, the minimum width of roads along evacuation routes is 7 meters, whereas the maximum walking distance is 5 minutes in terms of earthquake evacuation.

This type of analysis can assist in the identification of evacuation routes and help in emergency response planning.

☑ SAFE HAVENS

Safe havens are key to the response and recovery from natural hazards. In order to identify potential sites for safe havens, an analysis of public open spaces or indoor sports facilities and similar wide indoor spaces that are not exposed to hazards is important. The aspects of public open spaces such as water and wastewater and electricity infrastructure connections assists in their easy transformation to safe havens.

What data do I need to assess the availability of safe havens?

A. Hazard prone areas (by type of hazard, polygons)

B. Existing safe havens (by type, material, network connections)

C. Open public spaces

D. Sports facilities

Within the assessment or identification of safe havens, spaces with access to water, electricity and sanitation networks should be prioritized. The main criterion for safe havens is that they must be a hazard-free zone. In addition, 3.5 sqm per person is accepted as a minimum provision of space for a safe haven. However, this provision may vary due to climatic conditions.

REFERENCES

CITY ADAPTABILITY

Dong, L., Wang, Y., Ai, L., Cheng, X., & Luo, Y. (2024). A review of research methods for accounting urban green space carbon sinks and exploration of new approaches. Frontiers in Environmental Science, 12, 1350185.

tanton-Geddes,Zuzana; Simpson,Alanna Leigh; Ellmauer-Klambauer,Anita; Dengler,Solene; Staudinger,Michael; Zuvela-Aloise, Maja; de Wit,Rosemarie; Hollósi,Brigitta; Kainz,Astrid; Oswald,Sandro; Hahn,Claudia; Goler,Robert; Percec Tadic,Melita; Nimac,Irena; Herceg Bulic,Ivana; Bokwa,Anita. Analysis of Heat Waves and Urban Heat Island Effects in Central European Cities and Implications for Urban Planning (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/740251596528336330/Analysis-of-Heat-Waves-and-Urban-Heat-Island-Effects-in-Central-European-Cities-and-Implications-for-Urban-Planning

Pochodyła, E., Glińska-Lewczuk, K., & Jaszczak, A. (2021). Blue-green infrastructure as a new trend and an effective tool for water management in urban areas. Landscape Online, 92-92. Chicago

EMERGENCY RESPONSE

Jones, J.M., Ng, P., Wood, N.J., 2014, The pedestrian evacuation analyst—Geographic information systems software for modeling hazard evacuation potential: U.S. Geological Survey Techniques and Methods, book 11, chap. C9, 25 p., https://dx.doi.org/10.3133/tm11C9.

Sphere Project, Sphere Handbook: Humanitarian Charter and Minimum Standards in Disaster Response, 2011, 2011, https://www.refworld.org/reference/manuals/sphere/2011/en/92158 [accessed 12 September 2024]

Handbook, U. E. (2024, January 30). Emergency shelter solutions and standards. UNHCR. https://emergency.unhcr.org/emergency-assistance/shelter-camp-and-settlement/shelter-and-housing/emergency-shelter-solutions-and-standards

CONCLUSION

This publication provides the fundamental analyses that can be used in a diversity of contexts to understand and assess urban areas.

Running these analyses can provide great insight into current challenges and compounding challenges an urban area may be facing. By using an integrated approach, this publication groups analysis by themes, and repeats these themes within different objectives, answer different questions about a city or neighbourhood each time.

The outcome of these spatial analyses can inform decision making directly. They do not only provide numerical benchmarks, but supports the creation of spatial mapping as a way to direct and inform investment into infrastructure, development and design.

This document aims to be inclusive, however these analyses may not be applicable in circumstances such as conflict or post-conflict settings, in informal settlements or temporary shelter settings.

This is a constantly growing document, and welcomes inputs or amendments.

ANNEX

OPEN SOURCE DATA

Buildings

- Microsoft building footprint provides more than 1.4 billion buildings polygon worldwide. (1.1.1)
- Google Open Buildings V3 polygons, covering detections from Sub-Saharan Africa, South and South-East Asia, Latin America and the Caribbean. (1.1.1)
- Open Buildings 2.5D Temporal dataset, The dataset annually generates a map of estimated building presence, counts and heights from 2016, and covers a 58M km2 region across Africa, Latin America, and South and Southeast Asia using 10m resolution imagery from Sentinel-2.
- World Settlement Building height (German Aerospace Center (DLR), global estimation of average buildings height in meters at 90m resolution, using digital elevation data and radar imagery collected by the TanDEM-X mission. (1.1.1)
- World Settlement Building volume (German Aerospace Center (DLR), global estimation of buildings volume in cubic meters at 90m resolution, using digital elevation data and radar imagery collected by the TanDEM-X mission. (1.1.3)

Population

- WorldPop (University of Southampton), is an open and high-resolution global geospatial data on population distributions, demographic and dynamics, created by combining the best available census data with machine learning techniques. It can be used to assess population density and disaggregate measurements for population categories. (1.1.2)

Urban footprint

- GHS built-up surface (European Commission), provides global distribution of built-up surface expressed in square-meters, at 100m resolution, from1975 to 2030 in 5 years intervals. It can be used to measure urban compactness in terms of urban fragmentation. (1.1.1)
- GHS built-up volume (European Commission), provides global distribution of built-up volumes, expressed as number of cubic meters, at 100m resolution, from1975 to 2030 in 5 years intervals. It can be used to estimate Human Scale Building Density. (1.1.3)

Roads

- Microsoft Roads, covering the entire world with 48.9M km of all roads and 1165K km of roads missing from OSM. The roads were detected using ML on Airbus and Maxar high-resolution imagery. (1.1.1)(1.2.1)
- GRIP global roads database (PBL Netherlands Environmental Assessment Agency), covers 222 countries and includes over 21 million km of roads. The dataset was created using publicly available national and supra-national vector datasets from governments, research institutes, NGOs and crowd-sourcing initiatives. (1.1.1)(1.2.1)

Land cover

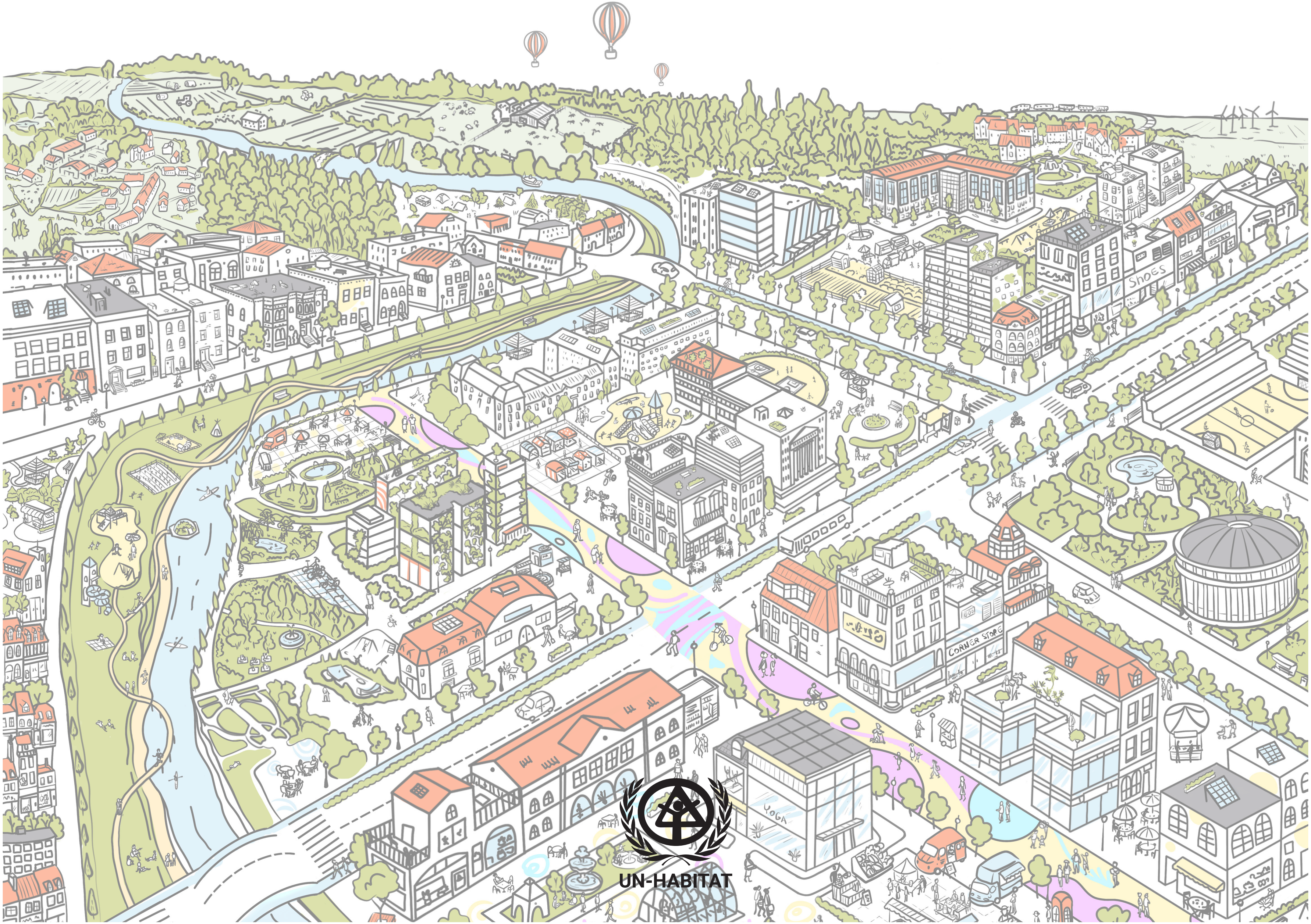
- Esri Land Cover, A 10-meter annual map of Earth’s land surface from 2017-2023 based on Sentinel 2, with a resolution of 10 m. The output provides a yearly 9-class map of the surface, including vegetation types, bare surface, water, cropland and built areas. It can be used in absence of land use data to measure the share of built-up, green spaces and vacant areas, as well as cropland in the peri-urban areas. (1.1.4)

- Global Canopy Height 1 m resolution (META AI Research and World Resources Institute), it provides a global map of canopy height by using ML to analyze satellite imagery spanning from 2009 to 2020, with 80% of the data produced from imagery from 2018 to 2020. The output can be used for multiple applications, like measuring the per-capita availability and accessibility of urban green spaces. (3.9)

- CORINE Land Cover, Vector/raster dataset inventory containing 44 land cover classes covering the years of 2000, 2006, 2012, 2018, 2021 and 2023. It is a part of Copernicus Land Monitoring Service. As CORINE provides data mainly for the European Economic Area, Copernicus Land Monitoring Service provides several global datasets.

Hazard Assessment

- UNDRR and International Science Council Hazard definition and classification review https://www.undrr.org/ publication/hazard-definitionand-classification-review
- WMO World weather and climate extremes archive https://wmo.asu.edu
- National Oceanic and Atmospheric Administration (NOAA) Collection of climatic data https://www.ncdc.noaa.gov/ cdo-web/datasets
- Copernicus Climate Change Service Past, present and future climate information in Europe and the rest of the world https://climate.copernicus.eu
- International Research Institute for Climate and Society Climate data library https://iri.columbia.edu/ resources/data-library/
- UNDRR: DesInventar National disaster loss databases https://desinventar.net/
- Emergency Events Database (EM-DAT) International disaster database https://www.emdat.be/ database
- Dartmouth Flood Observatory Flood event archive http://floodobservatory. colorado.edu/
- United States Geological Survey Earthquake catalog Earthquake catalogue https://earthquake.usgs.gov/ earthquakes/search/
- Global CentroidMoment-Tensor project https://www.globalcmt.org/
- Northern California Earthquake Data Center Earthquake events: date, location, intensity http://www.ncedc.org/anss/
- GEM Global Active Faults Database Global database of active faults https://github.com/ GEMScienceTools/gem-globalactive-faults
- NOAA Global historical tsunami database https://www.ngdc.noaa.gov/ hazard/tsu_db.shtml
- Smithsonian Institution Global Volcanism Program Global historic volcanic eruptions https://volcano.si.edu/search_ eruption.cfm
- European Space Agency ATSR World Fire Atlas http://due.esrin.esa.int/page_ wfa.php
- National Aeronautics and Space Administration (NASA) Global landslide catalogue https://data.nasa.gov/EarthScience/Global-LandslideCatalog/h9d8-neg4


Shoes
Corner Store
Yoga
UN-HABITAT