TWIN2EXPAND

Review of the State of the Art of EBDP

Deliverable 3.2

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

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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. 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.

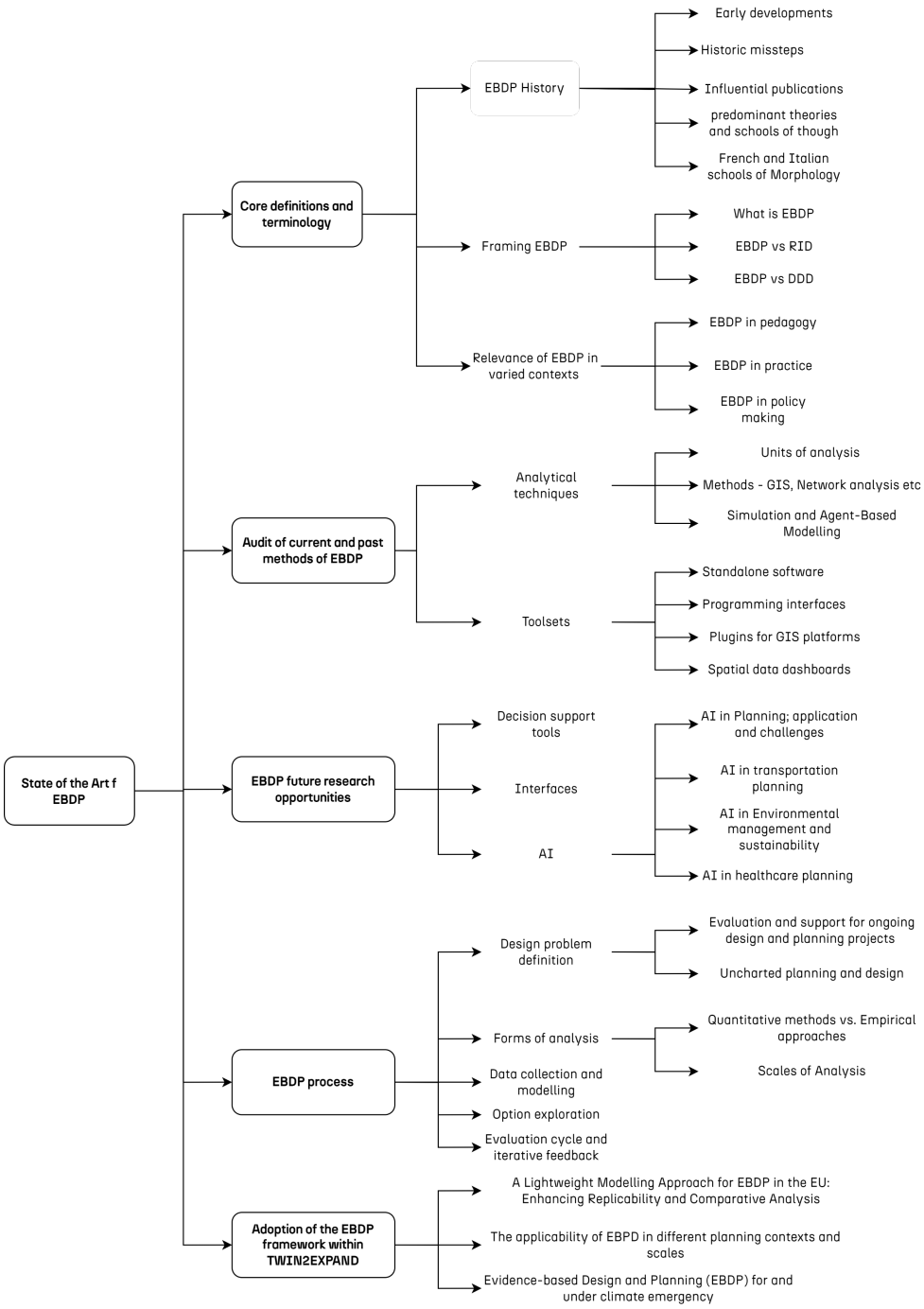


Figure 1-1 Report structure

2. Core definitions and terminology

2.1. EBDP History

Tracing the historical development of Evidence-Based Design and Planning (EBDP) offers critical insight into how and why it has emerged as a distinct field. By examining its chronological evolution, we can better understand the gradual integration of analytical thinking and cross-disciplinary methods into urban planning and design practice. This historical perspective highlights the shifting priorities, methodological advances, and contextual challenges that have shaped the field. It also establishes a foundation for evaluating current approaches and identifying the strategic steps needed to advance EBDP as both a research agenda and a practical planning framework.

2.1.1. Early development

The foundations of Evidence-Based Design and Planning (EBDP) can be traced to the late 19th and early 20th centuries, beginning with the pioneering work of Patrick Geddes. A biologist turned urban planner, Geddes introduced a context-driven approach to planning grounded in direct observation, mapping, and social surveys. His work emphasised the importance of understanding place through empirical study, arguing that careful, multidisciplinary surveying of the urban environment was essential to effective planning. This was epitomised in his collaboration with historian Raymond Unwin on the Survey of London, which meticulously documented the socio-economic conditions of the East End. Their efforts popularised the planning maxim “Survey before Plan,” a key philosophical precursor to EBDP.

Parallel to Geddes, the Chicago School of Urban Sociology, emerging in the early 20th century, advanced the empirical study of cities through systematic social research. Scholars such as Robert Park and Ernest Burgess applied statistical analysis and spatial mapping to examine patterns of urban form and social behaviour. Their work demonstrated how the built environment influenced community interactions and segregation patterns, offering early evidence of how urban form could shape human experience. The post-war period saw a shift toward modernist approaches in urban planning, characterised by an emphasis on rationality, standardisation, and functional zoning. Although these models employed forms of analytical reasoning, they often lacked the contextual sensitivity championed by earlier theorists like Geddes. Nonetheless, modernism institutionalised the idea that design could and should be guided by formal analysis, albeit within a top-down framework.

Responding to the limitations of modernism, new paradigms emerged in the mid-to-late 20th century. In Italy, Gianfranco Caniggia, building on the insights of Kevin Lynch, explored the geometric and morphological logic of cities. His research focused on how the structure of streets and the spatial arrangement of buildings influenced urban legibility and social behaviour, laying the groundwork for typological and form-based approaches to spatial analysis. Simultaneously, in Denmark, Jan Gehl and the Copenhagen School re-centred planning on the human scale, advocating for pedestrian-friendly environments. Gehl’s empirical observations informed a set of design principles promoting walkability, active public spaces, and a human-centric city. While some empirical studies yielded mixed results—particularly regarding the role of building height or facade design—his work contributed significantly to the methodological development of EBDP by grounding urban design decisions in behavioural data.

From the 1980s onward, movements such as New Urbanism sought to revive compact, walkable, and socially mixed neighbourhoods. These initiatives were supported by research into transit-oriented development, land use diversity, and social cohesion. However, critics noted a tendency to overstate the causal power of design in fostering community life, leading to a more nuanced appreciation of the interplay between physical form and

social context. Complementing this, the Healthy Cities Movement, launched by the WHO in 1984, introduced public health as a central concern in planning. This initiative highlighted the role of urban design in promoting physical and mental wellbeing, with a focus on active transportation, green space access, child-friendly infrastructure, and reducing health inequalities. These goals aligned closely with the EBDP ethos, reinforcing the need for interdisciplinary evidence in spatial decision-making.

One of the most significant methodological innovations came from the Space Syntax school, led by Bill Hillier. This approach developed sophisticated models for analysing urban space through configurational network analysis. Techniques such as axial mapping, pedestrian counts, and observational studies allowed planners to quantify spatial accessibility and movement potential, linking urban form to functional and experiential outcomes. The late 20th and early 21st centuries also saw the emergence of benchmark systems such as LEED Neighbourhood Design, which introduced measurable standards for sustainability and urban performance. These frameworks signalled a growing institutionalisation of evidence-based metrics within planning practice.

Finally, the widespread adoption of Geographic Information Systems (GIS) and other computational tools has dramatically expanded the analytical capabilities of urban researchers and practitioners. From spatial modelling and land-use simulation to demographic analysis and ecological sensing, these technologies have provided the technical infrastructure necessary for EBDP to operate at greater precision and scale. Together, these diverse intellectual and technological developments laid the groundwork for a more integrated, evidence-informed planning paradigm—one that combines historical insight, behavioural data, spatial analytics, and stakeholder engagement to better respond to the complexities of contemporary urban environments.

2.1.2. Historic missteps

Focusing primarily on the era of optimistic modern thought, which tended to overlook traditional planning and design principles, this section delves into the evolving conception of evidence within the context of advancing applied methodologies. The subsequent discussion offers a nuanced exploration, serving to underscore the significance of Evidence-Based Design and Planning (EBDP), particularly within the iterative framework and analytical techniques. While the trajectory of modern design and planning approaches is well-documented, along with the rationale underpinning decisions within that paradigm, this segment explains the shortcomings of the modernist approach. Furthermore, it explains the contrasts between the modernist perspective and the EBDP paradigm being examined herein.

From this point of view, the ideological, technological, and social underpinnings of modernist design and planning serve as evidential inputs that inform the process (Irwin, 2019). From societies grappling with the imperative of alleviating poverty during the 19th and 20th centuries and enhancing urban living standards, modernist design and planning emerged as a distinct approach to crafting ideal cities (Ravetz, 2013, p. 7). The growing urbanization propelled by industrialization, the shifting dynamics of labour markets, and the concentration of opportunities and amenities within cities necessitated a fresh perspective on urban population dynamics and distribution. The sweeping tide of urbanization during the late 19th and 20th centuries prompted a re-evaluation of conventional planning and design paradigms.

However, the radical changes implemented through modernism have been subject to criticism due to their perceived failures. This critique, rooted in an evidence-based perspective, questions the effectiveness of modernist approaches. Scholars such as Jane Jacobs, William H. Whyte, and Christopher Alexander initiated this critique by highlighting the deficiencies of modern planning theories, particularly their disregard for the human element in urban development. They argued that the cities constructed during this era prioritized the facilitation of car movement and the segregation of functions within densely packed building blocks (Whyte, 1980; Jacobs, 2011; Alexander, 2012). While these theories centred on the ideals of improved intra-city vehicular mobility and

the technological advantages of vertical density, Jacobs, Whyte, Alexander, and their contemporaries drew from empirical evidence to critique these endeavours, contending that they often lacked a humane dimension. In hindsight, it can be argued that the criticism voiced by these scholars does not reject the incorporation of analytical thinking into design and planning. Instead, it shows a rising concern in terms of using evidence-based thinking into urban planning and design, where singular evidence does not directly inform a decision, and the multiplicity of urban conditions are met with layers of information and a synthesis between these.

From this perspective, modern planning and design approaches presented a contrasting argument to traditional, subjective methods that resisted objective evaluation. However, what underscores the limitations of modern approaches is the absence of a human-centric focus, a hallmark of traditional methods in space creation. This paradox thus emerges, where both subjective, human-centred approaches and objective, quantifiable, and replicable methods developed during the modern era exhibit significant inadequacies in accommodating the requirements of evolving lifestyles. Subsequently, this section elaborates on the key deficiencies of these modern approaches within the context of Evidence-Based Design and Planning (EBDP). It will underscore that the inclusion of a human-centric perspective alongside quantifiable planning and design methods could have mitigated these deficiencies.

Disregard for Context

Within the framework of modern planning, a shift toward objectivity emerged, evaluating buildings and cities based on their isolated functions as the primary criterion for design assessment. Consequently, any plan or design was considered successful if it met its functional requirements during implementation. What often went overlooked, however, was the degree to which the designed object or urban plan related to its surrounding context. Højriis et al. (2014) have suggested that this relationship between urban design and planning and its context can be categorized into two dimensions: social contextualism and physical contextualism (Højriis *et al.*, 2014). Moreover Carmona (2014) argues that any intervention in spatial order – i.e., design or planning project – is an intervention in a continuum with historic, political, social and physical context. These make up the set of influences which shape the context of an urban context. He suggests that what organicists such as Christopher Alexander, introduce as the notion of pattern in this discourse would exemplify the importance placing the urban design or planning subject in the right context as what essentially happens in an urban project is linking up the patterns that many disciplines (designers, planners, engineers, stakeholders, citizens, etc.) are concerned with.

From the EBDP point of view, the modernist planning and design approaches put too much emphasis on functionality of their design as an entity whether it being a building or a whole city. While their use of evidence in optimizing the internal functionality of their design was assessed internally, the relevance of the design was never meant to be tested against the intertwining patterns of the context. Thus, with regards to this research significant evidence to address the modernist failure to envision design and planning in context would be to undertake

Separation of Functions

Supported by the political and social dynamics of early and mid-20th century – mostly in European and north American cities – there emerged a movement promoted and supported by the modernist architects and planners that prescribed for a city with high contrast in spatial mixture of functions. As Sevilla-Buitrago (2022) explains this from a political point of view this movement meant to *sanitize* the working and middle class from the decaying conditions of the traditional urban life. Thus a binary form of urban renovation based on segregation of core service areas and residential outskirts was promoted (Sevilla-Buitrago, 2022, p. 111). At the time the decaying urban life was branded as *slum living* and was associated with inferior quality, while the new campaigns suggested that the separation of the living areas from the core active city would alleviate the conditions(Macionis and Parrillo, 2001, p. 61).

From this point of view, one can argue that the modernist cities focused much on a conceptual arrangement that is facilitating a very specific narrative of urban life. Living in the outskirts and designating the centre to work and leisure works on a very specific basis, whereas the social, political and economic complexities of cities may not necessarily abide by this scenario and as a result the city either becomes non-functional and abandoned[1] or with the rising demand in city life, informal sector grows. This suggests that the criticism about the separation of functions is not about the realization of the functions, but about the lack of understanding about the network characteristics of the city. The relativeness and scalability of a city phenomenon is absent in the modernist movement, which suggests that urban life/activity is only meaningful in relation to other lives and activities. Thus, any design and planning would have to find its functionality in its relative centre. The separation of function in the modernist movement missed the chance to provide means of relative centrality for each function and in another words, did not incorporate how relative centrality of the functions are essential to their vitality. This applies to residential and commercial functions as well as other urban functionalities.

From the EBDP point of view, functional planning of cities depends on connectedness and relative centrality as much as it does on proportional provision of functions. As evidence the relative centrality of functions can be assessed against the proportion, and accessibility of the functions. Therefore, land use planning not only is evaluated based on the relative provision of certain use, but also how close and accessible (both on topological and metric terms) are.

Lack of Human Scale

A significant feature of modernist architecture and cities was the emphasis on built density. In the modernist cities, the movement in between destinations replaced the live experience of the space and cities were replaced by tall buildings. Similar to disregard for context, in this very feature of the modernist city, fast movement, and high point density was praised and assessed as a measure for the success of any design and plan. As Gehl (2010) explains the modernist architecture failed to incorporate the human element and did not design with human scale which according to him means "*providing good city spaces for pedestrians that take into account the possibilities and limitations dictated by the human body*" (Gehl, 2010, p. 33). While there has been different measures in the literature for human-centred urban design and planning (Blumenfeld, 1953; Lennard, Lennard and Bert, 1987; Trancik, 1991; Alexander, 2018; HEDMAN, 2019), it can be argued that soon after the realization of modern cities, the lack of human scale resulted in the loss of many aspects of city life most of which were associated with continuous and generative social interaction. In other words, the loss of human scale in the modernist era, reduced the probability of social interaction in the public space – either because the vertical development does not support that, or streets were occupied by cars, etc. – and as a result criticism of modernity in this regard began very soon.

While research in this respect has been taking place ever since, human scale becomes a central measure through the EBDP. The metrics to assess the human presence becomes central and ways of measuring it is essential to the evaluation cycle.

[1] Examples of this urban decline are well documented across the body of research in various disciplines. The same trends are noted in almost all developing and developed countries. Notable examples are Detroit (Nam, 2014, p. 19; Herbert, 2021), Chandigarh (FITTING, 2002) and Milton Keynes (Edwards, 2001).

Disruption of Urban Fabric

Implementation of modernist planning and architecture followed a series of radical urban interventions that aimed to modify cities in a better way. From street widening in Paris (Jordan, 2004; Choi, 2023) by Haussmann, to self-help urban renewal ideas proposed by Patrick Geddes in Edinburgh, and crookery clearance in London (Freestone, 2000, p. 22), all contributed to rationalization of direct intervention as a way of improving the quality of city life in the modernist movement. Throughout this time, the focus of these interventions was to improve the conditions of over crowdedness, density and hygiene (Koksal, 2023), through cutting the dense condition and creating a network with improved city-wide possible movement, reducing the possibility of congestion. The rationale behind this approach depended on evidence, and aimed to alleviate the mentioned conditions through intervention, that also provided some evidence. However, these interventions proved to have adverse impact on the city life.

The modernist interventions objectively (Trummer, 2013) approached the city, where the physical modification would follow cohesive improvement throughout. However, these interventions cutting through the urban fabric proved to be disrupting the urban life (Paccoud, 2016; Sendra and Sendra, 2020, p. 66) as it created disconnections in the network, and spatial configuration (Hillier and Hanson, 1984, p. 85) while adding certain new plans and connections. From this point of view the justification of these interventions in the city fabric were an isolated set of ideas and evidence, and with the technology at the time, could not be evaluated either.

With regards to the EBDP, city's physicality is not objectively separate from its social, economic or political structure, and an intervention in the spatial configuration of the city would have an impact across scales and throughout all these structures. Through evidential thinking, the impact of an intervention in the network becomes significant evidence through which the inter-relations between different processes and in different scales can be assessed.

Social Exclusion

Exclusion, being imposed or generated is a mechanism that controls access. From a general point of view exclusion can manifest in terms of controlled access to place, activities, resources or information (Madanipour *et al.*, 2000). As Madanipour et al. explain (2000) concentration of one or more of these limitations lead to some form of exclusion, and in turn this will be manifested in spatial segregation and polarization of cities where certain groups clusters based on the level of access to any of the mentioned amenities are limited.

This has been a theme of criticism in modernist architecture and planning approaches since its early days. Seen in forms of decline in ambitious social housing scheme in the second half of 20th century (Vaughan, 2007), spatial continuum has been impacted by the modernist architecture and planning. Dependency on vehicular movement, vertical development as opposed to horizontal development of cities, as core elements of the rationalist movements of the modernist architecture and planning, reduced the flow of social interaction.

The spatial regulations imposed during the modernist era essentially changes the balance between the frequent lines of controlled inclusion and exclusion and accordingly change the social dynamics that sustain these frequent mechanisms. These have been reported often as being influential in increasing social exclusion which essentially means less access to opportunities, services and in the large scheme of things, social interaction.

Lack of Sustainability

The issue of sustainability in the built environment has been a major point of discussion ever since the design and planning has been approached in a systematic and deterministic way. From this point of view understanding of sustainable development has been evolving as a way to push the theoretical and technical

understanding of development further. This also suggests that the issue of development and specifically urban development – as the prominent and rising way of living in the recent decades – has evolved as well. Sustainability remains a questioning mechanism rather than a guiding criterion that helps with design and planning of urban environments. Thus this really depends on how one views the city as it has been a question since Lewis Mumford questions the quiddity of the city (Mumford, 1937).

From the earlier dualistic view on physical versus social city, there has been different view on a city which in turn questions what is the priority that should be sustained through design and planning. As Bettencourt (2013) summarized this process grand theories in modernist planning inspired by inter-disciplinary metaphors (Varzi, 2021) or logical and artistic reductionism (Steadman, 2008; Hermansen Cordua, 2010, p. 152) would all result in a certain agenda, which also shows what should be sustained. From a logical modern city with frequent vehicular movement, to garden city (Howard, 2020) and grand modernist designs (Corbusier, 2013) connotations around sustainability has evolved. However, the current challenges of the development, including climate change, inclusivity, man-made disasters and grand mobilization of population in between rural and urban areas negate the agenda set by this idea.

With the deterministic and rigid design and planning approach during the modernist era, there was no room for speculation for the vulnerabilities to change that may limit or change the scope of the design. In this respect Roggema (2016) sums up the general approaches towards sustainability queries in three distinct areas, rather than item specific concerns of sustainability. He outlines the general concerns with respect to sustainability rises from three areas of uncertainty including *uncertain development, enforced uncertainties, and exposure to uncertainties.* From this point of view the modernist architecture and planning, did not have much interest in this way of thinking, and advocated impeccable designs. However, post occupancy analysis of such projects speculated through the works of Jacobs, Whyte and Alexander among others showed that in turn they are vulnerable.

With regards to EBDP, the sustainability concerns stem from the same historic mistakes that were presented here. Generally, the evidence-based approach advocates its advantage in providing a realistic picture of development and maintenance process of an urban project, which reflects on the issues of sustainability. Roggema outlines a sustainable process in urban planning and design projects with three main components including fixing the future, indulging the future and creating anti-fragile urban environments (Roggema, 2016). Within the EBDP framework, the present and future conditions of the project are evaluated according to its scope.

With multiple strands of evidence fed into the evaluation feedback loop, EBDP process tries to engage with the present facts and future scenarios to ensure sustainable development and integration of the project in the wider context. Having reviewed some of the major shortcomings in adopting an evidence-based approach, specifically through the modernist time, framing EBDP onwards will incorporate these, to enhance the process. This review showed that with the advancement of technology, necessity for urban settlements, and a dominant ideological thinking about pragmatic urban development, limited the scope of the projects of this era for articulation and future considerations.

Thus, a significant takeaway from reviewing the modernist missteps is the way urban problems are framed for planning and design. This also reasserts that the complexity of urban development dynamics cannot be dealt with only a linear evaluation cycle. What made these past experiences vulnerable and fragile in every aspect discussed here, is that the evaluation cycle configured the project as a closed system. Thus, any change outside of this closed boundary system was not taken into account when engaging with a spatial design project. Further, this study is complemented by landmark research studies of evidence-based planning and design that address the challenges and limitations of the approach as it was first introduced in the UK and Europe.

2.1.3. Influential publications

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 ideological 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
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.
1999	ESDP - European Spatial Development Perspective	The European Spatial Development perspective is a strategic framework that aims to bring cohesion and cooperation between European countries for spatial planning policies. This is based on a scientific approach in analysing and sharing knowledge, experience and evidence in planning.
2002	ESPON – European spatial planning observation network	The European Spatial Planning Observation Network (ESPON) is a network of European countries that aims to support policy development and territorial cohesion by providing evidence and analysis on spatial planning and territorial development. It was established in 2002 and is funded by the European Union's cohesion policy.
2002	Technocracy Reinvented: The New Evidence Based Policy Movement	In this paper Clarence argues that while evidence is important, it is only one factor among many in the complex and messy nature of policy making. She also acknowledges that evidence can play a limited role in policy making and that political concerns and public opinion must also be factored in.
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	Is There a Role for Evidence-Based Practice in Urban Planning and Policy?	In this paper Krizek et al. argue that although the use of scientific based approach to planning and integrating it with analytical methods is beneficial, raises a series of concern about the validity, availability, strength and clarity of evidence. They conclude that evidence-based practice needs careful implementation.
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.
2012	The Legacy of Positivism and the Emergence of Interpretive Tradition in Spatial Planning	In this paper S. Davoudi reviews the legacy of positivism interpretive traditions in spatial planning, and in this comparison looks into the use of evidence in planning as one of the aspects of comparison. Here she describes the difference between the two traditions in using evidence in planning

Table 2-1 Influential research and policy publications on the importance of evidence in planning and policy making

The cited studies within the European context underscore the growing significance of evidence-based design and planning, emerging in response to the diminishing credibility of unsupported theories in shaping the built environment. Although these studies were conducted according to specific criteria, collectively they contribute to a broader body of knowledge that has informed both research and practice. This evolving body of work has facilitated the development and application of analytical methods, leading to the formulation of evidence-based spatial theories, primarily grounded in European and North American experiences.

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 soft evidence

The theories, grounded in recent advancements in cross-disciplinary methods and enhanced by increased data availability and computational capacity, reflect an evolution in spatial analysis. However, earlier theoretical developments with similar intentions—albeit subject to criticism—were often founded on less empirical, "soft" evidence. These earlier theories, while promising, were primarily based on qualitative observations and rudimentary counts that lacked the replicability of contemporary methods. Despite this, their rigorous methodological frameworks and thorough theoretical discussions have ensured their continued relevance. They maintain a notable position within spatial theories and retain considerable applicability in evidence-based design and urban planning, even in the context of more data-driven approaches.

- Kevin Lynch's Image of the city

Kevin Lynch's work represents one of the early efforts to challenge the reductionist view of cities as merely materialistic entities, a perspective that was especially prevalent during the modernist era (Lynch, 1964). His research examines how the built environment is cognitively understood by its observers, proposing that a city's spatial organization forms a cognitive connection with its users. This connection is crucial for defining and distinguishing urban spaces. Lynch identifies three fundamental elements—identity, structure, and meaning—that collectively underpin the formation of recognizable and functional urban systems, which we commonly refer to as cities.

The core of Lynch's analysis focuses on the perception of urban systems, a concept with significant implications for urban design and planning. From an analytical standpoint, his research emphasizes the necessity of organizing material elements within a city into a coherent configuration—a purposeful and functional arrangement that informs and guides its inhabitants. He identifies five essential physical elements that contribute to the structural and perceptual composition of cities: paths, edges, districts, nodes, and landmarks. These elements not only shape the physical layout of the city but also create a hierarchical structure that is vital for a well-functioning urban environment.

Lynch posits that a well-functioning and usable space is one that is effectively perceived by its users, a process he describes as "the image of the city." This image, formed through the arrangement and organization of urban elements, is crucial for making the city both navigable and comprehensible. Additionally, Lynch's work suggests that the organization of these elements produces underlying spatial conditions, some of which may not be immediately apparent. While a city can be understood in terms of these components, it also exhibits emergent properties that cannot be entirely reduced to them. Although Lynch did not initially frame his ideas within the context of complex systems theory, his method of *analysing* urban perception provides a foundational framework for understanding cities as dynamic and emergent systems.

In relation to contemporary discussions on evidence-based urban frameworks, Lynch's emphasis on the organization of material elements and the design of perceptible spaces highlights the importance of composing an urban system that integrates the five elements he outlines. However, it is essential to recognize the limitations of this approach, particularly when applied to large-scale urban design and planning. As noted by Meilinger

(2008), human spatial cognition and the perception of space have inherent limits. Therefore, when addressing large-scale planning, the cognitive approach may not fully inform the decision-making process. Despite these limitations, it can be argued that spatial cognition—and by extension, the spatial arrangement of significant urban elements—offers crucial evidence that can inform the design of urban schemes. The broader implication of Lynch's work lies in its potential to transform qualitative, narrative-based configurations into quantifiable design criteria, thereby providing a framework that can be iteratively refined and improved.

- Whyte's Social life of small urban spaces

With a group of colleagues, Whyte presents a detailed examination of the performance of public spaces, specifically within the American context, through a rigorous methodological approach cantered on observation and data collection (Whyte, 1980). The core objective of the study is to understand the differences between various urban spaces and the underlying factors that contribute to these differences. The author commences by describing the everyday dynamics within these spaces, focusing on how they influence and are influenced by social behaviour.

The methodology adopted in the book is particularly noteworthy. It primarily involves observing the presence, movement, and interactions of individuals within different types of urban spaces. Rather than starting with preconceived notions of how certain spaces should function, the study categorizes spaces based on the behaviours they elicit. This approach allows the authors to make informed conjectures about the reasons behind observed activities by drawing comparisons across different settings. The observations are largely grounded in the premises established by earlier scholars, effectively testing these premises to reach coherent conclusions.

The work outlines several key observations concerning plazas and locally significant open spaces. First, it is noted that there is a reciprocal relationship between the quality of a space and the social life it supports—better spaces tend to enhance social dynamics, and vibrant social interactions, in turn, contribute to the quality of the space. Furthermore, the most successful plazas exhibit a higher female presence, suggesting that inclusivity might be a marker of quality. Additionally, the study observes that crowd dynamics tend to be self-reinforcing, with populated areas attracting even more people. Interestingly, the central areas of plazas are underutilized, with different spatial attributes fostering different activities.

The book also delves into the attributes of sitting spaces, offering several insights. Contrary to common assumptions, sunlight and aesthetic appeal do not necessarily influence where people choose to sit. Similarly, the proportions or shapes of spaces do not correlate directly with their popularity. However, there is a positive correlation between the size of plazas and the number of people they attract, though this relationship is not straightforward. Another important finding is that people prefer to sit where seating is available, with deeper ledges accommodating more people comfortably.

The book highlights the importance of considering environmental factors in architectural design, particularly the impact of sun exposure and wind. Poorly designed open spaces can become less desirable due to these elements. The authors suggest that design guidelines should address these issues by creating spaces that balance indoor and outdoor characteristics. Additionally, the book emphasizes the value of both large and small urban spaces, noting that thoughtfully designed smaller spaces can be just as effective as larger ones. Enhancing these spaces with amenities encourages people to engage with the city rather than seek to escape it.

An essential takeaway from the work is the argument that human interaction within spaces reveals how spatial properties are perceived and regenerated. The study challenges the notion that careful design alone determines the success of a space. Instead, it highlights the complex interplay between human perception and

the objective characteristics of space, particularly within smaller settings. This approach provides valuable insights into the dynamics of small urban spaces, which might be obscured in larger contexts.

- Rowe and Koetter's Collage city

Coline Rowe and Fred Koetter began to elaborate on the nature of the built environment, and specifically the quiddity of cities, considering the developments that shaped the modernist cities in the 19th and 20th centuries. They questioned some ambiguities that were raised through observation made on the modernist cities, and they were asking whether planning a city is possible or not. In their core argument in *collage city* (1984) they questioned the extent to which the city, or the composition of its elements should be thought of as logical and science based process. From their point of view the process of shaping the city at the larger scale – meaning to plan it through policy and overarching decision making – would have to be scientific and evidence-based. However, they also consider the individual citizens as agents that shape the physical environment, and from this point of view they question the feasibility of a holistic approach to urban planning with regards to science-based approaches.

However, considering the context through which they set their argument – the aftermath of modernist planning implementation – they seem to be criticizing isolated and unidimensional scientific calculations that view city as a product that can be easily reduced to its elements, thus if objectively calculated, it would function as a whole. What this criticism is concerned with is the missing procedural evidence in planning the city, where the occupancy and citizen life is detached from the physical factors. In other words, the evidence that incorporates human factor in planning cities, should be scientifically driving the planning process as well.

- Christopher Alexander's A Pattern Language

In his series of work, published under *The Pattern Language* (Alexander, 2018), Christopher Alexander et al., discussed the properties of the built environment in relation to their relationship with human life. Based on observing a huge number of samples, they argued that problems that occur repeatedly in our built environment, that are met with optimized solutions, generate patterns that are most likely to be suitable for repetition and have a timeless quality. He argues that as these observations are based on countless iterations of interaction between the social and physical elements of the built environment, they are irrelevant of urban or architectural styles and thus are reflecting basic human and social needs, which are valid without regard for micro cultural specificities.

He argues that patterns are organized hierarchically that range from the largest of scales (applicable to regions and metropolitan areas) to the smallest (applicable to buildings and rooms. Specifically, from a planning point of view, this approach argues that in shaping regions, cities, neighbourhoods etc., there is a hierarchy of influence that shapes the dynamics of development. From this point of view, together these patterns of influence, generate the balanced condition necessary to maintain or change the built environment. While he explains that in this hierarchical structure, each level of influence does not have direct impact on the higher or lower level of order however the direct influence of these inter-order dynamics generate the drive for development and change.

He elaborated on four arguments that inform this proposition:

1- The nature and limits of human government: In this argument he discusses that a well-functioning human settlement has limits as there are natural limits to the size of groups that can govern themselves in a human way
2- Equity among regions: Unless a region has at least several million people in it, it will not be large enough to have a representative in the governing circle.

3- Regional planning consideration: Unless a region has the power to be self-governing, they will not be able to solve their own environmental problems
4- Support for the intensity and diversity of human cultures: independent regions are the natural receptacles for language, culture, customs, economy, and laws and that each region should be separate and independent enough to maintain the strength and vigour of its culture.

With these four arguments, he proposes a series of guidelines which informs design, planning and maintenance of spatial structures that are self-sustaining and thriving. From this point of view, the evidence that is required to inform the planning and design – or reconfiguration and redesign – of spatial systems which basically try to reimpose the balance observed and classified as patterns. These include guidelines and suggestions for statistical and spatial distribution, as well as ways to configure the relationship between human settlement, social dynamics, natural resources, and political structures. From a planning and design perspective, the importance of these guidelines is that they bring about a reproducible system that can assess – and predict – the qualities expected in long term. Thus, encapsulating these in the umbrella term of *Language* he advocates learning from established norms and knowing the limits of human individuals and societies.

- Jan Gelh's Life between buildings

The development of the idea begins by asserting that human social activity is crucial to the success of any built environment. It classifies non-private space activities into three types: necessary, optional, and social. Necessary activities stem from life's essential needs, like work or school, and occur regardless of the surrounding physical framework. (Gehl, 1987) Optional activities, which are more recreational, depend heavily on the quality and design of the environment but are not essential for daily life. Jan Gehl's primary focus is on the third category—a mix of the first two—where everyday processes naturally bring people together, fostering social interactions and enriching communal life.

The central idea, termed "life between buildings," focuses on how physical spaces facilitate activities in accessible areas, enabling interactions among a wide range of people, not limited to close friendships. The book critiques the historical shifts in urban planning, particularly those changes introduced after the Renaissance. The author argues that early planning regulations, which aimed to improve the quality of life, prioritized visual appeal and functional modifications over psychological and social needs. This shift led to a departure from organic urban development, eventually resulting in social decline—a problem that became apparent only with the rise of modernist planning and design.

The author highlights several physical changes brought about by this approach, which hindered social interaction. The spread of functionalist design and an overemphasis on aesthetics reduced the opportunities for spontaneous social encounters. In contemporary cityscapes, significant distances between people, events, and functions, along with transportation systems designed around automobiles, have diminished outdoor activities. Moreover, the impersonal design of individual building projects has further exacerbated the decline in outdoor interactions. As demographic shifts, changes in family structures, and evolving work dynamics have altered the need for outdoor spaces, the established patterns of functionalist planning have fallen short in providing meaningful social conditions. The author emphasizes the necessity of spaces where people can move about with ease, linger in cities and residential areas, enjoy the environment, and meet with others—either informally or in more structured ways. These elements are fundamental to creating vibrant cities and successful building projects, both in the past and today.

The book advocates for flexible planning, where outdoor spaces—or in-between spaces—are organized in a hierarchy that accommodates different groups, programs, and conditions while remaining adaptable for various

uses. The layout of physical spaces should promote movement and interaction, with a seamless transition from private to public areas. Finally, the author discusses how the relationship between intensity, distance, and closeness should define the hierarchy of spaces suitable for different forms of human contact, whether intimate, personal, or social. The vitality of "life between buildings" depends on the frequency and duration of these interactions, as the presence and activities of people within a space are shaped by how often and how long these interactions occur.

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 rely more on soft evidence (qualitative, observational, experiential), while others use hard evidence (quantitative, analytical, empirical). Some of these theories are:

- Hillier and Hanson's Space Syntax

Similarly in response to the development of scientifically driven methods of planning, space syntax emerges in the 1970s as a way of understating the built environment as a relational entity, where the social and physical structures are not separable. From Hillier and Hanson's point of view (1984) as human communities occupy space, they are essentially spatial phenomena. Therefore, through evidence they show that there is a unified explanation for spatial and social processes, where the aggregate movement and activity of societies shape and are shaped by the physical structure. From this end, what they began explaining in their development of space syntax is how through analysing the spatial structure – meaning the organization of the spatial relations – one can understand or predict the spatial phenomena.

Space syntax proposes that built environment – including all cities, planned or unplanned – maintain a degree of structural stability which derives from the balance between their integral parts (houses, streets etc) that shapes relationships that make up the global collective system. While each of the elements in this definition only follow some local rules – or relations to their spatially immediate adjacent elements – they contribute to the stability of the system which generates a global rule as well. In other words, it is the rule of rules that enables the whole system, to identify and function at the scale that it does. The integral elements of the system are therefore making up a network, which is the material of study in space syntax.

Bridging from network theories, social studies and environmental studies, space syntax holds to main propositions. Firstly, that the space is intrinsic to human activity and not a background to it (Karimi, 2012), which implies that the human behaviour is reflected through spatial organization. And secondly, the space is fundamentally a configurational entity (Hillier and Penn, 1991). These highly researched premises enable a provision of a representation – or quantification – of space that provides a tangible medium which correlates highly with aggregate movement and activity. The significance of space syntax approach and what made it a breakthrough method in spatial analysis, is the simplicity of the modelling and representation, and its ability to translate into different disciplines, and unlike most traditional architectural discourses uses a scientific language that reaches out to a wider range of researchers and practitioners.

In development and in practice, space syntax is an umbrella term for a series of theories including *Theory of order and structure* (Hanson, 1990), *Theory of Natural movement* (HILLIER *et al.*, 1993), *Theory of Movement Economy* (Hillier, 1996), *Centrality as a Process* (Hillier, 1999) *Movement generated land use agglomeration* (Penn and Turner, 2004), among others. The development these theories happened in the context of technological development, where the computational capacity for the network analysis was growing, and thus more attributes of urban life could be integrated with the spatial organization and analysis. These developments have shown with

strong confidence that the spatial organization in the built environment have a close relationship with the social affairs and thus showing that there is a reciprocal explanation between the social and physical structure.

- Berghauser and Haupt's Spacematrix

Revisiting the notion of density, Bergahuser and Haupt argue that throughout the 20th and 21st centuries, density has changed from a mere resultant of complex process of urban development to a tool that is being consciously used in defining urban qualities that were otherwise not calculable. This transformation, they argue, draws from the shift in the way city planning regulation and centralized control, changed the way cities develop and through that change, density becomes a critical tool in controlling certain aspects of urban planning. As they show in a historical review of city development in European context, density in urban planning gained traction as with the modernist movements, density was used to both express the problems, as well as possible opportunities of compact settlements.

However, their research and publication on density shows that understanding density and relating it to urban form and life quality is not straight forward and although the initial concept of density is universally understandable, the way density translates to other certain indicators that are more prominent in today's planning discourse. Their discussion on the ways in which different variations and calculations of density is related to planning methods. The argument in their discussion happen in the context of intense urban development, and dramatic increase in space consumption, that calls for further research on the relationship between the capacity and quality of space. Therefore, examining different definitions of density, they show that there is valuable information within density about urban form and performance of the built environment.

A problem raised in their work which becomes central to the idea of density, is the definition of denominator – the total area of the land, as this definition gives rise to different understandings of density. Here they explain that there is a difference between perceived density and physical density, and thus explain different variations of physical density measurements which include: Population and dwelling density (number of people or households in an area), Land use intensity (This quotient uses the ratio of the land area -in the numerator- to the floor area -in the denominator-, and is inversely equivalent to the Ausnutzungsziffer, FSI or FAR.), Coverage (express the relationship between built and non-built land), Building height (expressed as the relation between street width (or court size) and building height), Spaciousness (the relationship between open space and total floor area, as a measurement of the quality of an urban plan).

However, they illustrate that there is little direct information with regards to the urban form and performance that can be extracted from these measurements of density and propose that a multivariate combination of these measurements can better inform the analysis and understanding of the built space. To simultaneously assess the properties of urban space – explained by density measurements – FSI (Floor space index – Intensity), GSI (Ground space index – compactness, and N (network density), they propose a 3-dimentional representation of space, which helps to extract patterns and attributes of space, and describe properties that were otherwise not perceivable from simple density measurements.

With respect to urban planning and design, SpaceMatrix draws from basic definitions of widely used density, while focusing its attention on the sort of information that can be extracted from density and uses this solid evidence to shape a theory-based method of analysis that extrapolates socio-economic, as well as performance information about the built environment that was otherwise not directly accessible from density information.

Evidence as explained through design and planning theories

As discussed in relation to the necessity of evidence-based design and planning, the built environment has long been the subject of systematic observation, prompting critical reflections that have shaped theoretical narratives. These observations vary in nature: some focus on the physical and measurable attributes of space—elements that can be systematically reproduced and analysed—while others address non-physical aspects, such as social dynamics and behavioural patterns, that are inherently qualitative but equally pertinent to spatial understanding. This dual approach has contributed to the development of a diverse range of theories grounded in observation, analysis, and methodical application. Notably, theories based on hard evidence often yield replicable methodologies and evaluative frameworks, enabling the assessment and prediction of the potential performance of proposed urban or architectural designs.

		Starting point	Evidential approach	Proposed approach
Theories structured through soft evidence	Kevin Lynch's Image of the City	Reductionist design methods emphasizing on the materiality of space	Understanding the relationship between the spatial arrangement and cognition	Design decision-making based on the cognitive properties, legibility and functionality of space.
	William. H. Whyte's The Social Life of Small Urban Spaces	The unexplained difference in the performance of urban spaces	Acknowledging the possibility of human flow and interaction with regards to the material properties of space	Enhancement of flow, providing a hierarchy of spaces that enable movement, interaction and activity on different levels
	Colin Rowe and Fred Koetter's Collage city	Decline of modernist cities	Detached physical form and occupancy and citizen life	Incorporation of multi-dimensional scientific calculations
	Christopher Alexander's Pattern Language	Negligence of frequently occurring patterns in social and physical structures	Reclaimed established patterns	Introduction of series of quantifiable benchmarks for design and planning.
	Jan Gelh's Life Between Buildings	The neglected importance of well thought design of public spaces	Refraining from the oversimplified and monotonic aesthetic, or functional design approach	Flexible and adaptable public space that facilitate continuous movement and interaction while observing degrees of hierarchy
Theories structured through hard evidence	Bill Hillier and Julienne Hanson's Space Syntax	Negligence of scientific method in Architectural discourse	Simultaneous physical and social representation	Configurational analysis and iteratively repeatable modelling.
	Berghauser and Haupt's SpaceMatrix	Frequently used but overlooked idea of density	Acknowledging the information pertinent to density that helps with understanding urban form and performance	Multivariate combination of density measurements to provide a coherent presentation of space

Table 2-2 Evidence-Based spatial theories and their approach

The review of major theories related to the design and planning of the built environment—particularly those that conceptualize space as a measurable and analyzable phenomenon—reveals that many of these frameworks

emerged in response to critical shortcomings in non-evidential approaches to urban design and planning. While each theory arises from distinct disciplinary or ideological concerns—ranging from social and political issues to economic and spatial dynamics—they collectively aim to advance the discourse by introducing replicable methods supported by verifiable forms of evidence. This theoretical foundation supports the development of an evidence-based framework in which diverse types of data—quantitative and qualitative—can be systematically integrated into spatial decision-making.

In addition to these widely recognized theories, the French and Italian schools of urban morphology offer another yet complementary approach to understanding spatial dynamics. The French school, rooted in historical geography and social theory, emphasizes the evolution of urban form as a product of cultural, historical, and political forces, often relying on cartographic and descriptive methods to interpret the layered complexity of cities. The Italian school, grounded in typological analysis and architectural theory, approaches the city as a system of evolving building and spatial types, emphasizing continuity and transformation within the urban fabric. Both traditions provide rich analytical frameworks for investigating urban processes, and their methodologies can inform design and planning practices that are responsive to local morphological conditions and historically embedded spatial patterns.

2.1.5. French and Italian schools of Morphology

The French school of urban morphology, exemplified by Marcel Poëte and later by Philippe Panerai, Jean Castex, and Jean-Charles Depaule, offers a deeply historical and interpretive approach to understanding urban dynamics. Poëte's work, influenced by Henri Bergson's philosophy, presents the city as a living, evolving organism shaped by unpredictable, internal forces—a concept he termed "Bergsonian urbanism." Key ideas such as *la durée* (non-linear historical time), the "principle of double frenzy," and a humanist critique of mechanistic planning guided his interdisciplinary, evidence-rich approach. As an archivist and urban historian, Poëte used diverse qualitative sources—maps, literature, and historical imagery—to reveal the city's layered physiognomy and cultural identity (Periton, 2006; Terranova, 2008).

Building on this tradition, Panerai, Castex, and Depaule focus on the transformation of urban structures, particularly the block, as a site of spatial and social meaning (Panerai, Depaule and Castex, 2014). Their method links physical form to socio-economic processes, emphasizing how architectural models evolve and how spatial organization affects lived experience. Through detailed morphological analysis and case studies (e.g., Haussmann's Paris, Garden Cities), they critique modernist planning's tendency to erase continuity and polyfunctionality. Both approaches stress that urban form is not static but a record of complex transformations—requiring rigorous observation and analysis to inform sensitive and context-aware planning and design.

The Italian school of urban morphology, pioneered by Saverio Muratori and further developed by Gianfranco Caniggia and Gian Luigi Maffei, views the city as a living, evolving organism(Maffei, 2009; Kropf, 2014). This approach focuses on uncovering the "formative logic" and "structural nexus" that shape urban form over time. Central concepts include the *typological process*, which traces how architectural and urban forms evolve, and a hierarchical understanding of built form, from materials to whole settlements. The Italian method emphasizes empirical, direct observation—studying buildings "house by house"—to understand how physical space records and expresses historical, economic, and cultural change (Maretto, 2018; Maretto, Ribeiro da Costa and Leão Rego, 2023).

Key to this perspective is the analysis of "morphological periods," where the material fabric of cities reveals distinct phases of development. Evidence is used to reconstruct these phases, enabling the comparison of urban forms across time and space. The approach also acknowledges ambiguity and overlapping functions in urban elements. This rich, interdisciplinary method connects history, geography, and sociology to inform contemporary

planning. By emphasizing continuity and adaptation over rupture, the Italian school provides a powerful framework for sustainable urban design grounded in the city's historical and typological depth. It ultimately offers a bridge between past and future in shaping contemporary urban form.

Feature	French School	Italian School
Conceptual Focus	Historical layering, socio-political shaping	Typological transformation, structural logic of form
Key Figures	Poëte, Lavedan, Panerai, Castex, Depaule	Muratori, Caniggia, Maffei, Portoghesi
Main Works	*Formes urbaines*, *Analyse urbaine*, *Histoire de l'urbanisme*	*Studi per una storia urbana*, *Lettura dell'edilizia di base*
Evidence Type	Soft, qualitative, cartographic	Structured-soft, typological, diagrammatic
Tools Used	Historical maps, sketches, observational analysis	Plan analysis, typological charts, transformation diagrams
Planning Influence	Adaptive reuse, site-responsive planning	Typologically consistent urban infill and regeneration

Table 2-3 Summary of French and Italian schools of morphology

2.2. Framing EBDP

So far, we have discussed the evolution of ideas and theories that had a critical position towards traditional and somewhat arbitrary way of planning and designing the built environment. Seeing that although there is a prevalence of evidence in some of these approaches and methods of thinking about planning and design, it is necessary to take a critical stance towards the implemented analytical approaches and identify what needs to be enhanced. Framing EBDP in this regard is not a new paradigm by itself, however the way evidential thinking, and the extent to which thinkers are contributing to this process must be discussed and formulated.

As discussed, evidential thinking in design and planning for the built environment, has been the subject to study of many thinkers and practitioners as mentioned above. From each of these critical points of view an aspect of a wholesome environment is neglected through urban design and planning and each of these theories try to incorporate the missing element and articulate on how certain elements would enhance both the process and outcome of the planning and design process.

Zeisel (1984) begins to critically look into the dominant design approaches informed by evidence, and at this point identifies four categories (Zeisel, 1984) of evidence which enhance the design if incorporated into the process. He recognizes personal experiences (Jones, 1970; Korobkin, 1976), observations (Zeisel, 1975) thinking and writings of designers (Foz, 1972) and analytical review of implemented design (Foz, 1972) as the four categories that would fed into a design process. However, his review considers this as indirect impact and learnings from evidence. He also considers analytical approaches to design evaluation (i.e., space syntax analysis) to be a rather new presentation of the status quo. In this process, the same design informants are evaluated in a cyclical feedback process, and initial design/plan concept is polished throughout (See Figure 2-1).

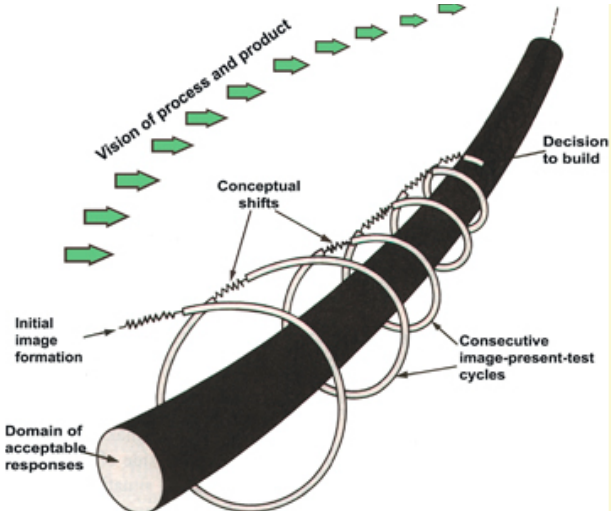


Figure 2-1 Design spiral by John Zeisel (Zeisel, 1975)

In the post-modernist design and planning paradigm, development of computational data driven methods impacted this model of evaluation cycle and introduced a series of reproducible evidence into the evaluation cycle. Carmona (2021) frames this process of designing built environment as to be either self-conscious or unselfconscious which can only be seen at a scale. When looking at the process of planning and design from a macro scale, built environment is informed either through structured top-down planning and design in which there is a high degree of determinism, or as a result of incremental change and organic growth. (See Figure 2-2)

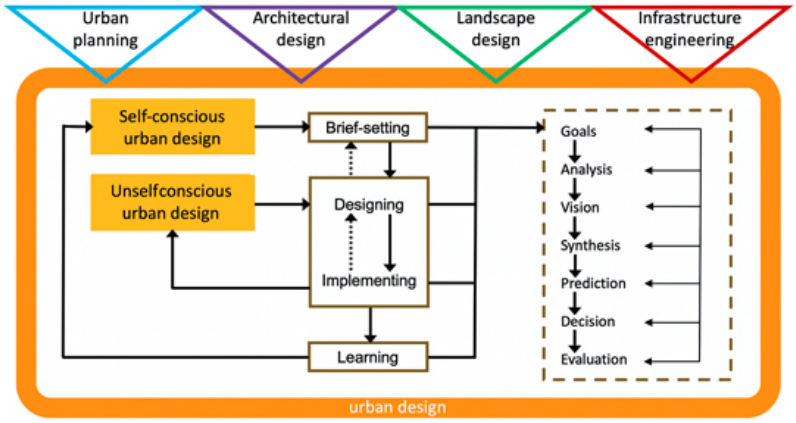


Figure 2-2 Self-conscious and unselfconscious urban design processes (Carmona, 2021)

Conventionally, the former is more preferable for the post-modernist city with expected performance and modes of governance. From this point of view in the planning and design of cities there is little room for trail-and-error, that is more predominant with the latter mode of urbanisation. Although there is a feedback evaluation cycle in both self-conscious and unselfconscious modes of urbanism, these generally function at different scales. in the self-conscious mode the feedback loop evaluates the integration of the designed unit with the larger system, while the unselfconscious is more inward looking, and the internal dynamics are better fit.

Given the upward trends of urbanization and the necessity for scaling up – specifically in urban settings – self-conscious urbanization mode tends to inform most of the urban spaces. With preset goals and agendas, the design and planning process becomes a predictable and controlled process, thus a core agenda to this process becomes minimizing deviation from the set goals, through understanding the impact of stakeholders, actors, budgetary concerns, political regulations etc.

Carmona presents this process as *integrated urban design process* within which there is a learning feedback loop, that only promotes improvements in the self-conscious process forward. From his point of view the integrated urban design process includes six stages of Setting the goals, Analysis, Visioning, Synthesis, and prediction, Decision-making and evaluation, where these stages are set in one direction and once the outtakes from implementation of a process are integrated into the design, the process would only move forward. From this point of view the EBDP would enhance the process by placing the iterative feedback loop across the stages of the process. The feedback from the back-and-forth discussion between the steps of the process then becomes major evidence that shapes each of the project's outline individually. Therefore, what essentially frames EBDP distinctively from the conventional IUDP (Integrated Urban Design Process) is the way this framework can work across scales as well as including a cress -sectional feedback loop that would inform all stages of the process.

Accordingly, the following looks into these fundamental characteristics and the variations of evidence and research informed design and planning that are incorporated into this definition.

2.2.1. What is evidence-based design and planning?

Evidence-Based Design and Planning (EBDP) can be understood as a comprehensive approach to planning and design that leverages empirical evidence to guide decision-making at every stage of a project. This methodology places a strong emphasis on utilizing the most reliable scientific evidence, rather than relying solely on tradition, intuition, or personal experience. In EBDP, design decisions are intentionally rooted in well-established research evidence, and the process accommodates a variety of evidence formats and sources.

One key aspect of EBDP is the integration of evidence from diverse stakeholders and active participants involved in the project. This integration allows for scalability and adaptability across various project dimensions. EBDP thrives on collaboration between an evidence-based designer and an informed client. Their combined efforts ensure that decisions are grounded in research and project evaluations, ultimately striving for the best possible outcomes in the built environment.

as explained before in detail evidential thinking has been a part of planning and design disciplines for a while. Specifically, since the modernist era when the inability of traditional thinking and methods have been criticized, and yet there were significant shortcomings with the modernist approach to the built environment, which were explained here. What is subject to improvement in this framing of EBDP is applicability across scales and integrability of the process with other technical or theoretical processes. Thus, in this framing there are differences between EBDP, RID (research informed design) and DDD (Data Driven Design).

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, recommendations, and implications for practice	Disseminate post-occupancy performance results through publication and presentation	Communicate process, share process and lessons learned

Table 2-4 Matrix of EBD and RID as proposed by Peavy and Vander Wyst (2017)

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 and challenges of evidence-based approaches to planning and design in different contexts

Exploring the relevance of evidence-based planning and design across various contexts enhances our comprehension of this process. This study seeks to illuminate the implications of planning and design decisions by dissecting the applicability of EBDP in diverse scenarios. Traditional approaches in design and planning have been critiqued for their reliance on communicable mediums for decision-making. Consequently, decisions spanning from junior design students to high-tier policymakers draw from the same process and evidence.

To better grasp the landscape, it's essential to scrutinize the ingrained analytical thinking, science-based iterative processes supporting decisions, and their roles in planning, design practice, pedagogy, and policymaking. This examination aims to demonstrate the current relevance of EBDP in these contexts and outline how it's positioned. Unveiling its relevance also prompts a query into the nature of evidence within each context, underlining their distinct dependencies.

To embark on this review, we begin by delving into the conventional methods prevalent in planning and design across various contexts. Subsequently, we explore the extent to which EBDP aligns with or diverges from each context's framework. The dynamics of EBDP's relevance may differ in processes, types of evidence, or post-occupancy evaluations. Amidst these considerations, the foundational traditional approach that resonates across contexts serves as the starting point for the evolution toward an evidence-based approach.

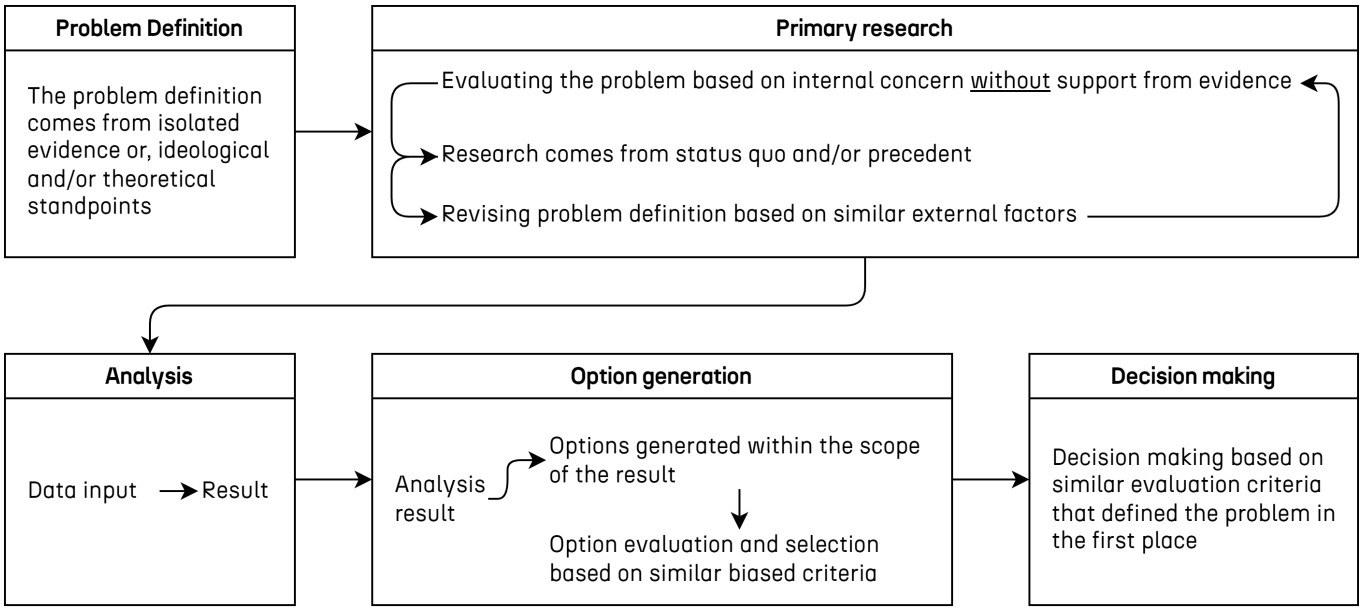


Figure 2-3 Conventional design and planning workflow

As shown in Figure 2-3 a conventional design and planning workflow is comprised of a linear and one way process. Although there are cycle loops in different stages of a conventional design process, the overall logic of the conventional workflow allows for little room for change in the previous stages. This marks the first essential difference between a conventional and an evidence-based approach to design.

secondly, a conventional planning and design process, has a set protocol in place for starting upon a project. This problem definition phase shapes the premise of the project based on isolated evidence – meaning that the outcome of the project seeks to address what that isolated project points out to – or theoretical, and ideological principles that may or may not be relevant to the project. This marks the second difference between the conventional process and the evidence-based process.

Thirdly, in the primary research phase of a conventional planning and design process, the problem is evaluated based on internal agenda, which may not appropriately define the problem and/or enable the research design. From this point of view the project agenda always remains within a limited scope of delivery as the re

2.3.1. EBDP in pedagogy

EBDP's relevance to pedagogy becomes apparent when considering traditional teaching methods in urban design and planning. Many architects, urban designers, and planners have academic backgrounds, and how design and planning are perceived in academia influences their implementation. This raises questions about the subject and medium of teaching that enable teachability and replicability in these fields.

The history of design and cities shows that teachings often stem from dominant theories or ideologies. Evidence-based urban design and planning, blending science, arts, and humanities, emerged later. Understanding EBDP's relevance in pedagogy hinges on whether design and planning should be treated scientifically or remain

subject to human interpretation. The significance lies in determining the extent to which scientific processes can be relied upon in these fields.

Thus, the relevance EBDP in pedagogy and academia relies on understanding the emerging notion of *urban science*. As is apparent from the term, it is reliant on the fact that a scientific approach is implemented in both understanding and proposing changes for the built environment and urban settings. Therefore, this involves all disciplines that discuss the appropriate quality and quantities necessary for human life and development. Given that any urban design and planning would look to enhance human life in the long term. This would engage all the various disciplines to approach design and planning through scientific method.

Looking at the idea of *urban science* from a pedagogic point of view, one could argue that due to the different nature of traditional pedagogy in design and planning, there are caveats associated with direct incorporation of scientific methods into urban planning and design and eventually defining the urban science. As Stephen Marshall lays it out the caveats with the urban science would include:

- The tendency to overlook the existing scholarship in the field in favour of scientific output.
- Ignoring an element of grand truthing
- Oversimplification in representation of urban models
- Spurious precision at umpteen decimal places that may or may not be relevant to an issue
- Trying to justify something as a significant output, that may not have a ground based
- Overclaiming the findings of a data-centric approach.

Therefore, the challenges and applicability of EBDP in pedagogy and academia is stemming from the established tradition of planning and design. While the incorporation of analytic methods and data processes (as practiced in urban science) is associated with the problems mentioned above, the process of thinking and developing the ideas in an evidence-based method is also different.

Essentially in the traditional pedagogy of planning and design there is a linear thinking process, where the design or planning is developed in response to the idea formation, followed by research – that by nature is limited and answering to the initial research questions only – and development of options. The options are also validated by similar linear

2.3.2. EBDP in practice

For the focus of the EBDP is in professional practice of urban design and planning, it is necessary to review the extent to which evidence-based approach and analytical thinking is embedded in current practice. This includes the overall process of from drafting a design brief to generating options and supporting a decision with the client through and iterative process. The following reviews the experiences of application of evidence in planning and design process through a project partner that pioneer in the matter. The intention for this is to extract the process of development and adapt to this process setting the image for a pragmatic process and possibly find the way in which a possible conceptual model can be improved.

Space Syntax ltd

The following consists of a review of Space Syntax Ltd, a spin-off company that originated from the Bartlett School of Architecture, where Space Syntax was developed by Bill Hillier and colleagues and was established to transfer the knowledge to the industry, through collaboration between academia and stakeholders. In this sense SSL is unique as its initial intentions were not quite industry-based but rather it was an effort to change the discourse of traditional design and planning. Since its inception at UCL in late 1980s, and early 1990s, SSL has

been central to development and testing of analytical and evidence-based methods in planning and design, and on the other hand has been a direct benefactor of advancements in academic research on space syntax at UCL. This collaboration between the company and the University, has contributed to solidification of EBDP as a field while, provides research material and affirmation to the academic community of space syntax and in this sense has become a model for realization of once-unimaginable academic methods.

This review looks broadly at the trends and developments in the company's profile as well as in depth review of a certain number of projects from a methodology perspective that can inform the discussion of framing EBDP. The first part of this review looks at the profile of the company from a project register since 2016, including public information of the projects, and the second part looks at some of the key project which are significant for their methodological and/or impact they had on the development of the practice of EBDP. Figure 2-4 shows the number of projects registered at the SSL since 2016, which shows the immense demand for consultation with analytical methods, as SSL does not initiate projects directly, and all the commissions are based on previously proposed projects, for which the client reaches out to SSL for advice and consultation.

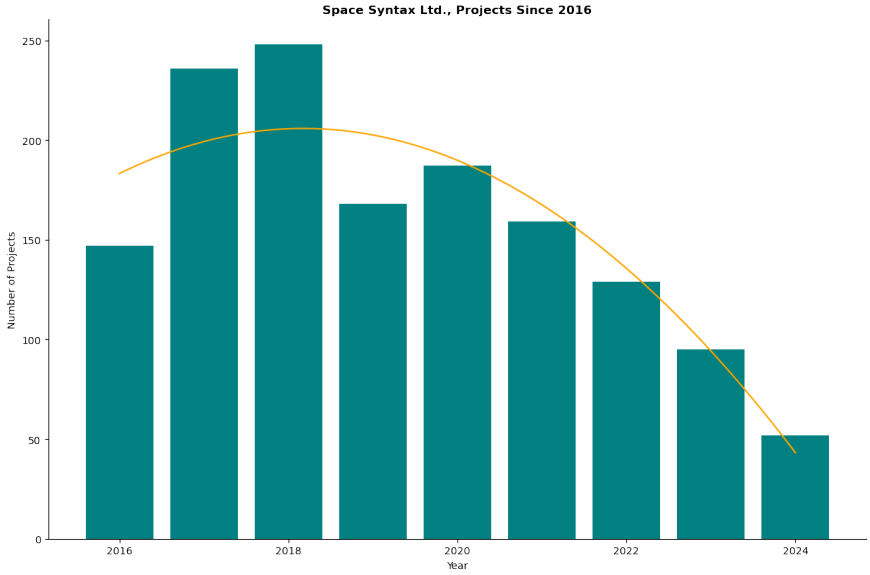


Figure 2-4 Number of projects per year at Space Syntax Ltd.

The total number of projects registered for investigation is categorized based on their development stage. These stages range from the pre-proposal phase, where SSL employs analytical methods to develop project proposals for clients, to on-site projects where investment intentions are already established and seek optimization. Figure 2-5 illustrates the distribution of projects by their respective stages. As shown in the figure, a significant number of projects do not proceed to further investigation (represented in grey in the tree map). This indicates ongoing challenges in implementing analytical methods during the planning and design phases, where evidential reasoning does not always lead to project commissioning.

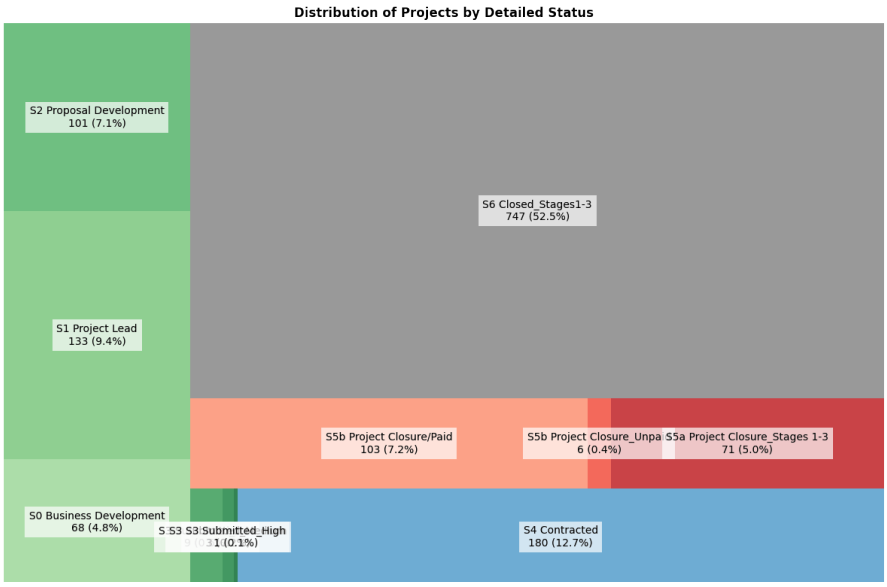


Figure 2-5 SSL project registered status

A closer inspection of the commissioned registered projects reveals that approximately half of them involve the development of a proposal. This observation suggests that, at a practical level, the Evidence-Based Design Process (EBDP) primarily functions as supplementary evidence for future projects. Consequently, the EBDP is instrumental in shaping the future trajectory of these projects and enhancing the potential efficiency of future investments.

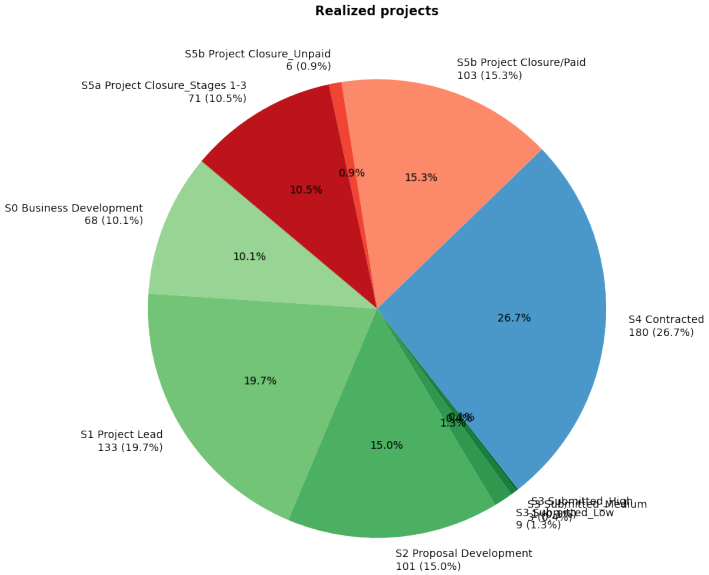


Figure 2-6 SSL projects that were proceeded with consultation and advice

Further looking into the client profile of the project register, it is observed that the majority of the projects (with the registered client on the project register) are private companies (See Figure 2-7). In comparison the summation of public and governmental projects does not surmount to the private sector clients that used SSL services. This suggests that EBDP is better received by the private sector than public, also suggesting that private investments are better familiar with the benefits of evidential and analytical thinking in long-term planning and design.

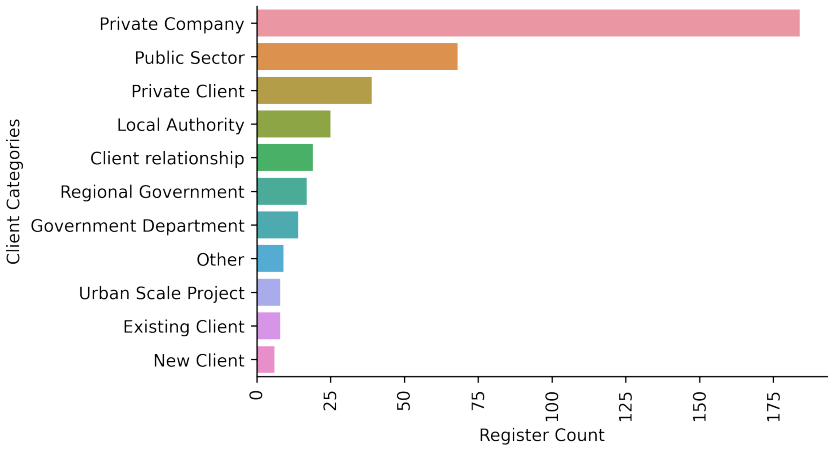


Figure 2-7 Client categories for SSL registered projects.

The following consists of a general overview as well as an in-depth review of projects developed informed by analytical and evidence-based methods in different scales by Space Syntax ltd, which is an industry pioneering and leading firm in the field of EBDP. The cases selected for in-depth review range from scale, and level of commission, as well as the chronological order which shows the development of unique techniques for each of the projects. The review specifically leaves out the details of the projects and instead focuses on the process through which the commission is explained, analysed and provided with evidence-based solutions. This review informs the process of framing EBDP and will therefore exhibit how it is implemented and can be improved.

- Nur Sultan Masterplan

The commission is to look into the condition of the city of Astana – the capital of the country after changing it from Almaty to Astana in 1997 – and improve the conditions, setting the guidelines and propositions for the city to grow and develop from its current status, and provide the necessary conditions for becoming a world class capital city. The acknowledgement of the city's status come from direct involvement of the company, observing the conditions from their own point of view as well as the details provided through the existing masterplan. From the point of view the two sets of observations are set against each other to make a justified and evidence-informed problem definition.

The review of the existing master plan starts with reviewing the applicability of the set agenda which have shaped the masterplan around the principles of *attracting people and investment, improving liveability, sustainability and health indicators and reflect on the geoplan boundary.* Within these high-level criteria, the review identifies certain issues to address, such as human-scale development integration of systems, phased development etc based on the premise that the agenda set in the previous document are valid, and in the right

order of importance. With set goals, then certain strategies are designed which would address liveability issues, sustainability issues and issues related to urban health.

These strategies set with 4 stages for implementation; however it is important to note that iteration over the outcome (and back propagation) is not mentioned in these 4 stages. These following are the summary of these stages:

1. **Vision stage**: This stage reviews the existing documents on the development of the city, identifying the indicators and studying the precedents for development phase.
2. **Baseline analysis**: This stage measures the status quo against the identified indicators, implements a baseline IUM, and performs custom analysis for KPI targets.
3. **Strategy**: Enabling existing city to transition, iterate through design solutions, and address shortages of social infrastructure
4. **Masterplan**: Developing detailed proposals, perform environmental analysis, implement local regulations, update IUMs, Stakeholder communication activities

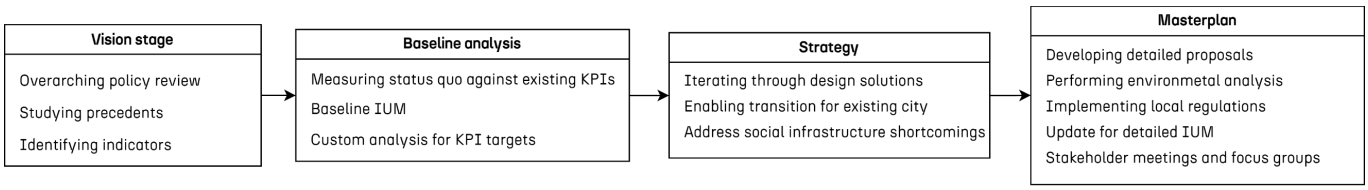


Figure 2-8 Methodology matrix of Nur Sultan Masterplan project

These stages and the design strategy has been structured around 3 design philosophies:

- Applying evidence-based design
- Considering city as a set of interconnected urban systems with multiple scales and
- Integration of system across.

The analysis evidently shows that urban systems are not integrated, there is low density and not walkable. This sets the agenda for change based on reducing urban growth boundary, providing tactical interventions, proposing strategies for brownfield regeneration and adding complementary economic sectors. Thess are complimented by linking non-spatial issues (such as population) to physical form, defining boundaries, centres, spines etc, creating a multi-scalar, multi modal systems that works across systems. The strategy also tends to provide physical space that accommodates growing population and economic growth.

From these strategies, design principles are extracted, however it is not clearly mentioned or explained, the mechanism through which the design principles are derived from the strategies. The design principles are structured around spatial configuration, spatial mobility and land use density. The following principles are set as indicators in spatial analysis and model revision:

Spatial network:

- Human scale development
- Interconnectedness of systems, avoiding dead ends
- Varying permeability depending on functions
- Combining movement modes

- Animated edges and modes of activity
- Year-round pedestrian movement

Land use density

- Controlling growth boundary
- Wider mix and work density
- Higher density and better connectivity
- Location based land use
- Define centres and clusters
- Provide social infrastructure land use

Sustainable mobility

- All areas accessible by all modes
- Provide high performance public transit
- Conscious mobility behaviour
- Prioritising soft modes

Further the proposal set out through these design principles were tested against KPIs using combination of factors, Machine learning and generative design, environmental analysis and focus groups. The design ideas also address the natural conditions of the city and layout structure that responds to these features. With reference to precedents, the masterplan, provides an evidence-informed steps and procedures which reflect on theories which are the premises of the work.

- Darwin city centre

The commission aims to provide a comprehensive analysis of a rather small-scaled city in Northern Australia and provide suggestions with respect to the conditions of the city. The scope of the project and its requirements allows for baseline analysis and evidence-based suggestions. The modelling approach uses a multi scalar output to identify location-based priorities, and over impose with layers of route hierarchy, land use, topography etc. This results in a location-based matrix of opportunity and constraints at different scales and modes that allows for decision-makers to discuss their priorities.

Further the design objectives and principles were extracted from the evaluation matrix:

- Exploit the natural and existing features of the city
- Enhance connectivity and density with and within CBD
- Integrate modes of transport
- Extending the CBD and linking it to the current CBD
- Planning and enhancing spine streets.

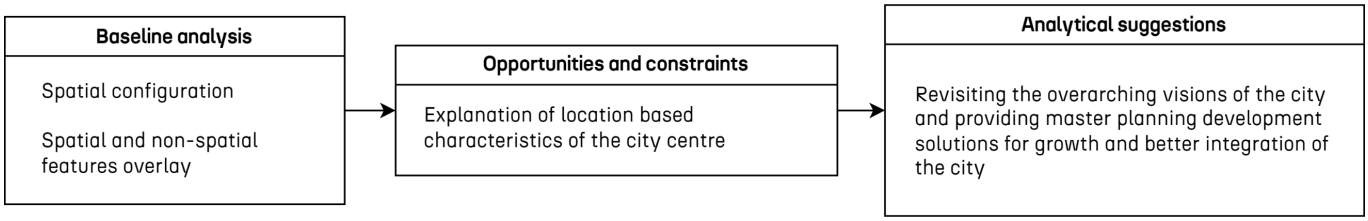


Figure 2-9 Methodology Matrix of Darwin city centre plan

These are complimented by a pedestrian and vehicular activity analysis to set the current and proposed plans and provide an urban performance index. The correlation analysis then shows a profit index which is drawn against all the proposed options. The significance of this project is that with the limited scope and resources, the analytical phase would only cover the high-level issues and therefore providing the options to the stakeholders would facilitate further decision support.

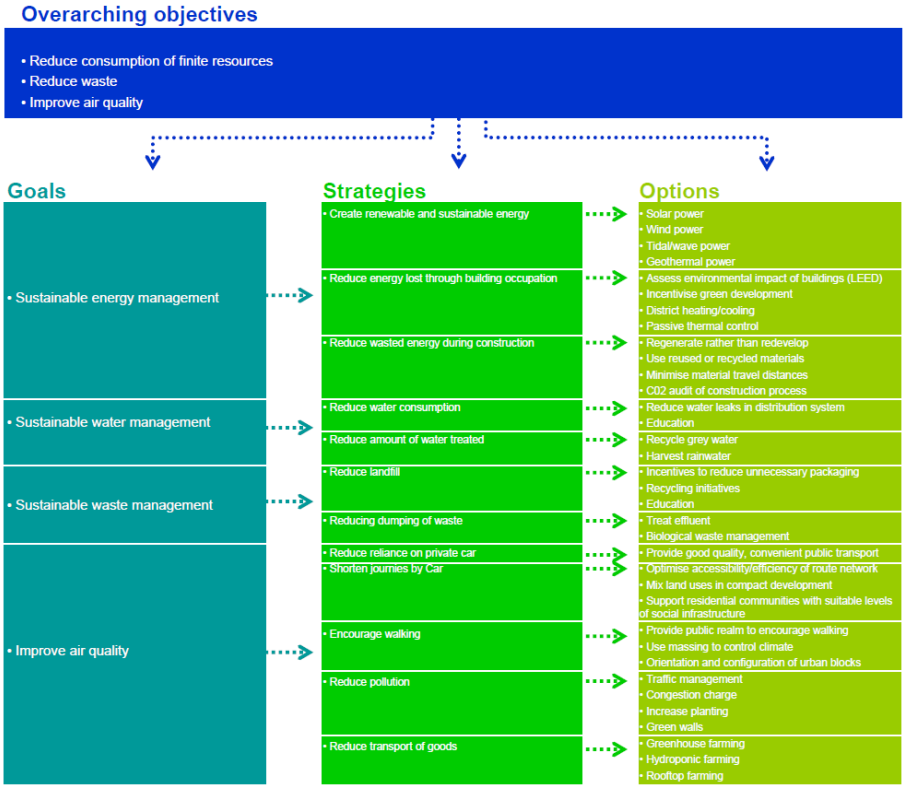
- Jeddah urban development framework and guide for addressing the unplanned settlements

The commission comprises of a series of projects that at its core tends to address the issue of informal growth and unplanned settlements within the formal boundary of the growing city of Jeddah. With a wider scope, the project implements a more in-depth and comprehensive pipeline. This pipeline begins with studying the existing condition and performing a baseline analysis, then assessing the impact of the issue regarding the overall development of the city and configure how the mega project approach changes the conditions of the city and advising on the level of intervention based on the performed analysis.

Through creating an IUM, the project incorporates several spatial and non-spatial parameters into the analysis including the spatial structure, land use mix, FAR, massing, population density and public space network. However, the framework relies on a few potentially unrealistic premises, such as guaranteed project completion, sustained funding, and continuous administration, which are uncommon in this context. The strategy and advice provided are at a very high level, offering guidelines and affordances to address questions and problems related to unplanned settlements. These recommendations are based on high-level analysis and assessment, aiming for large-scale and long-term changes.

To realise this strategy the following components have been developed and refined:

- Vehicular route network
- Traffic management
- Parking strategy
- Public transport
- Open space strategy



Further with the overall development framework set, a subject specific study is performed to analyse the relationship between the unplanned settlements, the city and issues in between with regards to development and growth of the city. Based on the framework and previous studies the commission aims to upgrade the unplanned settlements incrementally, through the following acts:

- Develop a rigorous, evidence-based methodology to fine-tune spatial interventions.
- Reconnect Jeddah's Central Unplanned Areas with their surroundings.
- Coordinate transformations with strategic proposals for the entire city, including the City Centre and Historic Core.
- Identify and redesign optimal route networks and urban block structures.
- Develop guidelines for land use, building heights, public realm, and parking.
- Identify special projects for development.

The project is defined into four stages of data gathering, analysis, strategy and design, each of which have several sub-stages.

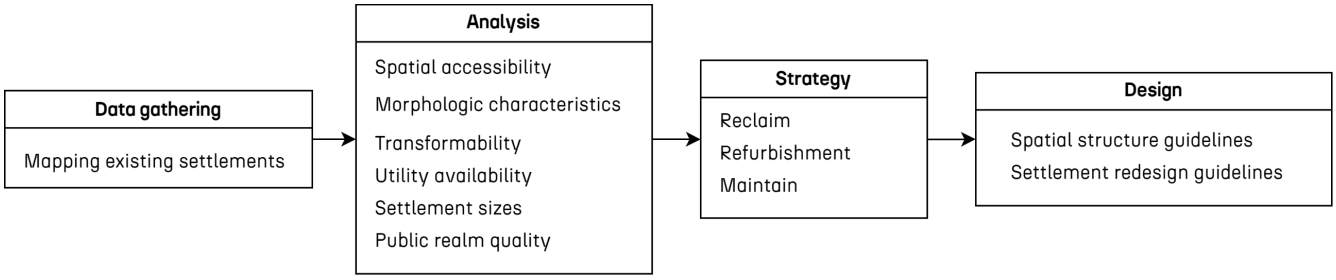


Figure 2-10 Methodology of Jeddah development framework and master plan

Based on the analysis certain indices were generated that rank the settlement according to their score of various metrics. These indices include urban morphology index, transformability index, public realm quality index, Utinility availability index social infrastructure provision index etc. having created a series of metrics, these were combined to create a prioritisation matrix which ranks the settlements according to their level of need for attention, intervention and importance to the overall city development strategy. This allows for budget and strategy decision support with regards to individual settlements. Further a settlement that ranked high on all feasibility, budget, and level of attention and intervention need was selected as a pilot project to test the design guidelines which addresses the meso and macro issues within the settlement.

The key findings for Thagar pilot project:

- Settlements are prioritized into four groups based on design data for quicker improvement implementation:
  - Group D lacks data; data collection and re-prioritization are needed for high-need settlements.
- Thager was selected as the pilot study project in November 2012 after assessing primary projects in Group B settlements for their improvement needs and pilot study value.
- A detailed design for Thager's primary route was developed, minimizing property acquisition:
  - Two options (10.5m and 7.5m street widths) were combined into a preferred hybrid, affecting 14 plots.
  - Next steps: confirm the preferred option and engage stakeholders.
- Thager's utilities have good access to mains water, sewers, and electricity, but lack stormwater drainage:
  - The pilot project uses Thager's topography and permeable paving to manage water.
  - Next steps: coordinate with a city-wide study and conduct a detailed topographic survey.
- Building facades in Thager need improvement to enhance overall project quality:
  - Proposed enhancements include rendering, painting, and planting.
  - The Municipality should establish funding mechanisms and incentives for residents to maintain these improvements.
- Dynamic cost models for Thager's design options were developed using Jeddah data and international quality levels:
  - Costs range from 15m SR to 22m SR.
  - Next steps: calibrate the model with contractor quotes.
- Implementation guidelines for Thager were prepared, including selling residual land to adjacent owners and engaging property owners:
  - Finalizing the design depends on engagement outcomes.
  - Steps for immediate, short, and long-term improvements have been defined.
  - Next steps: engage with owners and finalize the design.

- Trafalgar and Parliament Squares

The Trafalgar Square / Parliament Square project represents a pioneering application of an analytical approach to urban design, with a significant impact due to the importance of the locations involved. The project's primary objective was to address and improve specific issues identified through careful observation and testing. The challenges identified in this project serve as early examples of how syntactic analysis can reveal configurational properties that directly correlate with the social dynamics of a space. In this context, the project effectively demonstrates the application of scientific findings to a real-world case, where observed post-occupancy changes reflect the influence of configuration adjustments informed by analytical processes.

The methodology applied in this project is straightforward, reflecting the early stages of a scientific approach to urban design. Observations were systematically compared with modelling results, and the outcomes were thoroughly explained and justified. This analytical framework established the foundation for a transformative vision, shifting Trafalgar Square's role from that of a mere visitor attraction to a more active and focused urban space. The process began with an initial phase of observing movement and activity in both squares through gate counts and movement tracing. This led to certain hypotheses regarding the underperformance of these iconic urban spaces in attracting movement, facilitating activities, and hosting gatherings.

These hypotheses were tested against a spatial configuration model (axial line model), which reinforced and refined the analytical outcomes. There are two notable aspects of the Trafalgar and Parliament Squares project that distinguish it from subsequent projects. First, despite the analytical approach, the project maintains a descriptive narrative that is accessible and easy to communicate. Specifically, there was a deliberate effort to avoid the specialized jargon of space syntax, which became more prevalent in later projects. Second, the scope of modelling and analysis was more limited compared to other projects, aligning closely with the extent of empirical evidence and observations. Additionally, references were primarily drawn from within the UK, both historically and contemporarily, with minimal reliance on examples from other contexts.

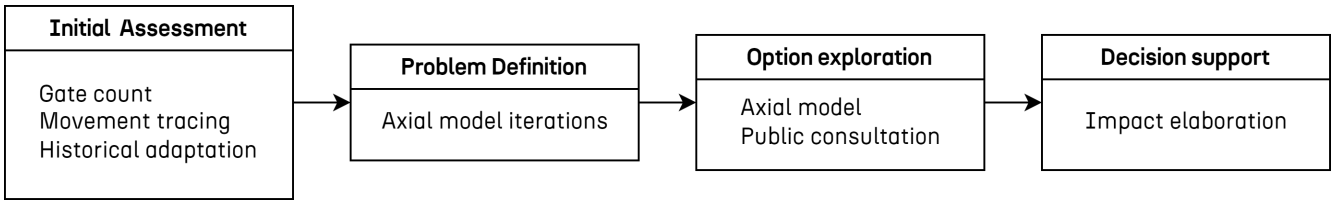


Figure 2-11 Methodology matrix of Trafalgar square reconfiguration project

This project exemplifies the first generation of applied analytical thinking in urban design. Considerable time was devoted to understanding the results and observations, integrating them with local knowledge from individuals familiar with the square's dynamics, including movement patterns and activity flows. As a result, the evidence informing the design outcome was derived not only from modelling and observation but also from ground-truthing and local expertise. In this sense, the evidence-based design relied on both descriptive and analytical data.

The design criteria were adjusted with precision, focusing on refinement rather than iterating multiple scenarios—likely due to the computational limitations of the time. This approach yielded a set of well-considered options aimed at maximizing the square's potential while addressing and overcoming existing challenges. Notably, the early hypotheses, observations, and modelling provided a clear description of the desired qualities of a successful square, establishing criteria that included specific aesthetic, functional, and programming parameters.

During the analysis phase, certain assumptions were made and subsequently detailed, particularly regarding how the proposed changes would enhance the square's dynamics. These options were later presented to the public through questionnaires and exhibitions, receiving positive feedback. The proposed changes were broadly supported by various groups, especially local workers and residents. Stakeholder responses were analysed to ensure a clear understanding of the distribution of support across different demographics, and these responses were used to reinforce the design proposals. However, the scale and methodology of the public consultation process posed challenges in fully capturing the complexities of the issues and the design's response to them.

Overall, this project can be regarded as a successful example of visionary thinking and applied analysis, integrated through a tailored methodology that engaged not only experts but also the general public, resulting in a project with a lasting impact.

Society and Urban Form lab (University of Cyprus)

- Design improvements Supporting Active Travel Around Secondary Schools (DESIRE)

Commissioned by the Cyprus Ministry of Transport, Communication and Works, this project analysed and assessed active travel/micromobility conditions around secondary schools in Nicosia, Cyprus and proposed evidence-based interventions. It identified high-risk areas for students commuting by walking, cycling, or electric scooters, assessed the adequacy of existing pedestrian infrastructure, and developed a framework for prioritizing safety improvements. The project ultimately aimed to inform policy recommendations enhancing student safety and promoting sustainable mobility.

The study followed a four-stage approach. First, in the data collection and modelling accident data from 2018 to 2023 was collected and mapped in relation to the city's road network, school locations, and pedestrian infrastructure. Spatial network model established baseline conditions and identified schools with recurring accident hotspots. The spatial characteristics of the street network across the whole city were examined, with a focus on the catchment areas of the schools at 400m, 800m and 1200m distance from the school entrances. Areas with potentially high co-presence of multimodal users, where there tends to be more interaction and possible conflict among cars, motorbikes, pedestrians, and micro-mobility users, and therefore a higher risk of collision among them, were identified. The spatial distribution of accidents in relation to the schools' catchment area were analysed and a detailed analysis of pedestrian infrastructure within the 400m catchment area was performed. The second stage analysed existing road safety measures, evaluating speed limits, pedestrian crossings, and traffic-calming infrastructure near schools in relation to the spatial network and features. The third stage proposed targeted interventions, including better pedestrian crossings, and expanded pedestrian and cycling infrastructure. Finally, the proposed measures were tested for their potential impact, forming the basis for a policy framework integrating road safety improvements into urban planning.

The findings provided a data-informed foundation for road safety improvements and for promoting active travel around secondary schools in Nicosia. By implementing targeted interventions, accident risks for students using active travel modes are expected to decrease significantly. The study also supported broader sustainable mobility policies by encouraging walking and cycling, contributing to reduced congestion, improved air quality, and public health benefits. Its recommendations align with city planning goals and offer a scalable framework that can be applied to other urban areas in Cyprus, forming the basis for a national road safety strategy for school commutes.

- Assessing accessibility and connectivity to greenspaces (Nicosia Linear Park) at urban scale (TWIN2EXPAND project)

This study evaluates the accessibility and connectivity of the Pedieos Linear Park in Nicosia, a 9.5 km green corridor that plays a vital role in promoting environmental sustainability and enhancing the quality of urban life. While the park is widely used and appreciated, its accessibility and distribution of amenities remain uneven, leading to spatial disparities in the quality of user experience. To understand the existing situation and assess the impact of a proposed masterplan, the study employed a comprehensive mixed-methods approach that combined participatory engagement with spatial analysis.

The qualitative component centered on a series of focus group meetings with local residents, stakeholders, and community organizations. These sessions were designed to capture community needs and aspirations, particularly regarding movement, safety, and service provision within the park. A total of 43 proposals emerged from these discussions, which were further refined and prioritized through a structured voting process. Key recurring themes included the demand for smooth, accessible pedestrian pathways; ramps for people with disabilities; better lighting and safety infrastructure; additional entrances; and the need to clearly zone areas for different uses, such as cycling, walking, and rest.

The spatial analysis involved assessing the park's current accessibility based on population reach and proximity to key amenities from and within the linear park. Data was collected on population reach within different accessibility radii, including 400, 800, and 1200 meters. In addition, accessibility to amenities from the park was evaluated, with healthcare, educational, sports, and cultural facilities analyzed for their proximity, within the park, social, sports, animal, commercial, and general amenities were mapped out to determine service distribution and accessibility.

Additional spatial layers included proposed elements from the masterplan—such as new entrances, pedestrian bridges, and pathway extensions—which were manually incorporated into the existing street network model using GIS. To evaluate the broader urban context, external points of interest related to healthcare, education, sports, and cultural services were sourced from OpenStreetMap (OSM). This allowed for a multi-scalar analysis of how well the park is embedded within the urban fabric and the extent to which it connects with essential services.

Through this integrated methodology, the study was able to compare the current state of the park with the proposed improvements in terms of accessibility, connectivity, and inclusiveness. The masterplan envisions a 20% increase in entrances, improved pedestrian and cycling infrastructure, stronger integration with public transport, and the expansion of social, ecological, and cultural facilities. These strategies not only aim to reduce reliance on private vehicles and promote sustainable mobility but also to enhance the equity and inclusiveness of public space provision in Nicosia. The findings underscore the value of combining community-based planning with spatial analytics to guide more just and effective urban interventions.

Takeouts

The integration of Evidence-Based Design and Planning (EBDP) into the professional practice of urban design and planning marks a pivotal shift toward more informed, responsive, and impactful decision-making. Rather than relying solely on precedent, intuition, or political expediency, EBDP empowers planners and designers to base their interventions on systematically gathered data, rigorous research, and measurable outcomes. This approach enhances the credibility and legitimacy of planning processes, making them more transparent and accountable to the communities they serve. Moreover, EBDP fosters interdisciplinary collaboration, requiring professionals to work across sectors—urban design, public health, transportation, sociology, and ecology—to co-

produce knowledge and develop integrated solutions. This kind of engagement ensures that urban interventions are not only technically sound but also socially inclusive and environmentally resilient.

However, the transition to evidence-based practice also demands a cultural and institutional shift. It requires investment in education and capacity building, institutional support for applied research, and mechanisms to translate findings into policy and design. Despite these challenges, the potential benefits—more liveable cities, healthier communities, and more equitable outcomes—make EBDP not just an innovation but a necessity. Ultimately, embracing EBDP signifies a maturation of the planning and design professions. It aligns them with broader societal expectations for transparency, effectiveness, and justice—marking a critical step forward in shaping cities that truly serve the needs of their people and environments.

2.3.3. EBDP in policymaking

The impact on design and planning is intricately linked to policy-making processes and their corresponding scales. These processes set the stage by shaping the adoption of design and planning methods through regulations and formalities. However, the dynamic nature of political processes and the complexity of governmental structures introduce diverse challenges, necessitating distinct types of evidence to drive informed planning and design decisions. The specific evidence required varies based on the priorities and agenda of the governing body responsible for shaping design and planning regulations. This multifaceted landscape gives rise to various interdependent departments, each playing a crucial role in advising on pertinent matters.

Consequently, the evidence input into vertical processes diverges from that involved in the horizontal processes that facilitate communication between these departments. This structural framework not only influences the nature of evidence but also determines the composition of advisors and experts contributing to the decision-making process. As a result, the process and utilization of evidence exhibit distinct characteristics based on this intricate interplay between governance, advisory bodies, and the multifaceted nature of evidence itself.

3. 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.

3.1. 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.

3.1.1. 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.

3.1.2. 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.

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 autocorrelation measures the relationship between the values of a single variable of features in close locational proximity. It helps to answer questions about the spatial arrangement and dependence of data (Dubin, 1998; Getis, 2008). The necessity for using spatial autocorrelation draws from potential bias errors that arise in statistical tests where the observation are assumed independent (Cliff and Ord, 1970; Dubin, 1998; Dale and Fortin, 2002; Getis, 2007). Ignoring the spatial autocorrelations leads to false or biased results in terms of statistical analysis (Dale and Fortin, 2002; Getis, 2008). There are numerous applications of spatial autocorrelation analysis including in urban economy, ecology and, epidemiology (Cliff and Ord, 1970; Dubin, 1998; Dale and Fortin, 2002; Getis, 2008). Using the spatial autocorrelation degree of global and local influences in similarity of certain variable can be assessed.

- Spatial interpolation

Spatial interpolation is a method to predict values of variables at unsampled locations within a region based on values at close proximity. It is particularly useful when acquiring data is expensive or difficult (Li and Heap, 2008, 2014). With respect to planning and design, the method has numerous applications in providing supporting evidence specially in terms of environmental factors such as noise and air pollution. In applying spatial interpolation there are various methods including Kriging, Inverse Distance Weighting (IDW), Regression models, and Thin Plate Splines (TPS) (Li and Heap, 2008).

- Point pattern analysis

Point pattern analysis is a series of statistical methods used to analyse and identify spatial patterns in the distribution of points in a given area, where the size of the points are not considerable comparing to their distance or the size of the area (Gatrell *et al.*, 1996; Velázquez *et al.*, 2016). With regards to the application of point pattern analysis, it can be used in various scenarios. Examples of this include studying crime patterns, analysing residential patterns, analysing the distribution of green spaces and understanding the impact environmental factors such as topography on urban development and public health.

- Spatial regression analysis

Similar to spatial autocorrelation analysis, spatial regression analysis is used to model and analyse spatial data accounting for spatial relationships and dependencies between the studied observations. While acknowledging the geographic nature of the data and account for biases in similarities found in observations closer in proximity (Dubin, 1998; Dale and Fortin, 2002; Getis, 2007). In urban planning and design spatial regression model can be used in decision-making in various scenarios. Examples of this application in planning and design include analysing housing markets for their proximity to amenities transportation networks and neighbourhood characteristics, and neighbourhood quality assessment (Dubin, 1998), Assessing environmental impacts, transportation planning, urban growth modelling (Chi and Zhu, 2008).

- Spatial clustering

Spatial clustering refers to the grouping of similar objects or events in a geographical space, allowing for a better understanding the spatial phenomena while trying to distinguish from the spatial randomness in observations that are uniformly or independently distributed (Gatrell *et al.*, 1996; Aldstadt, 2010). There are numerous applications of spatial clustering including analysis of social and economic patterns by mapping the spatial distribution of socioeconomic indicators, evaluating environmental risks by clustering the environmental hazards

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

With regards to the application of network analysis and graph theory in built environment analysis and studies, connectivity becomes an important measure in understanding the relationship between certain aspects of the built environment. Both in design and analysis, connectivity helps understand how well different parts of a network – spatial network, street network, etc – are connected to each other (Nag, Sen and Goswami, 2022). The importance of connectivity in urban planning and design relies in aspects such as travel time and cost, determining alternatives in traffic control, supporting emergency evacuation scenarios (Soczówka, Żochowska and Karoń, 2020), and promoting pedestrian activity and creating vibrant urban environments through attracting and promoting commercial activities (Hajrasouliha and Yin, 2015).

There are however some challenges in applying and interpreting connectivity in spatial analysis. Factors such as size and shape of the study area can significantly influence the calculated values leading to misinterpretation (Knight and Marshall, 2015). Further to this, connectivity in the built environment encompasses more than just physical connectivity (ease of access through physical space) but also includes visual connectivity which relates to how easy it is to see destinations and navigate environments (Hajrasouliha and Yin, 2015).

- Shortest path analysis

Based on Graph theory, shortest path analysis is a method used to find the most efficient route between two points in a network. In urban planning this is usually the street grid, and the analysis can be used to understand and predict the pedestrian and vehicular movement. The analysis can help identify areas that are highly accessible and those that are more isolated, which helps with decision-making with regards to location of shops, transport stops etc (HILLIER *et al.*, 1993; Penn and Turner, 2004; Hillier and Vaughan, 2007; Vaughan, 2007). There are multiple measures for the shortest path analysis including the metric shortest path (Based on metric distance), angular shortest path (Calculated based on the sum of angular changes (Turner, 2000)) and topological shortest path (Calculated based on number of turns on the network graph)

- Network clustering and community detection

Based on the network properties of the built environment, these are techniques used to identify groups of closely interconnected elements within a large network. These can reveal meaningful spatial clusters based on

the structure of the street network, offering how different areas of a given area of the built environment are functionally and socially linked. Incorporating the street characteristics beyond just topology, facilitates identifying meaningful urban communities (Law, Berghauser Pont and Shen, 2019). Various approaches have been explored in community detection including Street-Weighted Local Area (St-W-LA), Density Weighted Modularity, and Betweenness-Weighted Modularity.

- Centrality analysis

3.1.3. 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.

3.2.EBDP toolsets

The following addresses the latest open tool sets developed and commonly used for evidence-based design and planning. These cover the toolsets from standalone software to programming interfaces that incorporate methods and theories of design, and provide evidence for option development and scenario testing.

3.2.1. 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		

3.2.2. 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 / segment, simplest / shortest) Land use accessibilities Mixed-uses Statistical aggregations	Urban Planning Urban Design All methods applied over the network Bi-Directional datapoint assignment to adjacent network Distance weighted methods Simplest path compatible algorithm (no shortcutting)	Python API QGIS plugin under development	Python package Compatible with Network X Can link to varied formats vis python ecosystem	Python with Numba JIT Python with Rust under developme nt	
PySAL	Network analysis Network moBidelling/Visualiz ation	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, .GML, .WKT	R
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,	R

		.csv, .shp, .ACSII

3.2.3. 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	

3.2.4. 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:

	QGIS Dashboard	CARTO	D3.js	Kepler.gl	Tableau	Power BI	ArcGIS Dashboard
Map Customization	Extensive customization, ideal for urban projects	Strong customization, especially for web maps	Highly customizable but requires coding	High customization with focus on data-driven maps	Good customization, limited map styles	Basic map options, good for simple visuals	High level of map customization; suited for urban planners
Map Types	Supports most map types, including heatmaps, choropleths, and 3D views	Excellent variety, supports animated maps, 3D, heatmaps	Highly flexible, all map types possible with coding	Heatmaps, clusters, 3D maps, and animated maps	Supports heatmaps, point maps	Basic mapping; limited to simple maps	Advanced mapping, 3D, and heatmaps
Interactive Maps	Good interactivity, especially with plugins	Strong interactivity with web-based features	Fully interactive, but requires JavaScript skills	Highly interactive with easy click and hover functions	Interactive filters, limited map interactivity	Basic interactivity (click/hover)	Advanced, real-time updates, hover and click

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Built-in Spatial Tools	Robust spatial analysis tools, similar to ArcGIS	Strong spatial analysis tools, good for urban data	Minimal; requires custom scripting for spatial analysis	Moderate; spatial tools for common urban analyses	Basic tools; limited for in-depth spatial analysis	Minimal spatial functions	Robust spatial tools for proximity, boundaries, clustering
Data Filtering and Drill-Downs	Excellent filtering and drill-downs via plugins	Strong filtering options and drill-down features	Customizable, but requires development effort	Good built-in filtering, easy to use with visual filters	Excellent filtering and drill-down options	Strong filtering, especially for time and region	Strong for GIS-specific filters; extensive spatial drill-downs
Learning Curve	Moderate to high; technical GIS knowledge helpful	Easy to moderate; user-friendly for spatial users	High; requires JavaScript expertise	Easy; minimal training required for basic use	Moderate; requires some training	Easy to learn; user-friendly	Moderate; familiar for GIS users
Guided Analysis & Templates	Few templates, but highly customizable workflows	Good templates, urban-focused, easy to start	No templates; fully custom, developer-dependent	Limited templates but intuitive interface for custom views	Good templates for general data, but not urban-focused	Limited templates for urban projects	Extensive templates for GIS and urban data
Mobile Accessibility	Limited; primarily desktop-based	Strong; web-based, mobile-friendly	Depends on implementation	Moderate; web-based and mobile-responsive	Limited mobile access	Good for mobile views	Moderate; best on desktop for complex maps
Urban Data Sources	Supports extensive urban data formats (shapefiles, GeoJSON, etc.)	Strong urban data support, easy to import GIS data	Supports custom data formats via code	Supports GIS and urban data formats; straightforward importing	Supports various data formats, but limited GIS	Good for general data, limited for GIS	Excellent for GIS and urban data formats
Real-Time Data	Supports real-time data but requires plugins	Strong real-time capabilities for urban projects	Possible but complex to set up	Supports real-time data with minimal setup	Yes, but requires setup	Supports real-time data with some limitations	Strong, real-time integration
Collaboration Options	Limited; desktop-focused, but can export maps	Strong for web sharing, collaboration-friendly	Dependent on developer setup	Moderate; web-based, shareable views	Good; supports team sharing, embedding	Strong collaboration features	Moderate; team sharing, but more limited embedding
Dashboard Sharing and Embedding	Export options for static maps; limited live sharing	Excellent for sharing and embedding; built for web	Fully customizable, but requires custom code for embedding	Strong sharing and embedding features, web-based	Easy to share, embed, export	Excellent for sharing; easy to embed	Good for embedding in ArcGIS platforms, less flexible otherwise

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Cost for Urban Projects	Free and open-source; plugins may require additional tools	Flexible pricing; offers free tier and affordable paid options	Free and open-source but requires developer resources	Free, open-source; some advanced options may cost	Higher cost, limited free options	Free basic version; affordable Pro options	Higher cost; limited free options
Free Version	Completely free, open-source	Free version available with limitations	Free, open-source, but complex	Free version with robust capabilities; limited paid features	Trial version available, limited features	Free basic version; limited maps	Limited free version, mainly paid

4. 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:

4.1. Decision support tools

The demand for decision support systems in urban planning is increasing due to the growing complexity of issues related to the built environment, societal challenges, and the availability of big data. As the volume of information expands, the need to incorporate it into informed decision-making becomes more critical. Traditional methods, which relied on personal experience and expertise, are no longer sufficient to address these challenges holistically. Thus, there is a clear need for advanced systems. A key challenge, as identified by policymakers, is to provide stakeholders—such as industry, cities, and operators—with the necessary tools to make informed systemic or individual decisions and to facilitate the scaling up of solutions (Lombardi and Ferretti, 2015).

As previously discussed in the Framing EBDP, the complexity of adopting a holistic approach increases significantly as it forms a dynamic system (Kampmann, 2012) that involves continuous improvement and feedback loops of updated evidence. A common issue in this context is the independent development of analysis and planning systems that focus narrowly on specific problems. What is often overlooked in these systems is the long-term and broader impact of design decisions. Although real-world constraints and implementation limitations influence design, a growing concern in developing design and planning solutions is the need to address various aspects of sustainability through informed decision-making. This means that an analytical approach that does not leave room for feedback from other approaches will not have been addressed, and it is likely fail on the matters that are not included in the design scheme. This is similar to the problems that emerged during the modernist design and planning, where there was much emphasis on technological advances in construction industry as well as focus certain trends of spatial functionality. This led to negligence of human and social factors in the design that lead

4.2. Interfaces

In the context of urban planning and design, an interface can be defined as a tool or system that facilitates interaction and communication between different stakeholders, including urban planners, citizens, and other professionals, with the aim of shaping the built environment. Interfaces in this field are not merely about the visual presentation of data but are more importantly about enabling active participation, collaboration, and informed decision-making. To interact with complex spatial data and contribute to the decision-making process,

it is important to understand the importance of interfaces. Interfaces are an important tool in urban planning and design processes, with the potential to enhance communication, collaboration, and public participation(Hanzl, 2007). They provide a means for stakeholders, including experts and non-experts (Bugs *et al.*, 2010). With regards to the EBDP, this becomes even more significant as communicating analytical evidence and information to stakeholders that are most likely not experts in such fields is even more critical. An effective interface in urban planning and design has the following defining aspects:

- **Communication platform:** An interface provides a platform for different stakeholders to communicate ideas, share information and express their opinions about urban planning(Al-Kodmany, 2003; Münster *et al.*, 2017). This communication can be between planners and the public, among different planning professionals, or between various community groups (Hanzl, 2007).
- **Data Interaction:** Interfaces allow users to interact with complex spatial data related to urban environments (Bugs *et al.*, 2010). This includes the ability to explore maps, view 3D models, and access relevant datasets needed for planning and decision making (Al-Kodmany, 2003).
- **Participation Enabler:** A well-designed interface encourages and facilitates public participation in planning processes. It provides a means for citizens to contribute their local knowledge, express their preferences, and be actively involved in shaping their communities (Billger, Thuvander and Wästberg, 2017).
- **Decision Support:** Interfaces can aid in decision-making by providing a platform to evaluate different planning options, assess potential impacts, and make informed choices (Hanzl, 2007). They can support both individual and collaborative decision-making processes (Al-Kodmany, 2003).
- **Visualisation Tool:** Interfaces often employ visualization techniques to represent complex urban environments and planning proposals. This can include 2D maps, 3D models, virtual reality environments, and augmented reality tools (Al-Kodmany, 2003; Billger, Thuvander and Wästberg, 2017).
- **Collaborative Space:** Interfaces can act as a shared workspace for collaborative design and planning activities. This allows multiple stakeholders to interact with the same data, share their ideas, and work together towards a common goal (Hanzl, 2007; V. Maquil *et al.*, 2015).
- **Feedback Mechanism:** Interfaces provide a mechanism for stakeholders to provide feedback on proposed plans. This feedback can then be used to iterate on and improve the design process (Al-Kodmany, 2003).
- **Tangible Interaction:** Some interfaces utilize tangible user interfaces (TUIs), which use physical objects to interact with digital information. This can create a more natural and intuitive interaction for users, especially in collaborative settings (V. Maquil *et al.*, 2015)

While the interfaces are quite critical in effective design and implementation process, there are fundamental challenges associated with implementing them effectively. Billinger et al (2017) state that One of the biggest challenges is merging both quantitative and qualitative information onto a single platform. While hard data, such as energy consumption and transportation metrics, provide measurable insights, softer aspects like user experience, safety, and comfort are equally vital for a holistic understanding—yet often more difficult to integrate.

Equally important is the effective representation of data. Information must be presented in an engaging and easily comprehensible manner, which involves carefully selecting the appropriate level of realism and detail in digital models. Striving for photorealism may sometimes conflict with the need to create virtual environments that foster a clear understanding of planning proposals. Different levels of detail may be necessary at various design stages and balancing symbolic and realistic representations through colour and object placement in 3D

models remains a challenge. Moreover, visualization tools come with the risk of misinterpretation, misuse, or even mis-empowerment. People's prior experiences, intentions, and biases can shape their understanding of images, sometimes leading to skewed perceptions. The “wow effect” of visually striking representations may also distort judgment. Therefore, it is crucial to communicate messages clearly—maximizing comprehension while minimizing the risk of misunderstanding—to ensure that visualizations serve as effective decision-making tools.

Further to this engaging a representative group of participants presents a significant challenge. Public participation initiatives frequently experience insufficient user engagement due to factors such as limited awareness, cultural barriers, accessibility constraints, or a lack of motivation. Ensuring that the system is both accessible and inclusive for a diverse range of users requires careful consideration of their digital literacy, access to technology, and preferred communication channels. Additionally, fostering a sense of being heard and recognizing the value of participants' contributions is essential. When involving children, it is particularly important to ensure they understand how their input may influence the final outcome and to acknowledge the significance of their time and ideas (Münster *et al.*, 2017).

A critical challenge lies in achieving a balance between interactivity and visualization capabilities to develop an innovative and user-friendly tool. Interactivity entails enabling users to engage in meaningful communication with the system, while visualization refers to the effective representation of spatial data to ensure clear and unambiguous interpretation (Bugs *et al.*, 2010). Urban planning projects necessitate interaction and communication among stakeholders from diverse professional backgrounds. Establishing a shared platform for discussion and fostering mutual understanding across varying perspectives presents a significant challenge. Striking a balance between interactivity and visualization is essential for creating an accessible and user-friendly system. The platform must facilitate high levels of user communication while ensuring spatial data is represented in a manner that is easily interpretable (V. Maquil *et al.*, 2015). The usability of the interface plays a crucial role in enabling both experts and non-experts to explore data effectively (Capeleti *et al.*, 2023). Issues related to the user interface, such as inconsistent cursor behaviour, can negatively impact the user experience. A notable limitation is the inability to overlap comments, which poses challenges in areas with dense information (Bugs *et al.*, 2010). User evaluations have highlighted the need for enhancements in the affordance of interactive map elements and information filtering mechanisms. Additionally, ensuring a consistent visual hierarchy and maintaining uniform colour usage are essential for minimizing user confusion and enhancing data comprehension.

4.3. AI

Regarding Evidence-Based Decision-Making in Planning (EBDP), historical evidence shows that new technologies have increasingly shaped planning practice and research, from information technology to recent data science methods and artificial intelligence (AI) (Kontokosta, 2021; Sanchez *et al.*, 2023). Notably, these technologies and methods were often developed independently of urban planning, raising important considerations for their adoption in this field. Given that urban planning relies heavily on data and that advancements in data availability align with these technological developments, AI and data science have emerged as promising tools. However, the limitations of the scientific method in urban planning are well recognized in scholarly discourse (Marshall, 2012). This section examines the role of AI in urban planning and design within this context, outlining both current applications and future potential for AI in EBDP.

4.3.1. AI in planning; applications and challenges

Given the vast implications of artificial intelligence in all science and practice domains, and its less common prevalence in urban planning and design, the application and challenges of AI in urban planning and design is much speculative, with more prevalence in certain areas. Surveys from planning practitioners in varied contexts

suggests that certain areas are perceived to be benefiting from AI application in planning practice more than others. These include transportation planning, environmental management and sustainability and healthcare planning (Yigitcanlar *et al.*, 2020; Sanchez *et al.*, 2023). This overview suggests that while there is a positive tendency towards using AI tools in urban planning and design, and there has been advances in researching AI in urban planning and design, there is still a gap between academia and practice, that must be met so that tools are developed that are relevant and practical for real-world planning challenges (Son *et al.*, 2023).

It should be noted AI and its application to urban planning emerge at a time when there is a fast-growing trend in data, informatics and digital tools when the challenges and concerns of urban planning and their scale are changing as well. Rising challenges of sustainability, climate change and population and political concerns characterise the complex and wicked problems (Bibri, 2019). With the current state of affairs, the challenges of adopting artificial intelligence in urban planning and design can be categorized into three major categories:

Technical challenges

Given the high dependency of data-driven urban planning and use of AI in transforming the big data into consumable knowledge, there appears to be much concern about the challenges of accessibility, quality and integration of data into sophisticated systems. Knowingly, access to high quality training data is necessary to develop effective AI models and gaps or biases in datasets can result to inaccuracy or discrimination (Kamrowska-Załuska, 2021; Othengrafen, Sievers and Reinecke, 2025). Further to this is a recurring issue of lack of transparency in the used algorithms used for processing and creating the models. In the research and practice of adopting AI for urban planning it has been discussed that this lack of transparency results in lack of trust among stakeholders and poses challenges for ensuring accountability (Kontokosta, 2021; Sanchez *et al.*, 2023). It should also be noted that the complexity and high order of urban systems makes it difficult for AI models capture all the intricacies and it's been advocated to shift urban modelling from macro to micro, static to dynamics and linear to non-linear to address these issues (Kamrowska-Załuska, 2021)

Societal challenges

Apart from the technical challenges in adopting AI, there are social and personal challenges that hinders the application of AI amongst planners. These include the uncertainty that application of AI brings to the practitioners in terms of job displacement and the necessity to equip the planners with certain knowledge and skillset that currently does not exist among them (Peng *et al.*, 2023; Sanchez *et al.*, 2023; Son *et al.*, 2023). Further to these, there are ethical and equity concerns around the application of AI, where the bias in algorithms, privacy, surveillance and potentially exacerbating inequalities would damage the state of the built environment. Therefore, it is necessary to implement guidelines for data collection and use, using transparent algorithms and community engagement in the process of using AI in planning and design process.

Practical challenges

There are also practical barriers and institutional limitations in the application of AI in planning and design. Firstly, it is important that AI is tech dependent and in order to implement sophisticated AI process in urban planning and design, there would have to be financial support and investment in the infrastructure and personnel. This requires partnerships with private and academic sectors (Kontokosta, 2021; Peng *et al.*, 2023). Further to this is the significant gap between the AI research and practice conventions. This suggests that there has to be user-friendly tools developed and knowledge sharing between researchers and practitioners should be promoted. Additionally, the workflows, protocols for data management must be adapted for urban planning and an effective use of evidence from AI into the decision-making process should be properly studied.

4.3.2. AI in transportation planning

Given the amount of data, areas of decision making and intricacy of automation process in transportation planning, AL tools and models can be developed to make the best use of the available and growing data and inform decision making in the design and maintenance of transportation systems. There are major areas in transport planning processes that can benefit most from AI tools and algorithms: Traffic management, public transport and logistics.

AI in traffic management

AI in traffic management offers significant improvements through real-time traffic optimization, predictive modelling, and automated enforcement. By analysing data from cameras, GPS devices, and sensors, AI can quickly detect congestion, accidents, and other issues, enabling immediate responses such as suggesting alternative routes, adjusting traffic signal timings, and dispatching emergency services. Predictive models built from historical data help forecast traffic patterns and identify future congestion points, guiding long-term decisions like infrastructure investments, congestion pricing, and flexible work policies to reduce peak-hour loads. Additionally, AI-powered cameras and sensors can automatically detect traffic violations, enhancing enforcement efficiency and freeing human resources for other tasks. (Abduljabbar *et al.*, 2019; Yigitcanlar *et al.*, 2020; Iyer, 2021; Bharadiya, 2023; Son *et al.*, 2023)

AI in public transport.

AI enhances public transportation through smart scheduling, demand-responsive systems, and improved passenger experience. By optimizing schedules and routes based on real-time demand and traffic, AI reduces waiting times, improves punctuality, and uses resources like buses and drivers more efficiently. In areas with lower population densities, AI enables demand-responsive transport, dispatching vehicles based on passenger requests for more flexible service. Additionally, AI improves the passenger experience by providing real-time updates on vehicle locations, arrival times, and delays, supporting accessibility through personalized guidance, and enhancing safety with surveillance systems that can detect and respond to potential threats. (Bibri, 2018; Abduljabbar *et al.*, 2019; Iyer, 2021; Bharadiya, 2023; Peng *et al.*, 2023)

AI in logistics

AI is transforming logistics through optimized delivery routes, efficient warehouse management, and predictive maintenance. By analysing data on delivery locations, traffic, vehicle availability, and driver schedules, AI enables more efficient route planning, leading to lower costs, faster deliveries, and reduced fuel consumption and emissions. In warehouses, AI optimizes layout and inventory levels, helping to maximize space, minimize waste, and reduce storage costs. Additionally, AI-driven predictive maintenance uses sensor data to anticipate vehicle and equipment needs, enabling proactive maintenance that lowers repair costs and minimizes downtime. (Abduljabbar *et al.*, 2019; Iyer, 2021; Bharadiya, 2023; Peng *et al.*, 2023; Sanchez *et al.*, 2023; Son *et al.*, 2023)

Through real-time analysis, predictive modelling, and automated responses, AI is reshaping how cities and companies manage transportation and logistics. By making these systems more adaptive and efficient, AI contributes to faster services, cost savings, and a better user experience, ultimately helping to create smarter, more sustainable urban environments.

4.3.3. AI in Environmental management and sustainability

Improving urban environments

AI plays a crucial role in enhancing urban environments through data-driven urban planning and smart city applications. By analysing extensive datasets, AI aids urban planning by identifying functional areas,

analysing mobility patterns, predicting transportation needs, and designing sustainable infrastructure, such as bike lanes and energy-efficient buildings. It also assesses how urban development impacts the environment and public health. In smart cities, AI-powered applications optimize traffic flow, monitor environmental factors like air and water quality, manage energy and water resources, and improve public safety by detecting and responding to incidents and emergencies. Together, these applications make urban areas more efficient, sustainable, and liveable (Iyer, 2021; Kamrowska-Załuska, 2021; Kontokosta, 2021; Bharadiya, 2023; Peng *et al.*, 2023; He and Chen, 2024; Jevinger *et al.*, 2024).

Managing environmental resources

AI plays a vital role in managing environmental resources through optimization, conservation, and predictive monitoring. In resource management, AI supports efficient water use by predicting streamflow and monitoring quality, optimizes energy production and consumption through smart grids, and aids sustainable forest management by tracking deforestation and predicting fires. In transportation, AI reduces congestion and encourages sustainable transit options. For environmental monitoring, AI models climate change scenarios, assesses its impacts, and supports adaptation strategies. It also helps track pollution, identify sources, and develop control measures, while promoting biodiversity conservation by monitoring species and managing habitats. Together, these applications enhance resource conservation and improve environmental sustainability. (Abduljabbar *et al.*, 2019; Nishant, Kennedy and Corbett, 2020; Son *et al.*, 2023; He and Chen, 2024).

By leveraging AI for smarter urban planning and proactive resource management, cities can become more liveable, sustainable, and adaptable to future challenges. AI's capabilities in optimizing resources, reducing environmental impact, and enhancing public safety make it a powerful tool in building resilient cities and protecting natural resources for future generations

4.3.4. AI in healthcare planning

As already mentioned, application of evidence-based approach in healthcare design and planning is quite necessary and challenging at the same time. As a public matter the relationship between the healthcare and spatial planning become closely dependent, and therefore understanding this relationship becomes more urgent as the application of new tools and methods such as AI becomes central to the conversation. Hence understanding the challenges of healthcare from a spatial point of view can address the areas in which AI can contribute. Significantly there are issues with spatial planning and administration that have direct association with health care. It has been observed and suggested that the unequal spatial distribution of healthcare services results in disparity in access to healthcare specially in remote and underserved areas (Bond, Cave and Ballantyne, 2013; Polo *et al.*, 2015; ZUFFADA *et al.*, 2015). Further to this, it has been observed that distance alone does not determine accessibility, as travel time and availability of public transport are also determining fact (ZUFFADA *et al.*, 2015; Khashoggi and Murad, 2020).

It is also important to note that an important aspect in optimized healthcare planning is understanding the demographic composition of the community in a spatial territory. This understanding shapes an evidence-based demand for hospitals and healthcare services as it was shown in the case of Varanasi in India (Rai and Nathawat, 2013). Further to the demographic composition, the material properties of the built environment also impact the health outcome. Urban design, housing quality and access to green space all contribute to the matter and in this regard spatial planning could hinder or promote healthy environments and living (Chang, Green and Petrokofsky, 2022).

Given the myriad of attributes and dynamic interrelationships between the driving factors, AI models and tools can be used to optimize the planning of healthcare services and infrastructure considering the growing need for such services. These applications can be categorized into four different ways:

1- **Optimising Healthcare Access and Resource Allocation**: Using GIS and generative tools, population distribution data can integrate with healthcare facility distribution, transportation networks and socioeconomic factors and identify underserved locations (Walsh, Page and Gesler, 1997; Rai and Nathawat, 2013; Polo *et al.*, 2015; Li *et al.*, 2017; Khashoggi and Murad, 2020). Accessibility models that incorporate travel time, congestion public transport availability and pedestrian infrastructure can assess how easily individuals can access healthcare services (Bond, Cave and Ballantyne, 2013; Polo *et al.*, 2015; Li *et al.*, 2017; Khashoggi and Murad, 2020). Further to this the location-allocation modelling can simulate different scenarios for placement and optimization of coverage and travel time for patients. (Polo *et al.*, 2015; Khashoggi and Murad, 2020)

2- **Promoting Healthy Environments Through Urban Design**: Through designing environments that prioritise walking, cycling and public transport, and creating interconnected networks of pedestrians and cycle paths planners can promote physical activity and reduce air pollution. This can be integrated with increasing access to green spaces and parks which correlates positively with mental health. Further to this the distribution of food outlets. Further the mapping of natural and man-made hazards that can impact health negatively can help with improving health conditions (Bond, Cave and Ballantyne, 2013; Polo *et al.*, 2015; Ige-Elegbede *et al.*, 2021; Koksal and Wong, 2023).

3- Facilitating Collaboration and Informed Decision-Making: The level of complexity and variety of expertise required in optimising healthcare indicators, necessitates a high degree of collaboration between healthcare stakeholders, planners and policy makers (Li *et al.*, 2017). Using spatial decision support systems help create a platform for exploring different options, visualizing and identifying spatial patterns in different scenarios.

4- Data processing and analysis: As stated, the plethora of datasets and information, provides an opportunity for informing the critical health conditions in spatial terms. However, the amount of data and methods of analysis may lead to computational complexity and issues around understanding the data. The integration of diverse datasets, including patient data, healthcare facility locations, transportation networks, and socio-economic indicators can improve the comprehensive healthcare planning (Virtue, Chaussalet and Kelly, 2013; Li *et al.*, 2017).

5. EBDP process

As previously discussed, a fundamental distinction between conventional and evidence-based planning and design approaches is the incorporation of an iterative process in the evidence-based approach. This iterative process continuously revises and refines advice on potential options. This review demonstrates how this iterative process influences both individual stages and the entire process, forming the core of EBDP's evolution. This dynamic indicates that the evidence-based approach draws upon various types of evidence to guide different stages of the process, commencing with the initial problem definition. Moreover, it will be later demonstrated that this iterative process itself becomes a form of evidence within the overall framework of design and planning advisory.

This section delves into the intricate details of the EBDP process, unpacking its iterative logic and the analytical nature inherent to each stage. At each stage, evidence is integrated into the analytical algorithm, with the outcomes of one stage informing the next while being subject to cyclical review for further refinement. The exploration commences with problem definition through EBDP and systematically dissects subsequent stages of the process.

5.1. Design problem definition

From an analytical perspective, advice pertaining to design and planning can be applicable at any project stage and across all aspects. This suggests that when an analytical approach is adopted for planning and design, individual preferences have a lesser impact on the project's outcome. However, the specific timing of this adoption varies, influencing the nature of evidence and the process itself. Within this framework, the problem definition stage in the Evidence-Based Design and Planning (EBDP) process caters to two distinct project types:

1- Providing support and assessment for refining existing frameworks.
2- Offering proactive guidance for uncharted challenges.

Depending on when the analytical approach is introduced, the problem definition process integrates different forms of evidence, leading to diverse advisory approaches. This concept is summarized in Figure 5-1.

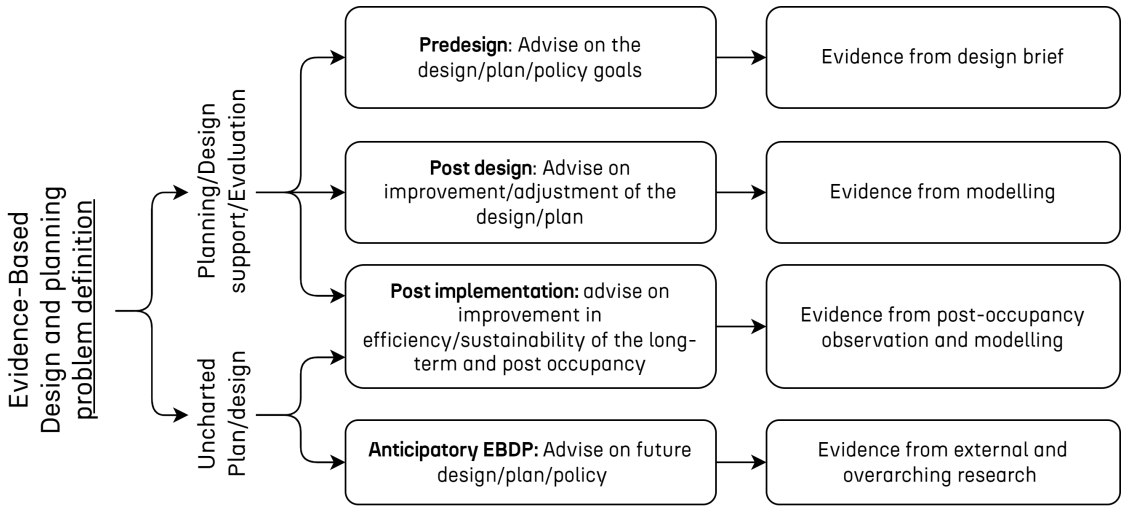

Figure 5-1 Categories on EBDP problem definition by stage of EBDP adoption and evidence

Amid shifts in both natural and environmental elements, along with transformations in human social structures, the built environment perpetually requires adjustments. Consequently, the integration of analytical and evidence-based methodologies into design, planning, and policy formulation would inherently consider these dynamics, offering remedies to facilitate such adaptations. Considering the continuous alterations in environmental and social parameters, comprehending the matter assumes diverse dimensions. As alluded to earlier, the point of incorporating Evidence-Based Design and Planning (EBDP) determines its influence, potentially altering project characteristics and involving distinct forms of evidence. This can be either the evaluation and support for ongoing projects, or anticipating possible future scenarios:

5.1.1. Evaluation and support for ongoing design and planning projects

The planning and design processes, inherently dynamic, have always positioned their agendas ahead of regulations and standards. This forward-thinking stance propels design into a continuous evaluation of the existing status quo, aiming to enhance the built environment by tapping into the manifold potentials—social, political, economic, and aesthetic—offered by human societies. Traditionally, however, this critique was rooted in non-evidential theories and ideologies. The historical trajectory of design reveals its theoretical origins in perceptions lacking substantial evidence, resulting in outcomes that often fell short of their anticipated impact. This deficiency in addressing the perpetual shifts within social and physical landscapes necessitates the infusion of evidential underpinning to inform design and planning processes.

In this context, this support manifests at two distinct junctures within the realm of design and planning. On one hand, design support and decision evaluation can galvanize the process right from a project's inception. On the other hand, the analytical approach, interwoven into interventions and design upkeep, can be introduced to enhance efficiency or rectify the deficiencies of projects already underway. This dichotomy in perspective reshapes the essence of problem definition. The scale and nature of the issue at hand determines not only the form of evidence but also the application of the analytical methodology.

Pre-design

Analytical thinking can play a pivotal role in shaping design and planning agenda right from their inception. This implies that the initial stages of project development are guided by a methodical and science-driven approach. In the context of crafting a design brief and defining objectives, the insights are derived from empirical analysis. These insights comprise factors such as design guidelines, stakeholder input, and budget constraints. At this point, the evidence primarily serves to evaluate project feasibility and objectives, thereby establishing a strategic direction for the subsequent design phase. The pre-design stage harmonizes logical analytical frameworks with design thinking, thereby aiding in envisioning a comprehensive project trajectory. In this regard, pre-design Evidence-Based Design Planning (EBDP) contributes significantly to delineating the project's managerial prospect and primarily manifests in the form of statistical syntheses.

Concurrent and post design enhancement

The integration of an analytical design and planning approach into a project can occur either during its design phase or subsequently. In this context, evidential analysis delves into the project's details and employs various analytical methodologies to evaluate its functional aspects. During this phase, evidential analysis explores the interplay between proposed spatial attributes and the underlying social, economic, or political functionality. In this perspective, the evidential basis for analysis necessitates a form of modelling or simulation. The choice of modelling techniques primarily hinges on spatial functionality, encompassing a spectrum of

simulation approaches like agent-based modelling (ABM) and cellular automata, or spatial modelling tailored to the specific design feature under scrutiny.

At this stage, EBDP directs its focus on enhancing project outcomes while working within the constraints of the ongoing design schema. From this point of view, evidence-based design and planning embody the application of logical thinking and evaluative analysis to design decisions. This could include the improvement of specific functionalities, extending operational efficiency, or minimizing maintenance costs for the design's lifecycle.

The process of defining the problem now entails engaging with the design and planning team, clients, and stakeholders. In this context, a distinctive form of evidence takes shape through the amalgamation of perspectives from the design team, clients, stakeholders, and the EBDP advisory team. As a result, EBDP emerges as a conduit, facilitating seamless communication among these stakeholders while embedding technical insights into the design process. As a consequence, problem definition at this juncture differs from the earlier stages, where the design agenda remains fluid. Problem definition now delves into resources, constraints, and a profound comprehension of ongoing processes. It's about determining what's realistically feasible and what adjustments can enhance the design's flow and outcomes.

5.1.2. Uncharted planning and design

Similar to any dynamic system, the built environment remains susceptible to change. Speculations about the functionality of a designed urban project might become obsolete over time, influenced by shifting contextual and overarching processes. Consequently, this perpetual evolution permits the assessment of an implemented project. This viewpoint permeates the design, or even re-design, problem with a distinct trajectory, thereby rendering the problem definition inherently dissimilar to a project in design phase. Similarly in cases where the changing nature of the built environment necessitates a design project not envisioned within the preexisting developmental framework of an area. In such cases, the problem definition demands an input that diverges from the established norm and the overarching agenda.

As Carmona (2021, p. 41) points it out, shaping the built environment as a process tends to take over the processes of contemporary polity, and in-spite of stable norms in a social, political or economic context, suggests changes or modifications to the urban setting that have not had a precedent in the context. This uncharted urban design and planning approach allows for sustainable flexibility that accommodates enforced uncertainty (Roggema, 2016).

Post implementation assessment

As previously mentioned, both the externalities of a project and its implementation can undergo change. Nonetheless, it's not automatic that adjustments, implying redesign and re-planning, are always anticipated alongside evolving contextual conditions. Changes in overarching policies, shifts in environmental conditions, or alterations in resource requirements for establishments are reasons prompting post-implementation assessments of projects. In this scenario, problem definition revolves around crafting a future for a plan or building that remains adaptable to ongoing and prospective changes.

In this context, problem definition in design and planning underscores the need to respond to evolving circumstances. Here, inputs for problem definition are drawn from both the existing status quo and the trajectory of changes. Consequently, information pertaining to the functionality of the implemented project, alongside insights into new overarching processes, needs to be integrated into the modelling and re-evaluation process.

Anticipatory EBDP

Anticipatory EBDP arises in scenarios lacking a prior design and planning framework. Proposed design or planning agendas stem from overarching research, identifying potential benefits, added value, or risk mitigation in the future. Consequently, project problem definition involves a fusion of spatial analysis and overarching research, encompassing political, economic, or social dimensions. In such cases, the problem definition aims to employ analytical design and planning thinking to enhance existing conditions, addressing unforeseen shortcomings absent in previous development documentation.

5.2. Forms of analysis

5.2.1. 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, etc

Table 5-1 Empirical vs. Quantitative methods of analysis

5.2.2. 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.

5.3. Data collection and modelling

With the introduction of EBDP, and its approach to integrate evidence, in form of quantified data, it is essential to understand how the feedback loops are informed through different layers of data throughout the work. Given the plethora of spatial or geo-tagged generated data every second, collecting, maintaining, and using the data in an informed manner is the core to the technical development of EBDP. Significant to EBDP and generally applicable to all data-centred methods, there must be a data collection pipeline that is informed and justified by the scale, and intent of the project.

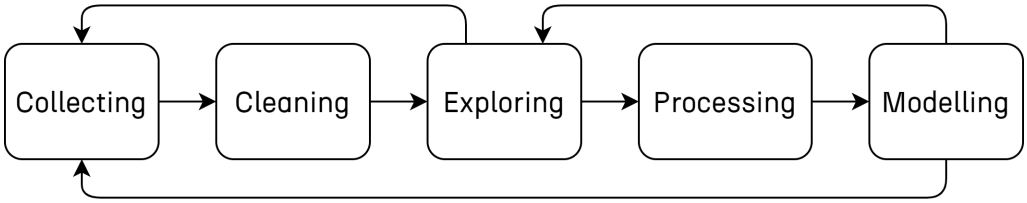

Figure 5-2 General EBDP data collection pipeline. Adapted from (David S. Jordan, 2023)

As the platforms and methods of manipulation, analysis and visualization of data have grown exponentially, spatial and/or geo-tagged data is available in various formats and resolution. Upon justifying the intent of the research, there would be an initial phase of collecting data that comes from various sources including GPS, high-res remote sensing, location-aware services, surveys and internet volunteered geographic information (Goodchild, 2007; Mennis and Guo, 2009). These series of data import direct attributes that associated with spatial properties would provide new information. Thus, in the first instance the varied data formats need to be cleaned and reformatted down to the same spatial setup. In this regard the input data can be direct collection (See Figure 5-3) of features with spatial properties or the indirect intrinsic properties of the spatial features, such as network centrality values.

With regards to direct inclusion of data with spatial feature, it is important to notice that collected data mentioned above essentially represent two different types of features. The first one represents static material features such as buildings or natural features, which are surveyed and mapped. The accuracy of such datasets depends on the resolution of observation and is subject to temporal changes. The second type represents recorded data associated with a specific spatial unit – a room, street, 10x10km land grid, etc– and comes as aggregated values in relation to the spatial unit. The example of this is the vehicular speed data in a street, or the temperature of the room.

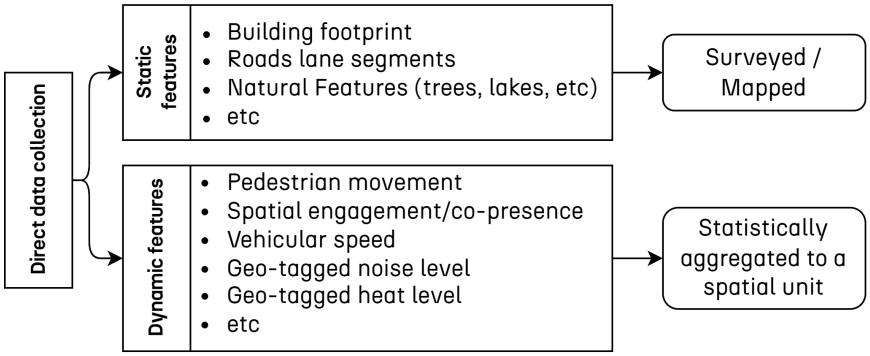

Figure 5-3 Dynamic and static spatial features

On the other hand, there are intrinsic information to the spatial features that are nor directly observable and/or collectable. This type of data can be inferred either from the geometrical, relational properties of the static or dynamics features. In this case the dataset will be collected through a primary calculation, and the attributes may be model size dependent. Examples of this type of data are centrality values of roads in a road network or floor to height ratio and built density of an urban fabric.

Further the aggregated dataset is always subject to scrutiny and cleaning. The goal for this investigation step is to have a consistent spatial database (Brisaboa *et al.*, 2015). As Brisaboa et al. show, cleaning is essential as datasets coming from various sources would naturally contain definitions that do not match. Therefore, with constraints set on a data base, various cleaning processes would have to enforce such constraints to address the inconsistencies. This means that for a model or spatial database a series of valid states must be defined that ensure the input and manipulation of the data produces dataset with a state of integrity. Deciding these constraints depends on an evaluation and availability of data, where the unyielding and inevitable dataset determines most of such constrains. An example of this is a 1km-by-1km population dataset that is necessary to the model, and thus all other datasets have to be reconfigured and cleaned to this resolution. The aggregation and cleaning cycle will further provide evidence into the modelling process which could initiate another round of data collection/aggregation, until the modelling criteria as well as the integrity constraints are satisfied.

Upon data collection, there are various ways in which the data can be modelled that informs the research questions. These can be modelling relationships, interaction or theoretical frameworks that are schematic representations developed for understanding and explaining reality (Haggett, 1965). There are various logical frames for modelling approaches that involve reality monitoring, deductive reasoning and simulations (Sanders, 2007, p. 26). Depending on the modelling question the initial step involves identifying the elementary objects for data collection. From this point of view the dynamic frameworks (measuring change) pose a challenge as there are always changes in semantics, identifiers and spatial extent of the objects (Cheylan and Lardon, 1993). Given the unequal distribution in space causing differentiation, segregation and discontinuities, and the constant

feedback loop existing between society's organization and spatial configuration, the next step would be to select the appropriate model and method of spatial analysis.

From the modelling perspective, once collectable objects are identified methods for measuring change need to be established. Here there are two categories of model to structure the procedure. the conceptual models can relate chosen indicators to the investigated phenomenon and data intensive models organize thematic and geometric information. These models need to be formalized which can happen in various ways:

- Geomatics Approach: Utilizes GIS functionalities for spatial analysis and find evidence of possible spatial regularities.
- Statistical Framework: Involves identifying explanatory and dependent variables, employing statistical models to test the relevance of the relationship between some of the variables. This can vary from basic relations to more complicated probabilities (Ripley, 2004)
- Dynamic Models: These are beneficial to investigate complex properties of spatial organizations. These include but are not limited to fractal and percolation analysis (Batty and Longley, 1994; Arcaute *et al.*, 2016)
- CS Framework: Utilizes cellular automata (White and Engelen, 1997) or multi-agent systems (Kowalski, 2019) for simulations.

The spatial models can also be classified based on their aggregation approach, determinism and dynamism. Sanders (2007) suggests a classification based on these three criteria, that facilitates with model selection when initiating with a project.

Aggregated models	Static	Deterministic	Traditional models of geography – Christaller
		Probabilistic	Distribution models of random points digital terrain models
	Dynamic	Deterministic	Models with differential equation
		Probabilistic	Diffusion models
Disaggregated models	Static	Deterministic	Urban Land Use Allocation model
		Probabilistic	Choice models
	Dynamic	Deterministic	Cellular automata
		Probabilistic	Microsimulation

Table 5-2 Classification of spatial analysis models. Adapted from (Sanders, 2007)

The technical and analytical variety of spatial modelling and analysis will be further explained.

5.4. Options Explorations

As explained in data collection and modelling, the approach to understanding the impact of imposing certain changes to a context can take into account different aspects of the built environment. Accordingly, generating options through adoption of each of these models will result in optimization of the very object that they model explains. From the modelling point of view, various models were designed to explore options by variations of a limited number of variables, thus showing possible outcomes in an isolated way. In smaller scales design problems – i.e., architectural design – single objective optimization methods (Koenig *et al.*, 2020) such as evolutionary system (Janssen, 2009), parametric modelling (Turrin, Von Buelow and Stouffs, 2011) and generative design (Stouffs and Rafiq, 2015). For the large-scale design problems – i.e., urban design and planning – the design exploration methods to a large extent depend on spatial analysis methods. However, due to complexity of urban issues, the models are hybrid and would optimize more than one objective. Koenig et al. (2020) proposed a model integrating urban analysis, generative design and evolutionary optimization, Celani et al. (2011) combined shape grammar and genetic algorithms, and Motieyan and Mesgari (2018) used an agent-based model for optimizing land-use and transport planning.

These approaches mutually insinuate that in-spite of the multiplicity of a design complication, there is always a limit - in input data and computational power - for optimization. Common in science and engineering as well, this frames a general problem associated with options exploration and decision making, where a multi-attribute utility function (Von Winterfeldt and Fischer, 1975) is not easy to establish. This is generally due to the fact that objective weighting has not been investigated or structured a model. As a way of optimizing the choices, as well as the process of generating choice, a multi-criteria average-weighted model (FILIP, 2018) can address this issue. However, coming from other disciplines, this needs to be adopted for spatial analysis models.

To put it simply, devising a weighted – or scoring – system for generating options for a design or planning problem, changes the nature of the problem from a complex issue into a non-linear and iterative cycle, where through unravelling the implications of the design objective, the weighting for certain inputs change. As

5.5. Evaluations cycle and iterative feedback

Given the high order of urban systems (Forrester, 1969) and the multitude of information, analytical output and evidence that can potentially inform the design and planning process, the iterative feedback loop of EBDP can get complicated and computationally expensive very quickly. This as well as the variety of information formats that feeds the iterative process suggests that the design and planning process – where budgetary considerations are met – can be dealt with as a system dynamics problem, where the iterative feedback loops are looked at as evidence, refining and optimizing the process. With such level of complexity and number of inputs, on the one hand and the promise to reach out the wide community of users – planners, designers, policy makers etc – who possibly lack technical knowledge and have no empathy for such level of technicality, the EBDP evaluation cycle and feedback loop would develop into different stages of intensity

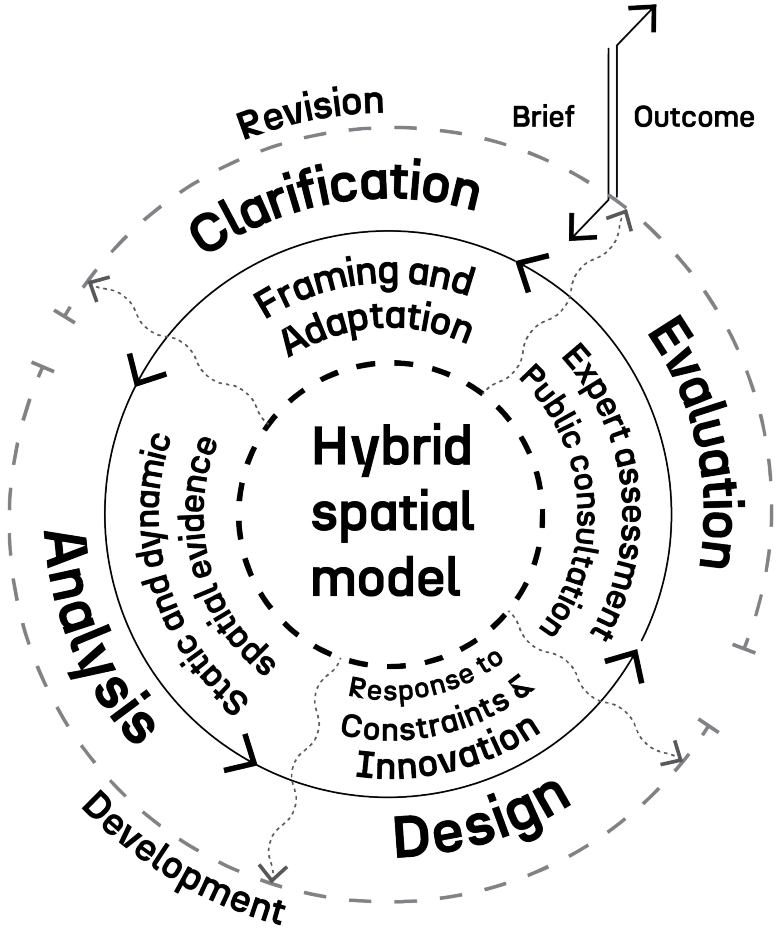

Figure 5-4 A possible scenario for an optimized feedback loop that incorporates different formats of evidence.

6. Application of the conceptual framework in TWIN2EXPAND research project

The following three projects demonstrate how the conceptual framework of Evidence-Based Design and Planning (EBDP), developed through the TWIN2EXPAND initiative, was operationalised through structured experimentation across diverse spatial scales, methodological intensities, and institutional settings. As both a research platform and a capacity-building programme, TWIN2EXPAND placed evidence-based thinking at the centre of its scientific strategy—prioritising methodological innovation, iterative development, and institutional learning over linear or prescriptive models of practice.

Each of the three projects was deliberately structured to explore a different aspect of EBDP application, enabling a multi-scalar and layered investigation into how the framework performs under real-world conditions. The first project was foundational and horizontal in scope, focusing on the collection, preparation, and management of spatial and non-spatial datasets, as well as conducting a critical review of current research and practices in EBDP. It provided the infrastructural and intellectual groundwork needed for subsequent methodological development. The second project served as the core vertical research component, aimed at robustly framing key spatial planning challenges and advancing a cohesive conceptual model for EBDP. This

included evaluating the adaptability of analytical methods across contexts and identifying their limits and potential. The third project was derivative and vertical, applying the developed methods to real-world challenges—particularly those related to the Sustainable Development Goals (SDGs)—and producing transferable outputs, policy insights, and dissemination tools. It acted as a testbed for applied research, bridging theory with action through stakeholder engagement and communication strategies.

Across these three strands, the EBDP framework was not imposed as a fixed sequence but used as a flexible and evolving guide—capable of informing analysis, design generation, and evaluation. Rather than aiming to enact the entire EBDP cycle in each case, the projects served as targeted research probes designed to test the framework's robustness, refine its methodologies, and assess its practical feasibility. In doing so, they revealed how iterative, evidence-driven engagement—whether through hybrid spatial modelling, community-led insight gathering, or scenario testing—can progressively sharpen both the problem framing and the analytical tools used to address it.

Ultimately, these projects reflect the central ambition of TWIN2EXPAND: to enhance scientific excellence in evidence-based urbanism by building a resilient, adaptive, and transferable framework that is responsive to the practical complexities and policy demands of contemporary spatial planning and governance.

6.1. A Lightweight Modelling Approach for EBDP in the EU: Enhancing Replicability and Comparative Analysis

The SOAR (Scalable, Open, Automated, Reproducible) project addresses a persistent challenge in urban design and planning: the absence of scalable, comparable spatial data suitable for evidence-based analysis across multiple cities. Conventional spatial workflows—relying on detailed modelling of street networks, land use patterns, and demographic data—are typically resource-intensive, time-consuming, and dependent on specialist skills. As a result, most practitioners and researchers are unable to construct datasets for location-specific insights or of sufficient quality and coverage to support cross-city or generalisable studies. SOAR explores the feasibility of automating such workflows by integrating open-access, pan-European datasets—Eurostat's census and high-density cluster data, Copernicus Urban Atlas, and Overture Maps—via the open-source cityseer Python package. The project applies this framework to 699 EU towns and cities, generating metrics for street centrality, land-use proximity, building and block morphology, access to green space, and interpolated census attributes. A core aim is to evaluate how well such a workflow can support methodological consistency and comparability across diverse urban contexts. SOAR's contribution lies in testing the limits of open, automated workflows for urban data production and assessing their potential to inform future research, planning, and policy across varied geographies.

6.2.The applicability of EBPD in different planning contexts and scales

The central objective of this research is to evaluate the applicability of Evidence-Based Design and Planning (EBDP) methodologies within varied planning contexts, particularly those characterised by limitations in data availability, data quality, and institutional capacity. Using Cyprus as a case study, the research seeks to advance the operationalisation of EBDP by developing a methodological framework that is both adaptable and transferable across diverse planning scenarios, including those situated in resource-constrained environments. The study's methodological design involved two principal lines of inquiry. The first examined the extent to which spatial models constructed using open-access and automated data sources could yield robust and policy-relevant insights. These models were systematically compared with counterparts derived from conventional, manually assembled, and officially sanctioned datasets to assess their validity and analytical rigour. The second dimension of the evaluation focused on the practical application of the proposed approach within real-world planning

processes. This was operationalised through six case studies at varying spatial scales—encompassing local urban settings, regional districts, and the national context—thereby enabling an assessment of the methodology's scalability, contextual adaptability, and resilience to data-related constraints. By situating the analysis within the broader discourse on evidence-based planning, the study contributes to ongoing efforts to democratize planning tools and techniques, especially for contexts where traditional data infrastructures are weak or fragmented. The findings underscore the potential of open and automated data-driven approaches to support more inclusive and context-sensitive planning practices.

6.3. Evidence-based Design and Planning (EBDP) for and under climate emergency

To achieve global sustainability goals, planners and decision-makers worldwide have adopted strategies that promote denser cities. However, while higher densities can have positive effects at larger scales, they often have negative effects locally. Among these is the loss of biodiversity, which is crucial for human health and well-being. The question, then, is: If density is the pathway toward sustainable urban development, can we still build denser cities without jeopardizing biodiversity?

To answer this, we need empirical evidence and data on urban biodiversity at high spatial and temporal resolution. In this project, we overcome the limitations of conventional ecological data collection methods (e.g., field observations/counts and citizen science) and leverage advances in low-cost acoustic sensors and deep learning to systematically collect data on avian diversity across three types of dense urban areas/forms in Gothenburg, Sweden. The results aim to provide a better understanding of the relationship between the characteristics of different types of dense urban forms and various biotic conditions in cities.

7. Discussion and conclusion

This report investigates the growing integration of data-intensive and computationally analytical methods in urban planning and design, with a particular focus on formulating a coherent framework for Evidence-Based Design and Planning (EBDP). The aim is to critically examine how empirical and data-driven approaches reshape conventional practices, while addressing both theoretical and practical considerations inherent in their adoption. The impetus for this inquiry stems from a fundamental critique of traditional urban planning paradigms—rooted in philosophical, aesthetic, or ideological models—that have historically lacked empirical validation and systematic evaluation.

The report begins with a historical contextualization of how urban planning and design transitioned from intuition-based and normative approaches toward more rational, scientific methods during the 19th and 20th centuries. This transition marked a turning point wherein logic, empiricism, and positivist thought started to influence the design disciplines. However, as the report illustrates through a review of scholarly critiques, these early attempts—epitomized by modernist planning doctrines—were often flawed. While scientifically inspired, they neglected the complexities of social dynamics, human scale, cultural specificity, and environmental sustainability. The resultant urban environments, characterized by homogeneity, segregation, and ecological degradation, underscore the inadequacy of purely technocratic planning approaches.

These historical limitations provide the critical foundation upon which EBDP emerges. Rather than rejecting empirical methodologies outright, EBDP seeks to refine them by embedding a more context-sensitive, interdisciplinary, and reflexive understanding of what constitutes valid "evidence." The report explores how evidence is conceptualized not merely as quantifiable data, but as an integrated assemblage of social, spatial, economic, and environmental indicators that can inform design decisions. Drawing on contemporary European scholarship, the report highlights instances where evidence-based frameworks have been cautiously applied to policymaking and urban development, offering early models of hybridized, empirically grounded planning practices.

The report then traces the intellectual lineage of EBDP through various theoretical currents that have incorporated evidence as an essential design input. A chronological exploration reveals a shift from narrow empirical reasoning to a more expansive and multidimensional interpretation of evidence. Spatial analytics, behavioural data, and socio-economic metrics have increasingly become part of the design toolkit. Among these, the Space Syntax methodology is singled out for its pivotal role in reconceptualizing the relationship between spatial configuration and human behaviour. By positing that spatial form and social processes are co-constitutive, Space Syntax provides a rigorous analytical framework through which design and planning can be evaluated and iteratively improved.

Subsequently, the report examines the technical apparatus and methodological trends shaping contemporary evidence-based planning. It observes a paradigmatic shift from static modelling and GIS-based tools toward more dynamic, code-based environments. This shift enables higher degrees of automation, reproducibility, and customization—qualities increasingly demanded in the face of complex urban challenges. The emergence of computational urbanism and the "science of cities" underscores the growing appeal of scientific and data-driven methods. However, the report is careful to note existing limitations, such as the lack of field validation ("ground-truthing"), and the persistence of disciplinary silos, which often hinder the full integration of analytical findings into design practice.

In addressing future trajectories, the report explores the intersection of EBDP and artificial intelligence (AI). It surveys the state of research and application in this area, finding that AI is beginning to function as a powerful

extension of EBDP, particularly where massive datasets, real-time monitoring, or predictive analytics are involved. In domains such as climate adaptation, urban health, and ecological resilience, AI-enhanced EBDP provides planners and designers with unprecedented analytical capabilities. These tools help shift the profession away from reliance on intuition or prescriptive models, especially where design decisions carry significant societal and environmental consequences.

The final section of the report presents case studies of successful implementation of EBDP in professional practice, focusing on research-driven consultancies and academic spin-offs. Space Syntax Limited, derived from University College London, and the SURF Lab at the University of Cyprus are examined in depth. Both institutions exemplify how EBDP can be operationalized through a structured, multi-stage workflow in which evidence is not only consumed but also continuously generated throughout the design process. Two central themes emerge: first, that EBDP is inherently iterative, with feedback loops embedded at every stage to allow for recalibration and adaptation; and second, that spatial logic—whether through syntactic models, simulation engines, or spatial network analytics—serves as the epistemic core of the entire process. This central logic evolves over time, enriched by new insights and cross-disciplinary evidence, ensuring that the planning process remains both rigorous and responsive.

In sum, the report argues that EBDP offers a promising alternative to both conventional and overly technocratic planning methods. Its emphasis on iteration, integration, and empirical rigor reflects a maturing discipline that is increasingly equipped to tackle the complexities of contemporary urban life. However, the report also calls for continued research into the epistemology of evidence, the ethics of data use, and the institutional frameworks needed to mainstream these methods into practice.

8. Glossary

Cases

CLI: Command Line Interface 50, 51

DDD: Data Driven Design 8

EBDP: Evidence-Based Design and Planning ..... passim

GUI: Graphic User Interface 50, 52

RID: Research Informed Design 8

9. Bibliography

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