INTEGRATED PLANNING APPROACHES IN HIGHER EDUCATION:
COLLABORATIVE EDUCATIONAL PROTOTYPE TOWARDS
INTEGRATED APPROACHES IN THE PLANNING OF INCLUSIVE,
PEOPLE-CENTRIC AND CLIMATE-RESILIENT CITIES

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Planning support tools and methods for integrated planning

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What are “planning support tools”?

- **Planning support tools**, in the context of integrated planning could be defined as geo-information technology-based instruments (computational tools/methods/techniques) that assist planners in their tasks, by incorporating various components to support the planning process (Batty 1995, 2007; Klosterman 1997; Geertman 2013).

- Furthermore, they facilitate **the dialogue among all stakeholders** (planners, policy-makers, community) by providing ways to *read*, *understand* and *discuss* about the city and have the potential to enabling citizens to actively participate in decision-making processes (Jiang et al., 2003; Talen, 2000)

- **Planning support tools** utilize data (geospatial and tabular), spatial and geostatistical analysis, modeling-simulation, quantitative research methods (e.g. focus groups, semi-constructed interviews) and geovisualization to support, planners, policy-makers, stakeholders and the community during integrated urban planning processes

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Contents of this lecture

- The multifaceted nature of planning support tools cannot be exhausted in a lecture.

- To this end, in this presentation we will focus on the fundamental aspects of city, that are components of integrated planning, under our point of view.

- We will describe on the **background & the fundamental metrics**, the **methods**, the **computational tools**, and the **data-sources & datasets** needed for the analytical tools supporting integrated planning approaches of the contemporary city.

- More specifically we will focus on the following subjects, framing the various aspects of built environment, urban mobility and urban fabric in general:
  - **Built form and built density**
  - **Urban mobility, and network configuration**
  - **Uses, activities and functional mixture**

Analytical tools supporting integrated planning
Background and Metrics

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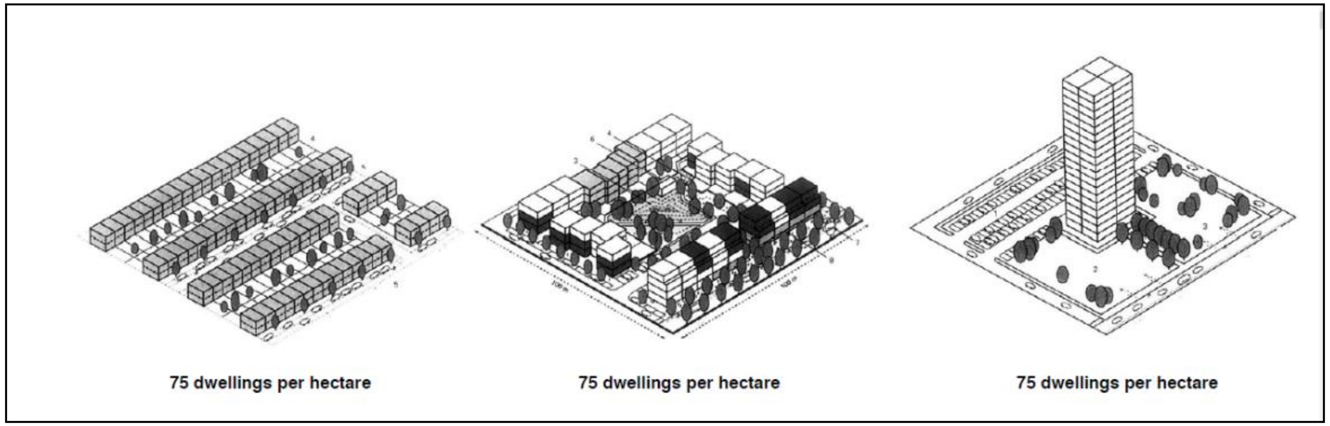
Built form and built density

Background

- Buildings and built form is a crucial aspect for describing and planning the city, and a fundamental element of urban form *(Smailes, 1953; Shirvani, 1985)*
- However, built form and built density, should be approached as the multi-variable phenomenon that it is to ensure useful findings *(Van Nes, et al., 2012; Berghauser Pont & Haupt, 2010)*



Source: *Fernandez Per & Mozas 2004: 206-207*

- We need **multiple metrics** to meaningfully capture building form and more importantly the socio-spatial meaning that it encompasses.

Built form and built density

Some fundamental metrics (1/2)

- **Construction Period:** Construction period is an important metric since it describes the historical period –and therefore broader context- that a building has been developed. Additionally, analyzing building construction periods can inform strategies for urban renewal, redevelopment, and the preservation of culturally significant structures.
- **Main Construction Materials:** The main construction materials describe the materials that has been used for constructing building (e.g. *concrete, steel, wood, brick, glass, and various composite materials*). This metric could be utilized as a proxy for the socio-economic status of the area and its residents, as well as for other aspects relevant to climate change (e.g. *building's energy efficiency, environmental sustainability, and the response of buildings to local climate conditions*)
- **Urban Permeability**: Urban Permeability is the degree to which a specific urban structure is penetrated by publicly accessible areas (Marshall, 2005 pp. 88–89). It encompasses the ease of navigating through an urban environment and the variety of route options between any given pair of points. Therefore, permeability is associated with the ability to move freely and engage with potential interactions in urban spaces.

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Built form and built density

Some fundamental metrics (2/2)

- **Building height and Number of levels:** The height of building and the number of levels are important aspects of built form, affecting environmental psychology as well as the conditions of the shared urban space in general (i.e. *zoning regulations, cityscape assessments, and the impact of structures on the urban environment*).
- **Ground Space Index (GSI)**: It is the ratio of the area of built-up surface to the sum area of the urban fabric. It reflects the coverage, or compactness, of the development. A higher GSI indicates a more significant portion of the land covered by buildings, which can have implications for urban density, open space availability, and overall land utilization. *A comparable term for GSI is Ground Coverage Ratio (GCR)*.
- **Floor Space Index (FSI)**: It is the ratio of Gross Floor Area to the sum area of the urban fabric. It can be also calculated if the Ground Space Index is multiplied by the Height of Building (or by the Number of Levels). It provides an ***indication of the built intensity*** in an area. *A comparable term for FSI is Floor to Area Ratio (FAR).*
- **Open Space Ratio (OSR) or spaciousness**: OSR, which is expressed as a ratio, refers to the open (unbuilt) space within the area of interest in relation to its total land area. This metric provide an *indication of the pressure on non-built space.*

Urban mobility, and network configuration

Background

- City can be approached as a structure-function spatial system that is self-organized through the interaction of network (structure) and human activity (function) into busy and quiet zones (Hillier, 2003)
- The street network is the urban element connecting all urban configurations (*land-uses, transportation infrastructure, real-estate values, built form, etc.*). It has an **architecture**, that is a certain geometry, a certain topology and a certain scale (Al_Sayed, et al., 2014).
- Network configuration, as defined by **space syntax** (Hillier & Hanson, 1984; Hanson & Hillier, 1987), addresses this inherit property of space to shape human movement and ultimately activity in space (Hillier, et al., 1993; Penn, et al., 1998)
- Apart from the analysis of network configuration, in the context of integrated planning, conventional sustainable urban mobility metrics are also important.
- More specifically, the analysis of pedestrian accessibility and active mobility characteristics, as well as analysis of public transportation network are crucial for supporting the people-centric planning of the cities.

Urban mobility, and network configuration
Some fundamental metrics (1/4)

- **Walkshed area from public transit stations and other nodes of interest:** Walkshed area refers to the geographic expanse or zone within which pedestrians can comfortably and feasibly walk. It is a metric that quantifies the reachable area around a node of interest on foot, providing insight into the accessibility and walkability of the surrounding urban environment. *Typical walkshed areas refer to 5' walking (~400m), 10' walking (~800m) and 15' walking (~1.2 km).*
- **Density of public transport stations**: It is a metric that quantifies the concentration of public transport stations within a specific urban area. It reflects the number of transit stations present relative to the total land area, providing a measure of how closely spaced these transportation facilities are in each locality. This metric is valuable for assessing the accessibility and availability of public transit options in an urban environment. It may be useful to calculate the density separately for bus stations and subway stations since they address different mobility needs.
- **Frequency of public transport service**: It is a metric that gauges how often public transportation vehicles, such as buses, trains, or trams, operate within a specific urban area.. A higher frequency indicates more competent level of service, which can contribute to improved accessibility and convenience for commuters within the urban transportation network. It may be *useful to differentiate the calculation between different types of public transport (e.g. busses vs subway).*

Urban mobility, and network configuration
Some fundamental metrics (2/4)

- **Evaluation of level of service based on the pedestrian accessibility infrastructure:**
  - **Adequate level of service for able-bodies street users**: Min sidewalk width ≥ 1,5 m, as the minimum requirement to ensure comfortable movement of one person per direction on the sidewalk
  - **Adequate level of service for all street users:** Min sidewalk width ≥ 1,5 m AND existence of tactile paving AND presence of two curb ramps per sidewalk section
  - **Adequate level of service for all street users:** Min sidewalk width ≥ 2,1m AND existence of tactile paving AND presence of two curb ramps per sidewalk section, as the minimum sidewalk width should be at 2,1m for the service of any person as well as the installation of streetscape features (e.g. streetlamps, trees, etc).
- **Mapping of pedestrian/cycle/living streets network and its share to the whole network**: It refers to the analysis of the streets dedicated to pedestrians, cyclists, and other non-motorized activities in an urban area. These metrics specifically assess the proportion of these designated streets relative to the entire road network within the urban environment. They provide valuable information about the extent of infrastructure dedicated to promoting pedestrian and cyclist-friendly spaces, offering insights into the walkability and livability of the city.
- **Modal split/share**: It refers to the distribution or percentage share of different transportation modes (such as walking, cycling, public transit, private car, etc.) utilized by individuals for their daily commuting within a specific urban area. This metric provides insight into the preferences and choices of transportation modes among the population, supporting planning process towards sustainability, efficiency, and overall effectiveness of the transportation system in accommodating diverse mobility needs.

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Urban mobility, and network configuration

Some fundamental metrics (3/4)

- **Intersection density**: Intersection density is defined as the number of intersections per square kilometer at a local scale, where intersections are the junctions at which three or more road segments intersect. A high intersection density indicates a walking-friendly environment.
- **Number of dead-ends or cul-de-sacs**: It counts the instances of streets or roads that terminate with no through access, typically in the form of dead-end streets or cul-de-sacs, within a specified area. This metric helps evaluate the street network's layout and design in an urban environment. A higher number of dead-ends or cul-de-sacs may result in a less connected and more discontinuous road network, potentially affecting traffic flow, accessibility, and overall transportation efficiency.
- **Connectivity:** It is a metric that assesses the level of interconnection and accessibility within a street network and it often measures the number of spaces immediately connecting a space of origin. Higher street connectivity, in particular, implies a more interconnected urban grid, providing multiple direct routes and alternative paths for pedestrians, cyclists, and vehicles, accordingly, to travel between different locations. Improved street connectivity is associated with enhanced accessibility, shorter travel distances, and better overall urban mobility.
- **Network Intelligibility**: It refers to the degree to which the number of immediate connections a line has is a reliable guide to the importance of that line in the system as a whole (namely, it is a correlation between local and global network characteristics). A strong correlation, or '**high intelligibility**', implies that the whole can be read from the parts (Hillier et al., 1987).

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Urban mobility, and network configuration

Some fundamental metrics (4/4)

- **Angular Space Syntax Analysis** takes into account the least angular deviation of each segment from all other segments (hence it takes into account *the relative straightness of a route*). Movement patterns in cities have shown that people move by reading the angular geometry of the network, not actual metric distances (Hillier & Vaughan, 2007). Thus, angular analysis, particularly the one constrained by metric radius , is found to be instrumental in detecting major to- and through-movement routes in a street network and two powerful measures for identifying these potentials are integration and choice (Al_Sayed, et al., 2014, p. 73).
- **Angular Integration** measures how close each segment is to all others in terms of the sum of angular changes that are made on each route (Vaughan, 2015, p. 310). It expresses the ***closeness*** of a space for the system, that is, how easily it can be approached. It is the quantification of ***network-based accessibility*** of a space in relation to the urban system to which it belongs (***to-movement***).
- **Angular Choice** is calculated by counting the number of times each street segment falls on the 'shortest path' (the path of least angular deviation through the system) between all pairs of segments within a selected distance (termed 'radius') (Vaughan, 2015, p. 310). It expresses the ***betweenness*** of a space for the system, that is, how likely a space is to be used as a passage/route for its urban system and constitutes the quantification of its ***network-based centrality*** in relation to the urban system to which it belongs (***through-movement***).

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Uses, activities and functional mixture

Background

- The combination of land-uses, as well as economic and human activities –which we term as "***functional mixture***"- encompasses important information about the socio-spatial characteristics of a city (Araldi & Fusco, 2019)
- The functional mixture influences (and is influenced by) almost all aspect of urbanity, ranging from *urban mobility*, and *urban practices*, to the *cultural* and *economical* characteristics of an urban area (Shen & Karimi, 2017; Hillier, 1996/2007; Sevtsuk, 2010).
- What is more, the presence of such activity nodes in urban space is of utmost importance for city life. It enhances the multidimensional interaction in the community and contributes to the dynamics of the city (Gehl, 1987; Jacobs, 1961).
- Despite the increasing importance of new technologies and their impact on residents' daily lives (especially in the post-pandemic city) digital social and commercial life is just a "*sparse imitation of [...] real closeness*" (Greenberg, 1995).
- To this end, the metrics and indicators describing the various dimensions of functional mixture are crucial supporting information towards the integrated planning of livable cities and urban districts.

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Uses, activities and functional mixture

Some fundamental metrics (1/2)

- **Population Density**: It refers to the population (number of residents) living per square meter and depicts the residential (or non-residential) character of an area. A similar metric is Residential Density which measures the number of people living in a specific area.
- **Functional Density**: refers to the intensity of non-residential activities as captured by the corresponding area (sq.m) or count of non-residential activities (or features of interest). It describes the functional centrality of an area meaning the intensity of human activity. It is crucial aspect for human presence, urban vitality, and finally the character of the various areas of a city.
- **Functional Diversity**: It describe the vibrancy, the vitality and ultimately the different dimensions/characters of an area. A method to quantify it is the ***Land-use entropy index*** (Cervero & Kockelman, 1997) which measures the degree of heterogeneity among the different categories of activities/functions. Another metric for quantifying functional diversity is the ***Mixed-use Index (MXI)*** (Hoek, 2008) that measures various degrees of multi-functionality.
- **Density and of Public Open Spaces**: It measures the concentration of publicly accessible open areas within a specific urban environment. It is typically expressed as the ratio of the total open space area to the total land area of a designated region. The public open spaces with free access are the *"natural" places where social practices of coexistence and encounter can manifest* and as such are extremely important for planning a livable city.

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Uses, activities and functional mixture

Some fundamental metrics (1/2)

- **Prevailing land use:** This metric refers to the predominant or most common type of land use within a specific area or neighborhood. In most of the cases it may be useful to differentiate the metric for ground level and floor level characteristics. A vital metric for supporting planning decision regarding *zoning regulations*, *infrastructure development*, and overall *urban development strategies*.
- **Identification of urban centres and centralities**: Utilization of relevant urban elements, (such as functional density, functional diversity, job density, population density, network centrality) to identify urban centers. The identification of urban centers/centralities is vital for effective spatial planning, as it informs decisions related to zoning, sustainable mobility planning, and inclusive urban spaces.
- **Mapping of urban vitality**: Exploitation of the various relevant urban elements to identify and assess the level of vitality in an urban area. Such urban elements could be *functional diversity, functional density, density of public open spaces, density of public open spaces* etc. It can inform and support planning strategies for enhancing urban quality of life, promoting economic development, and creating more engaging and resilient urban environments.
- **Spatiotemporal analysis of urban activities**: It refers to the analysis of the different spatial and temporal functional patterns that emerge in an urban area. It provides a comprehensive understanding of how people interact with the urban environment over time and space (e.g. *Day vs Night* or *Weekday vs Weekend*).

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Analytical tools supporting integrated planning Methods, Computational Tools and Datasets

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Methods

Methods and techniques for geospatial and geostatistical analysis:

- **Overlay, Extraction and Proximity analysis**: Basic analytical techniques describing the fundamental spatial relations between various spatial features of the city. Important relevant geoprocessing methods are the following: *Buffer*, *Intersect*, *Union*, *Spatial Join, Creation of Voronoi/Thiessen polygons*
- **Mapping patterns and clusters**: More sophisticated spatial data analysis techniques for identifying complex urban phenomena. Important relevant geoprocessing methods are the following: *Kernel Density Estimation, Spatial Autocorellation (Global Moran's I), Cluster and Outlier Analysis (Anselin Local Moran's I), Multivariate Clustering (unsupervised classification)*
- **Network Analysis**: A series of geoprocessing methods and algorithms for analyzing the various aspect of urban street including more specific analyses of network configuration such as space syntax analysis. Important relevant geoprocessing methods are the following: *Walkshed Area/Service Area Analysis, Origin-Destination Cost Matrix Analysis, Closest Facility Analysis, Angular Integration, Angular Choice, Attraction Reach, Attraction Betweenness*

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Computational Tools (1/2)

- **DepthmapX** is a stand-alone space syntax tool to perform a set of relevant spatial network analyses. It works at a variety of scales from building through small urban to whole cities or states. It computes 2-d depth, integration and choice within a network-Euclidean or topological radius.
- **Place Syntax Tool (PST)** open-source tool for performing spatial analyses. It combines the space syntax description of the urban environment with conventional descriptions of attraction into the combined accessibility analysis tool PST. It is currently available as a plugin for the MapInfo Professional GIS software and *QGIS* (Ståhle et al., 2005)
- **Space Syntax Toolkit** is a QGIS plug-in for spatial network and statistical analysis. It provides a front-end for the depthmapX software within QGIS, offering user friendly space syntax analysis workflows in a GIS environment. It is primarily aimed at supporting the standard space syntax methodology, and enhancing its workflows with standard GIS data, analysis and visualisation features.
- **Spatial Design Network Analysis plus (sDNA+)** is a toolbox for 3-d spatial network analysis, motivated by a need to use network links as the principal unit of analysis. sDNA is usable from QGIS & ArcGIS, AutoCAD, the command line, and via its own Python API. It computes measures of accessibility (reach, mean distance/closeness centrality, gravity), flows (bidirectional betweenness centrality) and efficiency (circuity) (Cooper and Chiaradia, 2020)

Computational Tools (2/2)

- **Momepy** is a python library for quantitative analysis of urban form - urban morphometrics. Some of the functionalities that momepy offers are: quantification of shapes of geometries representing a wide range of morphological features, estimation of density and other types of intensity characters, estimation of diversity of various aspects of urban form, connectivity analysis of urban street networks, generation of relational elements of urban form (e.g. morphological tessellation) (Fleischmann, 2019).
- **MIT Urban Network Analysis (UNA)** is a plugin for ArcGIS and RhinoCAD toolbox for urban network analysis. UNA doesn't directly calculate statistics for network links; instead, it focuses on a layer of point or polygon buildings in a 2-dimensional network to infer connections. It evaluates various metrics such as reach, gravity, betweenness, closeness, straightness, redundancy index, and paths, along with the wayfinding index.
- **AwaP-IC** is an open-source GIS Tool for measuring walkable access. More specifically it calculate the *Area-weighted average Perimeter (AwaP)* which is a measure for urban permeability *and Interface Catchment (IC)*, two measures developed by Pafka & Dovey (2017), that combined, *capture the capacities of urban morphologies to enable and attract pedestrian movement* (Majic and Pafka, 2019).
- **OSMnx** is a Python package to retrieve, model, analyze, and visualize street networks and other geospatial features from OpenStreetMap (Boeing, 2017).

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Data sources and datasets (1/2)

- **Urban Atlas**: Urban Atlas is composed of a suite of products for the Functional Urban Areas (FUA) with more than 50,000 inhabitants in EEA38 countries and UK, that encompasses:1/ Land Cover Land Use products, 2/ Street Tree Layer, showing contiguous rows or patches of trees covering 500 m² or more over "Artificial surfaces", 3/ Population estimates per Urban Atlas polygons, 4/ Building Height layer in a 10 x 10 m grid.
- **Imperviousness Density**: Copernicus Land monitoring services High Resolution land cover characteristics that describe the imperviousness degree showing the sealing density in the range from 0-100% for the EEA-38 countries and UK.
- **Corine Land Cover**: It is a pan-European dataset consisting of an inventory of land cover in 44 classes. The dataset has a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a Minimum Mapping Width (MMW) of 100 m for linear phenomena and is available as vector and as 100 m raster data
- **Tree Cover Density**: The High Resolution Layer Tree Cover Density product offers information on the percentage of tree cover in a given area. Provides at pan-European level in the spatial resolution of 10 m and 100 m the level of tree cover density in a range from 0% to100% for the 2018 reference year.

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Data sources and datasets (2/2)

- Open Street Map (OSM) is a global, free, and open geographic database updated and maintained by a community of volunteers via open collaboration and it includes a multitude of attribute-rich spatial datasets, Its main limitation is that since it relies exclusively on crowd-sourcing its degree of completeness and accuracy is always an issue, especially for some geographic areas and for specific features and categories. In the context of integrated planning, the most relevant datasets of Open Street Map, are the following:
    - street network,
    - points of interests,
    - transport infrastructure,
    - Building outlines, and
    - Land-uses
- **City-specific data**: Important geospatial data sources are always the city and national authorities (e.g. city geoportal, national statistical authority, national data portal). These sources may vary on the terms that they provide the data (open-access, restricted–access, or paid-access), however it is an invaluable source of reliable detailed data.

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Analytical tools supporting integrated planning
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PEOPLE-CENTRIC AND CLIMATE-RESILIENT CITIES

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