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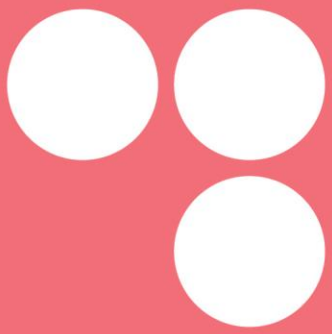

Review of the State of the Art of EBDP

Task 3.2

twinning towards
research excellence
in evidence-based planning
and urban design

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Document Description: The document shows a WIP framework for the Task 3.2 that looks into the state of the art of EBDP. It Informs the scientific paper on the state of the art of EBDP, the conceptual model and methods, and Is part of the larger research framework of the project.

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Table of Contents

1. Introduction

This report looks into the state of the art of EBDP (evidence-based design and planning). Partly addressing how EBDP can be enhanced, this report reviews the process of development of EBDP, as well as the common tools and methods in academia and practice to address the possible avenues of research and development, while identifying the challenges and obstacles that hindered the application and/or adoption of EBDP.

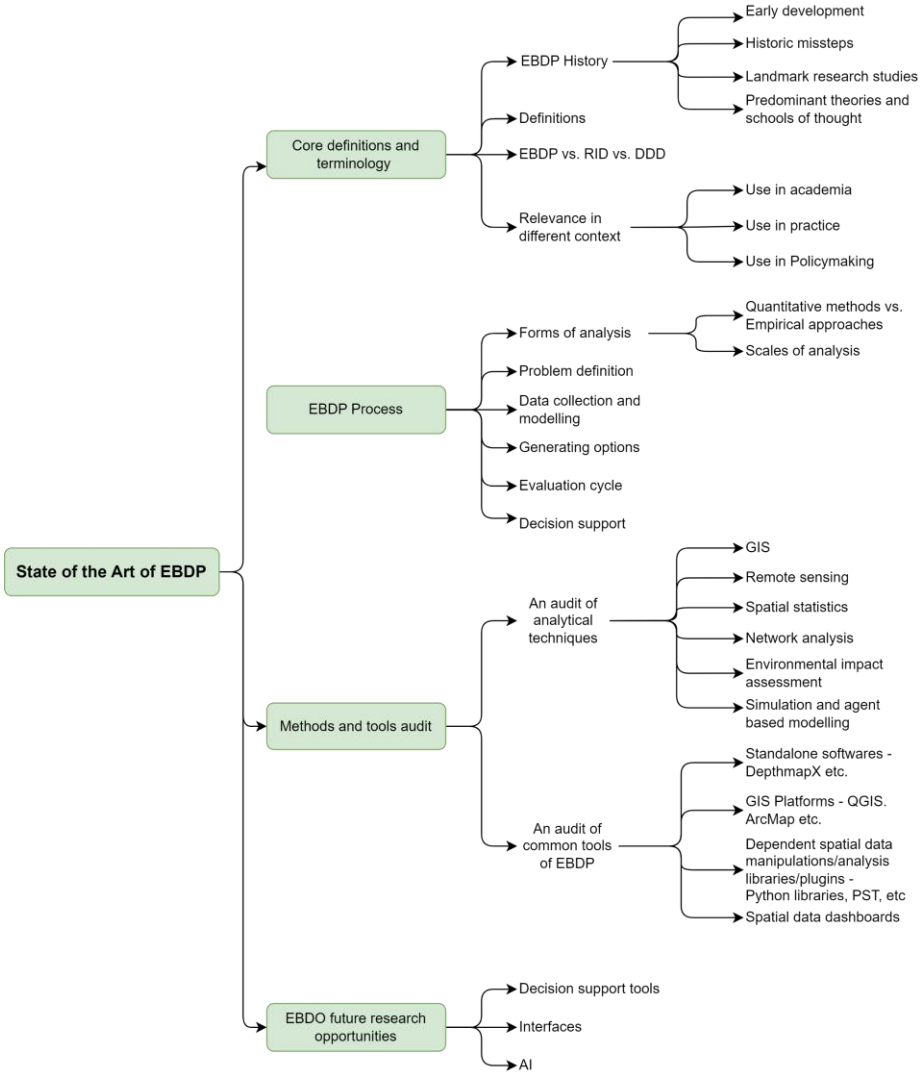

Figure 1-1 Report structure

As shown in the above diagram this report begins with an overview into the core definitions of EBDP and how it distinguishes from RID (Research Informed Design) and DDD (Data Driven Design). Then

it reviews the different approaches and scales of analysis in EBDP. This helps to navigate EBDP among other practices and helps to define EBDP as a field.

2. Core definitions and terminology

2.1. EBDP History

Reviewing the development of EBDP through a chronological point of view is necessary to understand why and how EBDP becomes a field. Shedding light on the historical development of the analytical thinking and application of cross-disciplinary methods into framing existing built environment issues and preparing for future development provides a platform for discussion on priorities and necessary steps in the field. This also provides some support for the

2.1.1. Early development

- Haussmann's Paris (1800s): Measuring and mapping of buildings, streets, spaces and topography; population density, income levels, social conditions. Informs design strategy for Paris.
- Walter Christaller / Central Place Theory (1933): Uses fieldwork, observations, census data, government reports to gather information on economic activity and spatial distribution of urban settlements. Leads to Central Place Theory on optimal sizes and locations for urban centres.
- Patrick Geddes (1800s, 1900s): surveys, mapping, observation, interviews to inform context driven approach.
- Chicago School of urban sociology (early 1900s): Robert Park and Ernest Burgess. Analysis of spatial distributions with mapping and statistical analysis to identify patterns and propose theories on how physical environment shapes interactions.
- Modernist approaches (1950s onwards): so-called rational analysis and functionalism to inform design.
- Italian School - Gianfranco Caniggia - inspired by Kevin Lynch (1960s). Mapping of geometry of streets and arrangements of buildings. Relationships between built environment and behaviour.
- Copenhagen School - Jan Gehl - designing for pedestrians. Some mixed empirical results on Gehl's guidelines for walkability (e.g. smaller vs taller buildings, facade quality).
- New Urbanism (80s onwards): Studies on walkability, transit-oriented development, mixed land uses, mixed socio-economic groups, etc. Studies raise some controversy on overstating role of urban design in shaping neighbourliness / social cohesion of communities.
- Healthy Cities Movement (1984 onwards): focused on health and wellbeing through planning and design. Child-friendly, active transportation, health inequalities, green spaces, affordable housing, public transportation.
- Space Syntax - Bill Hillier & colleagues. Spatial configurational understanding of cities. Use of network analysis, pedestrian counts, surveys, observational analysis.

- LEED Neighbourhood Design - benchmarks for neighbourhood design and associated accreditation.
- GIS and computationally enabled forms of spatial analysis (variety).

2.1.2. Historic missteps

Mainly looking into the age of wishful modern thinking, who disregarded the traditional logics of planning and design, this section tries to review how the idea of *evidence* has changed from the modern times given the development of applied methods. The following will be discussed in more detail as a way to re-emphasize the process of EBDP and specifically in iteration process, and analytical techniques.

Disregard for Context

Separation of Functions

Lack of Human Scale

Disruption of Urban Fabric

Social Exclusion

Lack of Sustainability

2.1.3. Landmark research studies

As discussed, the core paradigm in emergence of evidence-based planning and design, was to criticize the dominant approaches in planning and design that relied on philosophical and/or intuitive perceptions to develop place-making ideas. Supported by civil movements and scientific approaches, the criticism on these ideas increased and analytical thinking based on evidence grew to be more influential in the logics of planning and city making. Some of these landmark studies and ideas that reinforced the idea of evidence-based design and planning are summarized in the following table:

Year	Research/publication	Core idea
1961	The Death and Life of Great American Cities	this influential book challenged traditional urban planning practices and advocated for a more bottom-up, community-oriented approach. Jacobs emphasized the importance of observing and understanding the dynamics of city life through empirical evidence and direct experience.

1999	Towards an Urban Renaissance	Led by Urban Task Force and Richard Rogers, this report examined the state of urban areas in the United Kingdom and proposed recommendations for sustainable urban development. It highlighted the importance of evidence-based planning, emphasizing the need for rigorous analysis, research, and data-driven decision-making in shaping urban environments.
2004	Design for Diversity: Exploring Socially Mixed Neighbourhoods	by Joseph Rowntree Foundation (2004): This research study explored the benefits and challenges of creating socially diverse neighbourhoods. It examined the impact of different design factors on social integration and cohesion, providing evidence-based insights into the design principles and strategies for promoting social diversity in urban areas.
2006	Evidence-based planning: rhetoric and reality	In this article Simin Davoudi (2006) traces the history of the use of evidence in planning and highlights the need for a more critical perspective on evidence use in policy, which recognizes the limitations and potential biases in evidence and the importance of context in shaping policy decisions.
2006	Introducing evidence-based planning	Faludi and Waterhout (2006) in this paper try to evaluate the theory and practice of evidence-based planning through case studies. Looking into various aspects such as the role of evidence in decision making, organizational form of evidence collection and interpretation etc., along with theoretical argument presented provide some insight on the trend of evidence-based planning since early 21st century
2009	Planning Support Systems for Cities and Regions	by Stan Geertman and John Stillwell (2009): This book explored the use of planning support systems (PSS) - computer-based tools and models - for evidence-based planning. It discussed the integration of geographic information systems (GIS), spatial analysis, and decision support systems to facilitate data-driven decision-making in urban and regional planning processes.

2.1.4. Predominant theories and schools of thought

Given the context of the research identifying predominant theories and schools of thought in relation to evidence-based planning and design can differ, based on what is considered evidence. Depending on how the evidence is defined, measured, or assessed, organization of theories around them may differ. As the intent for the review of the prominent theories in the field of evidence-based planning and design is to take a critical position and concisely address major thinking that inform planning and design through analytical thinking. From this point of view the following typology of prominent theories may be address the issue.

Theories concerned with hard evidence

These theories inform planning and design based on types of evidence that can be measured and assessed without personal judgement. These theories are mainly informed by other disciplines and their methods are repeatable with reproducible outcomes. Some of these theories are:

- Rowe and Koetter's Collage city
- Hillier and Hanson's Space Syntax
- Alexander's A Pattern Language
- Berghauser and Haupt's Spacematrix

Theories concerned with soft evidence

These theories also incorporate evidence in evaluating the situation and

- Jan Gelh's Life between buildings
- Whyte's Social life of small urban spaces
- Kevin Lynch's Image of the city

2.2. Framing EBDP

2.2.1. What is evidence-based design and planning?

Evidence-based design and planning involves using empirical evidence to inform decision-making through the processes of design and planning. It emphasizes relying on the best available scientific evidence rather than tradition, intuition, or personal experience alone. Evidence-based design (EBDP) follows this approach by intentionally basing design decisions on the most reliable research evidence. EBDP involves the collaboration between an evidence-based designer and an informed client to make decisions informed by research and project evaluations. The goal of EBDP is to achieve the best possible outcomes by incorporating credible research in the decision-making process for the built environment.

2.2.2. EBDP vs. Research Informed Design

Research-informed design involves examining a specific case to gain insights into a narrowly defined area, which then informs the design process. On the other hand, evidence-based design incorporates a wide range of information and analytical methods to inform the overall design. In research-informed design, the findings from specific research are broadly applied to the design and decision-making process. In contrast, evidence-based design applies a broad range of information and methods in a more focused manner specifically within the design and planning process.

Peavey and Vander Wyst, (2017), provide a Matrix of steps that clearly define the differences and similarities between doing research, Evidence Based Design and Research informed Design.

Matrix of steps for research, EBD and RID

steps	Research	EBD	RID
	Adapted from polit and Beck (2008 and Stichler (2010b)	Adapted from the center for health design 2008	Adapted from Burghardt and hacker (2014)
1	Identify problem, research question or hypothesis	Define Evidence based goals and objectives (with client and interdisciplinary team	Clarify design problem and project-based goals and constraints
2	Perform literature review	Find sources for relevant evidence	Identify research on related problems and populations
3	Use a theoretical framework to explain the relationships among variables	Critically interpret relevant evidence, assess evidence applicability, quality, and strength	Assess Research applicability, quality, and strength. Use research to assess variables that affect performance
4	Select an appropriate research design to test the hypothesis	Create and innovate EBD concepts	Use knowledge gained from Steps 1-3 to generate design options
5	Identify measurements to quantify variables	Develop a hypothesis	Design evaluation, choose the best option using research to weigh pros/cons
6	Select the sample	Collect baseline performance measures	Develop a prototype (virtual, physical
7	Data collection and analysis	Monitor implementation of design and construction	Design testing, evaluate prototype using empirical observation or testing with target audience
8	Statistical and data analysis	Measure post- occupancy performance results	Iterative improvement, use results from testing to drive greater research inquiry, to improve, and to iterate the design process
9	Disseminate results in publications and presentations including study limitations,	Disseminate post-occupancy performance results through publication and presentation	Communicate process, share process and lessons learned

	recommendations, and implications for practice

2.2.3. EBDP vs. Data Driven Design

Data-driven design is a design approach that utilizes data and analytics to inform and guide the design process. It involves collecting and analysing data on user behaviour, preferences, and needs, as well as data on the performance and functionality of the design. This data is then used to make informed decisions about the design, with the goal of creating a product or system that is optimized for its intended use and user experience. Both EBDP and DDD try to limit the error in post-occupancy caused by limited intuitive and theory driven design and planning, while what place them apart is the stage at which they put the iterative evaluation process.

In Data Driven Design, the input data is set through a generative unsupervised algorithm which an option based on previously set metrics. The process outputs an optimised option which corresponds best to the pre-set metrics. However, in the EBDP process there is an element of human supervision when it comes to reviewing the output options. Basically, the main difference between the data-driven design and evidence-based design and planning is that through DDD, the process produces one option that corresponds to the design agenda, however through EBDP the pre-set agenda is broad, and the analysis informs the limitations and available options. This leaves some area for human input and experience for evaluating the options which in return may change the agenda as well.

2.3. Relevance in different context

An overview of EBDP usage to capture aims, use in academia, and use in practice.

2.3.1. Relevance of EBDP in academia
2.3.2. Relevance of EBDP in practice
2.3.3. Relevance of EBDP in policymaking

3. EBDP process

A prototypical overview of EBDP usage during design processes.

3.1. Forms of analysis

3.1.1. Scale of Analysis

Depending on the research question defined and available/achievable data, the scales of analysis and their output can be different. Although in built environment research defining the scale of analysis can have multiple aspects, in urban design and planning the scales of analysis are largely informed by the raised question in the research and can be categorized into three different scales based on their applicability in the research. These are Macro, Meso and Micro scales:

Macro scale

At the macro scale, analysis focuses on the entire city or urban region. It involves examining broad patterns, trends, and dynamics that shape the overall form, structure, and function of the urban area. This includes studying regional planning, transportation networks, land use patterns, economic systems, and demographic trends.

Meso Scale

The meso scale analysis zooms in to a neighbourhood or district level within the city. It explores the characteristics, spatial organization, and socio-economic dynamics of specific areas. This includes analysing land use patterns, building typologies, transportation infrastructure, public spaces, and social amenities within the neighbourhood.

Micro scale

The micro scale analysis zooms further into the fine-grained details of urban design. It focuses on individual streets, blocks, buildings, and public spaces. This includes examining the layout, density, architectural design, pedestrian accessibility, and visual aesthetics of specific elements within the urban fabric.

3.1.2. Quantitative methods vs. Empirical approaches

With regards to EBDP, methods of analysis can have a significant impact on the way one's understanding of the issues are defined. Based on the research questions and feasibility of the methods the analysis can be implemented through either empirical approaches or quantitative methods. In this respect the major difference between the two is the scale of analysis and method of data collection. As for the empirical approaches there is an extent of ground truthing, through which data is observed and collected by the researchers and based on their ability of observe and interpret the evidence. These approaches can be applied to smaller scale and provide high resolution analysis for sites that are accessible by individuals. However quantitative methods investigate large scale phenomenon and are used in studies where simply ground truthing is not feasible. These methods largely rely on data gathered from crowdsourcing, remote sensing, official census, or automated data collection.

	Empirical approaches	**Quantitative methods**
Input data	Observation – Not reproducible	Numerical data – reproducible
Scale of analysis	Micro, Meso	Meso, Macro
Data collection	Observation, gate counting etc	Official census, remote sensing, crowdsourcing etc

Analytical techniques	Statistical method, participatory methods, Evaluation and feedback loop	Spatial statistics, mathematical modelling, Geostatistics

4. A review current and past methods and tools of EBDP

The following provides an outline which will be further developed for inclusion in D3.1 – Paper on State of the Art and Conceptual Models & Methods and D3.2 – Report on EBDP.

4.1. Analytical techniques

Depending on how the process of evidence-based design and planning is defined, the methods applied to the process can differ. With the availability of affordable technology and data, EBDP has been adopted in the methods and depending on project specific and priorities, these methods can address the criteria of planning and design separately. Currently There is a divide between these methods – given that they rely heavily on tools – and expansion of the methods define certain disciplines.

4.1.1. Units of analysis – zonal, network point, etc

Depending on the model of analysis designed for the research specific agenda, different units of analysis are suitable for analysis. These models and units associated with them each have their own limitations and in numerous occasions these may not suffice to address the raised question in the research. reviewing these models and units of analysis inform the process through which the research is designed. These models and their associated units of analysis can be categorized into the following:

Grid Cells

Dissecting a landscape into equal units of coverage that capture the spatial properties of the area each cell covers. In these models the size of the grid cells determines the spatial resolution of the model and are best suited to represent continuous phenomena such as natural features and population.

Polygons or objects

These are mostly associated with spatial features with geometrical attributes are among the essential properties of the units. Therefore, these datasets are usually associated with human activity and represent attributes of the *built environment*. What is commonly problematic with these datasets are the consistency in definitions especially when it comes to comparison analysis.

Agent based units

In spatial analysis the number of agents and their defined behaviour is determinant in analysing the properties of a planned and/or designed space.

Network units

When modelling the spatial relations and represent spatial arrangement in a network model, nodes and edges of the network carry information that can address association and can be scaled. These models and units of analysis can represent either natural or man-made features such as street network or species disparity.

Continuous/raster units

These models usually represent features without geometry regular disparity that show similarities and/or patterns in large scales of analysis. Natural features such as topography and population density are examples of this unit of analysis.

4.1.2. Methods – GIS, Network analysis, CA, ABM, etc

Geographic Information System (GIS)

A generic term for platforms that incorporate soft data and geometry, GIS is a powerful tool for capturing, storing, analysing, and visualizing spatial data. With respect to EBDP, it provides a platform that can integrate different datasets, spatial querying, map creating and spatial modelling as well as testing and comparing certain impacts different planning and design scenarios could have.

Remote Sensing

A way of acquiring information about the spatial features through using sensors (mounted on aircraft, GPS signals, voluntary cell movement data etc.) it is a good method of understanding the inter-relationship between the existing spatial features and dynamic processes. This includes natural and synthetic dynamical processes such as rainfall and people's movement within a given area. With regards to EBDP, remote sensing can be great real-time analysis tool as well as post-occupancy monitoring.

- Optical remote sensing
- Multispectral remote sensing
- Hyperspectral remote sensing
- Thermal remote sensing
- LiDAR
- Radar remote sensing
- Synthetic Aperture Radar

Spatial Statistics

Given the availability of data in various formats, statistical methods can be applied to spatial data to allow for analytical understanding of spatial relations. These methods such as spatial autocorrelation, Spatial interpolation, point pattern analysis, and spatial regression help understand patterns that might otherwise be harder to understand relying only on physical relationships. With regards to EBDP, this method can evaluate some of the rather complicated aspects of post-occupancy that are not immediately comprehensible. The common methods in these are:

- Spatial autocorrelation
- Spatial interpolation
- Point pattern analysis
- Spatial regression analysis
- Spatial clustering
- Geostatistics
- Hotspot analysis

Network Analysis

Rooted in graph theory, network analysis investigates topological relationships between spatial features and can help interpret the relationship between spatial and non-spatial features. Common methods of design and planning such as Space Syntax are also built on the same idea, which assess the inter-relations of human behaviour and spatial configuration. Some of the spatial network analysis methods are:

- Connectivity
- Shortest path analysis
- Network clustering and community detection
- Centrality analysis
- Network robustness analysis
- Network expansion and growth analysis

4.1.3. Environmental Impact Assessment

Environmental Impact Assessment (EIA) is a systematic process to evaluate the potential environmental consequences of proposed development projects. It assesses the impacts on ecosystems, natural resources, and communities.

4.1.4. Simulation and Agent-Based Modelling

Simulation and agent-based modelling (ABM) are widely used methods in spatial analysis to understand the impact of decision-making and planning on on-going setting and context. These methods are specifically useful in dealing with complex systems and predict outcome non-linear processes to support decision-making. Some of these methods are:

Simulation

The general simulation method involves creating a model that imitates the behaviour and dynamics of the real-world scenario with limitations and/or regulations. The model can be applied to various dynamic systems such as transport systems and urban growth. The significance of simulation models is that through adjusting parameters, different scenarios and outcomes can be explored

Agent-Based Modelling

Focusing on behaviour and interactions of individual agents in a system, the agents represent the real-time features, and the simulations speeds up all possible interactions within a controlled set of measures.

Cellular Automata

Cellular Automata are computational models consisting of grid of cells each having a state that evolves over time based on a set of rules. In spatial analysis and planning, these can be used to predict the impact of spatial phenomena. This includes land use and demographic change, and ecological processes. The cells in this method represent a geographical point and at periodic intervals its status updates based on the rules and relations with neighbouring cells. This simulation is based on progressive relations and is a good way of investigating contagious impact of spatial phenomena.

Monte Carlo Simulation

This simulation method involves generating and assigning random samples to spatial locations based on characteristics of the study area. The simulation takes into account spatial dependencies and interactions between neighbouring points. The iterative process of generating these samples help quantify the probability of different scenarios and uncertainty.

4.2. EBDP toolsets

A matrix of EBDP toolsets and related considerations.

4.2.1. Standalone software

Software	Embedded tools	Applicability	Interface	Format/ Distribution	Language	Advantages/ Limitations
DepthmapX	Network analysis (Axial and segment) Agent Based modelling Visual Graph analysis Network Visualization	Urban planning Urban design Interior layout analysis and design	GUI	Graph Open-source	C++	Specific to space syntax analysis – Does not directly communicate with other platforms
ISOVIST	Visual graph analysis	Urban design	GUI	.dfx		
GeoDA	Spatial statistics	Urban planning Urban design	GUI	Open-source		

4.2.2. Programming interfaces (e.g. Python based tools)

Software	Embedded tools	Applicability	Interface	Format/ Distribution	Language	Advantages/ Limitations
OSMNX	Network analysis (Node via NetworkX) Visualization	Urban Planning Urban Design	CLI	OSM .gpkg	Python	
Cityseer	Network preparation (graph cleaning, network decomposition, primal to dual) Network analysis (primal / dual, node /	Urban Planning Urban Design All methods applied over the network Bi-Directional datapoint assignment to	Python API QGIS plugin under development	Python package Compatible with Network X Can link to varied formats vis	Python with Numba JIT Python with Rust under development	

	segment, simplest / shortest) Land use accessibilities Mixed-uses Statistical aggregations	adjacent network Distance weighted methods Simplest path compatible algorithm (no shortcutting)		python ecosystem	
PySAL	Network analysis Network moBidelling/Visualization	Urban Planning Urban Design	CLI	.gpkg, .shp, etc	Python
GeoPandas	Geo data manipulation and handling	Urban Planning Urban Design	CLI	.shp, .geoJSON, . gdb, .kml, .gpkg, .wkt	Python
Shapely	Manipulation and analysis of geometric objects	Urban analysis	CLI	.WKT, .WKB, Coordinate array	Python
Fiona	Manipulation of geo data to and from GIS platforms	Urban analysis	CLI	.shp, .geoJSON, .gdb, .MapInfo Tab, . PostgewSQL/PostGIS	Python
Rasterio	Manipulation and handling of gridded raster dataset	Urban analysis,	CLI	GeoTIFF, GeoJSON	Python
PyProj	Manipulation and handling coordination reference systems for geospatial data	Urban analysis	CLI	CRS strings, EPSG codes, Proj4 strings, .WKT	Python
CartoPy	Processing and visualization of Geospatial data	Urban analysis	CLI	CRS object, EPSG codes, Proj4, .WKT	Python
SF (Simple features)	Encoding spatial vector data, binding to GDAL, GEOS and PROJ	Urban analysis	CLI	.shp, .GeoJSON, .gpkg, .gdb, .KML,	R

				.GML, .WKT	
SP	Spatial data manipulation, visualizing etc	Urban analysis	CLI	shp, .GeoJSON, .gpkg, .gdb, .KML, .GML, .WKT	R
Raster	Reading, writing, manipulating, analysing and modelling of spatial data	Urban analysis	CLI	GeoTIFF, ASCII Grid, NetCDF, ENVI .hdr, ESRI Grid	R
spatstat	Support for 2D and 3D point patterns.	Spatial points analysis	CLI	SpatialPoints objects, .csv, .shp, .ACSII	R

4.2.3. Plugins for GIS platforms

Software	**Embedded tools**	**Applicability**	**Interface**	**Format/ Distribution**	**Language**	**Advantages/ Limitations**
Place syntax tool	Network analysis	Urban Planning Urban Design	GUI	.tab and .shp	Python	Quick analysis algorithms - Dependent on QGIS
SSL Toolkit	Network editing Network analysis (Catchment analysis) Visualization	Urban Planning Urban Design	GUI	.shp, .dfx	Python	
Geographical detector						

4.2.4. Spatial data dashboards

Spatial data dashboards are useful tools for mediation between experts, stakeholders and designers when it comes to providing an overview into projects. The general application of the spatial data dashboards is visualizing the spatial as well as non-spatial data and see a real time image with changes applied to existing and proposed schemes. Although these are not directly used to design, they can incorporate a larger audience's input when it comes to option explorations. Some of these dashboards are:

- Tableau
- power BI
- ArcGIS dashboard
- QGIS Dashboard
- CARTO
- D3.js
- Kepler.gl

5. EBDP future research opportunities

Identify and reflect on pertinent issues for future research studies; these will be uncovered during the research process, with themes potentially including topics such as:

5.1.1. Decision support tools
5.1.2. Interfaces
5.1.3. AI