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Framing Evidence-Based Design and Planning: An Analytical, Multi-Scalar and Iterative Framework for Urban Design and Planning

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Abstract

The increasing complexity of urban environments has exposed the limitations of prescriptive approaches in urban design and planning, highlighting the need for more adaptive, data-informed, and methodologically rigorous processes. Evidence-Based Design and Planning (EBDP) offers a promising response by embedding evidence as a continuous and iterative element throughout design and decision-making. Yet, its adoption in practice remains uneven, constrained by project limitations, data availability, and the challenge of operationalising analytical workflows. This paper addresses these challenges by proposing a transferable framework for EBDP, developed through the review of six realised projects, ranging from public space enhancements to metropolitan masterplans and policy studies, undertaken in both professional practice and academic research. Examined alongside existing theoretical models, these cases revealed recurring patterns that informed the framework. The resulting model consists of four interlinked phases: clarification and evidence-based project definition; integration of an evidence base through analysis and modelling; generation of options synthesising diverse evidence; and evaluations to guide adaptation and decision-making. Rather than a linear or prescriptive sequence of stages, the framework uses iteration and flexible feedback processes anchored by a unifying Hybrid Spatial Model to synthesise evidence, support the generation of design options, and underpin engagement and feedback processes considering project objectives. This paper offers a systematic yet flexible framework for EBDP that can be adapted across scales, project types, and contexts.

Keywords: evidence-based design and planning (EBDP); analytical workflows; iterative feedback loop; hybrid spatial models; space syntax; spatial configuration

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1. Introduction

Rather than relying solely on precedent, intuition, orthodoxies, or pre-assumptions, Evidence-Based Design and Planning (EBDP) incorporates empirical research and analytical methods in the shaping of the built environment. The growing complexities of urban planning and design in relation to social, economic, and environmental impacts make EBDP-grounded approaches increasingly important. Emerging tools and datasets further support its potential adoption.

While the theoretical principles of EBDP have gained significant traction, it remains challenging to translate these into an adaptable process that can be operationalised within the complex, real-world constraints of professional practice. To do so effectively, it must remain open to ongoing adaptation, feedback, and evaluation so that it can integrate data and evidence-informed analysis with insights from stakeholders and experts.

This paper addresses this challenge by asking the following: how can EBDP be framed for effective use in practice? To answer this question, we compare and analyse the workflows of six projects, from both mature professional practice and emergent academic research environments, that are diverse in their scale, context and implications. Through this comparative analysis, we identify recurring patterns and core methodologies encountered in the application of EBDP across varied scales and contexts of application. This work is then synthesised as the basis for a proposed EBDP framework bridging theory and practice.

1.1. Overview

The integration of evidence into planning and design has a complex historical trajectory, gaining momentum in response to the limitations of both traditional and modernist paradigms. This lineage can be traced to early ideas such as the 'diagnosis before treatment' ethos found in the work of Patrick Geddes, whose survey-analysis-plan methodology emphasised contextual observations and site-responsive interventions [1]. The influential critique of mid-20th century modernist urban renewal, in the writings of Jane Jacobs and Christopher Alexander, further reinforced the need to ground planning decisions in the empirical reality of urban life rather than ideologically driven modernist paradigms [2,3]. More recently, the scope and ambition of EBDP has been broadened by a confluence of expanded data availability, advanced analytic techniques, and the emergence of Artificial Intelligence, giving rise to new paradigms such as the 'Science of Cities' [4].

EBDP can be situated within the broader landscape of evidence-based approaches by distinguishing it from two related paradigms: Research-Informed Design (RID) and Data-Driven Design (DDD). While all three paradigms share an emphasis on embedding knowledge into the design process, they vary in how they define evidence, structure workflows, and incorporate human judgment. RID, as described by Peavey and Vander Wyst [5], focuses on understanding specific topics through targeted research and the application of these insights to inform design intentions. DDD, by contrast, emphasises computational and algorithmic approaches that use large-scale data sets to generate optimised design solutions, with minimal human intervention [6]. EBDP synthesises aspects of both approaches, but places stronger emphasis on iteration and improvement, contextual interpretation, and the use of diverse evidence types, including both qualitative and quantitative inputs, but particularly obtained through a rigorous, analytical process. The key attributes distinguishing the three paradigms are summarised in Table 1.

While the boundaries between these approaches are not absolute and often blur in practice, recognising their conceptual differences is helpful for framing appropriate workflows. As computational methods and interdisciplinary research continue to evolve, EBDP offers a middle ground: sufficiently systematic to leverage formal analytics, yet flexible enough to incorporate expert judgment, stakeholder feedback, and contextual nuance.

Zeisel [7] outlines four categories of evidence that have been associated with design: personal experience [8,9], direct observation [10], the reflective writings of designers [11], and analytical reviews of implemented projects. Though often qualitative, these sources contribute to a cyclical, feedback-based design process in which initial ideas are continuously refined; an iterative principle that forms a common thread linking traditional experiential practices (in the sense argued by Alexander), with contemporary data-intensive methods. Building on this, Carmona [12] distinguishes between "self-conscious" planning processes, which are top-down policy-driven interventions shaped by formal constraints, and "unselfconscious" approaches, which evolve incrementally through adaptive and more informal decision-making processes. Carmona proposes an integrated planning logic embedding structured feedback within procedural planning models. His six-stage linear model—goal setting, analysis, visioning, synthesis and prediction, decision-making, and evaluation—closely parallels Zeisel's feedback cycle and supports a more dynamic model of evidence integration.

Table 1. Overview of analytical methods for design and planning.

Aspect	Data-Driven Design (DDD)	Research-Informed Design (RID)	Evidence-Based Design & Planning (EBDP)
Source of Input	Quantitative data (e.g., sensors, usage patterns); algorithmic generation	Specific case studies and prior research	Broad range of evidence generated through exploration of data, the literature, expert input, and particularly systematic analytics
Process Approach	Automated, metric-based optimisation	Insight-led, applying research findings	Iterative, evidence-integrated with human judgment
Role of Human Input	Minimal during design generation	Interpretation of research to inform design	Active throughout; evidence interpreted and applied contextually
Design Output	Optimised solutions based on preset metrics	Options guided by research insights	Refined options shaped by feedback loop and stakeholder input
Flexibility	Low; agenda fixed by initial metrics	Moderate; dependent on relevance of research cases	High; agenda evolves as evidence is gathered and interpreted

In architecture, evidence-based design (EBD) gained recognition in the 1980s, particularly in the healthcare sector where the need to quantify the impact of spatial decisions on patient outcomes led to a more empirical, outcome-focused approach. This shift produced a well-established research base [13–16], eventually influencing architectural education and practice more broadly. However, the translation of EBD principles from architecture to urban design and planning presents additional challenges. In architecture, the smaller and more focused scale of intervention allows for greater control, thereby permitting more direct forms of experimentation and measurement (e.g., post-occupancy evaluations). This is in contrast to urban-scale projects, which are influenced by multifactorial and emergent forms of behaviour [1], making assessment more difficult. Additionally, the time lag between planning, implementation, and use can make it harder to assess and facilitate interventions based on real-world feedback.

It is necessary to acknowledge the limitations of data-informed approaches in urban planning. As Marshall [17] and Raford [18] argue, the adoption of quantitative methods in planning brings with it methodological caveats: the risk of misinterpreting abstracted data, over-reliance on computational precision, underuse of domain knowledge, and practical constraints such as limited funding or trialability. These limitations are not necessarily seen as reasons to dismiss data-informed approaches but serve to highlight the need for critical and reflective application of quantitative forms of evidence.

1.2. Emerging Evidence and Toolsets

Several theories of urbanism, originally qualitative, can increasingly be operationalised through evidence-based methods. Empirical studies now link urban form to health, mobility, equity, and sustainability outcomes. In parallel, increasingly accessible spatial analytics tools enable iterative design testing capable of bridging theory with measurable impacts. For example, emphasis on walkable street networks and coherent public spaces, long inspired by the work of Lynch [19], Jacobs [2], and Alexander [20], have been validated by studies correlating street network centralities, density, mixed-uses, and access to green spaces with factors such as walkability, health outcomes, and environmental benefits [21–25].

These forms of empirical research, emerging toolsets, and analytical frameworks support the translation of conceptual urban qualities into measurable parameters. For example, space syntax [26,27], which models spatial configuration in relation to movement, and Spacematrix [28], which offers a multidimensional framework for urban density by modelling the interrelation of floor space index, ground space index, and network connectivity. Similarly, evaluations of urban-scale interventions are increasingly feasible; for example, an assessment of Barcelona's superblocks and their impact on reducing mortality and improved quality of life [29,30]. Likewise, insights into the relationship between urban form and timely policy interventions are increasingly tangible; for example, studies confirming the link between compact and walkable forms of urbanism and transport behaviour in light of emissions reduction, emphasising the important role of urban planning in addressing climate-change mitigation [31,32].

Despite the growing body of evidence linking urban form to health, environmental, and social outcomes, these analytical and evidence-informed approaches have yet to be adopted more broadly by urban design and planning practice. We postulate that this can be attributed to several interrelated challenges. Firstly, many approaches lack a coherent spatial theory mapping morphological patterns to observed outcomes. Secondly, the absence of easily replicable practice-oriented workflows and tools limits the translation of these insights into design processes that professionals can readily apply. Thirdly, real-world applications often face practical constraints, including client-driven priorities, limited resources, and uneven data availability which may hinder the integration of analytical methods into routine decision-making. As a result, while these theories, studies, and tools have advanced our understanding of evidence-informed design principles, they have not yet merged into a replicable methodology capable of shaping mainstream planning and design practice.

The trajectory of the preceding literature and its relevancy to the continued evolution of EBDP is summarised in Table 2.

Table 2. Summary of literature on the evolution and trajectory of EBDP.

Theme	Summary of Findings
1. Origins and Evolution of EBDP	EBDP emerged as a response to both traditional and modernist shortcomings in urban planning, emphasising empirical observation and contextual understanding. Early influences such as Geddes's survey-analysis-plan model [1] and critiques by Jacobs and Alexander [2,3] shaped a shift toward evidence-grounded design. Advances in data availability, analytics, and AI have since expanded EBDP's scope, contributing to new paradigms like the "Science of Cities" [4].
2. Conceptual Position within Evidence-Based Approaches	EBDP sits between Research-Informed Design (RID) and Data-Driven Design (DDD). While RID focuses on targeted qualitative research [5] and DDD relies on computational optimisation [6], EBDP integrates both, combining quantitative analysis with expert judgment and stakeholder input. It promotes iteration, contextual interpretation, and feedback as key mechanisms of design.

Table 2. *Cont.*

Theme	Summary of Findings
3. Operationalisation and Tools	Theories by Lynch [19], Jacobs [2], and Alexander [20] on urban form, legibility, and human-scale design have been increasingly validated through analytical methods linking form to outcomes such as health, mobility, and sustainability [21–25]. Tools like Space Syntax [26,27] and Spacematrix [28] translate these theories into measurable parameters, enabling practical assessment of interventions (e.g., Barcelona's Superblocks [29,30]).
4. Ongoing Challenges and Limitations	Despite theoretical and technological progress, EBDP remains difficult to apply broadly in professional practice. Key barriers include: (1) lack of coherent spatial theory linking design to outcomes, (2) limited availability of replicable, practice-oriented workflows, and (3) practical constraints such as resources, timelines, and data availability [17,18,31,32]. These issues highlight the need for adaptable frameworks that balance analytical rigour with contextual flexibility.

2. Methodology

While challenges such as data complexity, skills gaps, and project constraints may hinder wider adoption of EBDP in practice, the provision of a coherent framing may help to guide the broader understanding and adoption over time. This leads to a central question: How can EBDP be framed for effective use in practice?

To aid in answering this question, we provide a comparative review of real-world projects that have employed evidence-based approaches. A dual-perspective analysis draws on two distinct contexts of application to explore the potentially diverse ways in which EBDP is operationalised under real-world constraints. The first perspective is taken from established professional practice, represented by Space Syntax Limited (SSL), a consultancy spun off from UCL (University College London) in 1989. The SSL cases offer insight into how EBDP methods are developed and applied under the commercial and logistical demands of projects ranging from street-level to metropolitan masterplans. The second perspective is from an emergent academic context, represented by the Society and Urban Form (SURF) Lab at the University of Cyprus. The SURF cases offer insight into how new theories and analytical methods are translated into application through partnerships with local governance. By examining these complementary viewpoints, we seek to identify the shared challenges, strategies, and workflows that are used to formulate a generalisable approach to EBDP in practice.

The selection and documentation of the case studies is guided by several key considerations. First, to support a more generalisable model, projects were chosen to broaden consideration across varied contexts. Cases were selected from diverse geographical locations, across multiple scales, and with differing implementation periods. Second, the projects were selected for their contribution to understanding EBDP through aspects of technological innovation, methodological development, or enhanced public and expert engagement. Third, access to these projects was facilitated through the TWIN2EXPAND research consortium (for more information see the note on 'Funding' at the end of this article), which enabled discussions with project representatives. This allowed the reconstruction of project workflows to understand how they were adapted within professional practice to account for constraints such as client requirements, limited resources, tight timelines, and data availability. Finally, projects were selected where sufficient documentation was available, and details of the projects could be publicly shared.

The projects were reviewed in two stages. Firstly, a high-level review and summary of each project was compiled, providing an overview comparison of the respective projects regarding the incorporation of evidence-informed procedures. Secondly, a comparative framework was defined through the lens of the preceding literature review to further clarify commonalities or differences across projects. It is important to note that the examined cases do not aim to represent the full range of possible scenarios in urban design and planning. The intention is rather to identify broad, transferable patterns that are commonly encountered across EBDP projects. Secondly, while EBDP can be applied at multiple scales, this review focusses on the urban scale, ranging from public spaces to master plans, and excludes architectural and regional or sub-regional scales, where the complexities specific to these, fall beyond the scope of this review.

Comparative Framework

The methodologies proposed by Zeisel [10], Carmona [12], and Karimi [27,33,34] demonstrate a continuous line of research with several elements in common. The models emphasise the incremental development of design options through reflection on the initial brief, context, resources, and constraints, supported by expert feedback and evaluation. These elements inform the following comparative framework, which is used to contrast application across the selected projects.

A. Project Vitals and Context.
  - Project Identification: Title, Client, Location, and Year.
  - Scale of Intervention: e.g., Street, Neighbourhood Block, City District, Metropolitan Region.
  - Primary Objective: What was the core problem or goal as defined in the project brief?
  - Key Constraints: Were there any notable constraints affecting the project? (e.g., Budget, timeline, political factors, data availability or quality).

B. The EBDP Workflow in Action.
  1. Clarification & Objectives:
     - How was the initial brief translated into specific analytical questions?
     - What methods were used to clarify the problem (e.g., stakeholder workshops, preliminary data review)?
     - What was the final, refined problem statement that guided the analysis?
  2. Analysis & Modelling:
     - What specific evidence was generated (e.g., accessibility models, network analysis, land use metrics)?
     - What primary analytical tools were used (e.g., GIS, custom scripts)?
     - What important insights emerged from this stage?
  3. Design & Option Generation:
     - How did the evidence from the analysis stage inform the creation of design options or strategic principles?
     - Were multiple, distinct options generated to address the problem?
  4. Evaluation & Decision-Making:
     - How were the design options tested or compared (e.g., comparative modelling, expert review, public consultation)?
     - Who was involved in the final decision-making process?
     - What was the ultimate outcome or selected design direction?

C. Iteration and Feedback Loops

This section focuses on the dynamic and non-linear aspects of the process.

- Presence of Iteration: Did the project workflow include explicit feedback loops where the team revisited a previous stage?

- Trigger for Iteration: What caused the iteration? (e.g., unexpected analytical results, client feedback, negative evaluation of an option).
- Nature of the Loop: Describe the iterative path. (e.g., "Evaluation results prompted a return to the Analysis stage to model a new variable," or "Client feedback on design options required a return to the first stage to clarify objectives.")

3. A Comparison of EBDP Projects

This section proceeds with an overview of each project accompanied by a comparison according to the above delineated comparative framework. The subsequent section synthesises the analysis and explores the implications for a cyclical structure of EBDP.

3.1. A Review of Selected Projects Undertaken by Space Syntax Limited (SSL)

3.1.1. Trafalgar Square

The 1998 redevelopment of Trafalgar Square, undertaken by the City of Westminster in partnership with Foster and Partners, represents an early and influential example of applying analytical methods to urban design, particularly in addressing pedestrian accessibility within complex urban environments. The project aimed to resolve long-standing mobility challenges caused by heavy vehicular traffic, which had significantly limited the square's use as a public space. Its design process was structured through a sequence of interrelated analytical and consultative steps, collectively demonstrating one of the earliest practical implementations of evidence-based design thinking in an urban context.

This case is particularly significant due to its location within the historically and politically sensitive fabric of central London, where any spatial intervention demands robust justification supported by empirical evidence and stakeholder consensus. The redevelopment required negotiation among diverse actors, city authorities, designers, heritage bodies, and the public, each bringing different perspectives and priorities. Examining how the project balanced "hard" evidence (analytical and spatial data) with "soft" evidence (community feedback and political reasoning) provides valuable insight into how evidence-based design can operate within real-world governance and planning constraints. The feedback loops established between experts, communities, and decision-makers not only ensured legitimacy and responsiveness but also contributed to a sustainable and publicly accepted design outcome.

The project began with systematic observation of pedestrian movement patterns across the site. These observations guided the formulation of hypotheses concerning the spatial and functional underperformance of the square. In parallel, the design team prioritised a qualitative understanding of the square's social and historical context. The symbolic and civic significance of Trafalgar Square, as a central space in London's public realm, was examined and integrated into the design rationale. These narratives were not only interpretive but played a role in framing the design hypotheses.

To test and refine the hypotheses, the team employed an "axial" street network modelling technique to evaluate the spatial implications of proposed design changes (Figure 1). Given the technological constraints of the period, the analysis was not iterative in a computational sense but focused on targeted refinement to support specific interventions. However, refinements did occur as part of evaluations and consultations with varied specialists to inform the final design solution. The space syntax axial analysis, along with observations and empirical data, served to validate and adjust the design strategy based on projected pedestrian flows and movement logic.

Figure 1. Observational study and spatial network models used for Trafalgar square, investigating the existing and proposed design scenarios [35].

The project incorporated public consultation into its evidence base. Surveys and exhibitions were used to solicit feedback from stakeholders and the public, providing further support for the design direction. This integration of public input reinforced the analytical findings and contributed to the validity of the proposed interventions.

The Trafalgar Square project provides an early example of evidence-based urban design. It combined both qualitative insights and spatial analysis in a structured workflow centred on hypothesis generation, targeted modelling, and participatory validation. Despite the limitations in computational capacity at the time, the project represents notable groundwork for the incorporation of analytical reasoning into complex public realm transformations.

A summary of the comparative analysis of the project processes is presented in Table 3.

Table 3. Comparative Analysis, Trafalgar Square Redevelopment.

Aspect	Details
A. Project Vitals and Context	
Project Identification	Trafalgar Square Redevelopment [35]. Client: City of Westminster. Partner: Foster and Partners. Analyst: Space Syntax Limited.
Scale of Intervention	Major urban public realm/civic square.
Primary Objective	Resolve poor pedestrian accessibility and underutilisation of public space caused by heavy vehicular traffic.
Key Constraints	Limited computational power for modelling (late 1990s technological restrictions).
B. The EBDP Workflow in Action	
Clarification & Objectives	Combined systematic pedestrian movement observation with qualitative analysis of the square's social and historical role. Informed design hypotheses.
Analysis & Modelling	Employed space syntax axial modelling to evaluate spatial implications of design proposals and predict pedestrian movement flows.

Table 3. *Cont.*

Aspect	Details
Design & Option Generation	Analysis used primarily to refine a central design strategy, rather than generate multiple alternative options.
Evaluation & Decision-Making	Public consultation via surveys and exhibitions. Feedback incorporated into the evidence base and influenced final design decisions.
C. Iteration and Feedback Loops	
Presence of Iteration	Iteration occurred, focused on targeted design refinement rather than computationally intensive cycles.
Trigger for Iteration	Expert review and public consultation.
Nature of the Loop	Feedback loop primarily between Stage 2 (Analysis & Modelling) and Stage 3 (Design & Option Generation).

3.1.2. Darwin City Centre

Commissioned by the City of Darwin and in partnership with Design Urban, Urbacity, Michels Warren Munday, and Clouston Associates, the Darwin City Centre project was undertaken with the objective of guiding the strategic extension of the city's central area in 2013. The design aimed to enhance the utilisation of existing urban assets, improve street connectivity, encourage higher mixed-use density, and facilitate the emergence of a vibrant local high street.The methodology combined spatial analysis with iterative modelling and strategic evaluation, grounded in both professional expertise and empirical evidence (Figure 2).

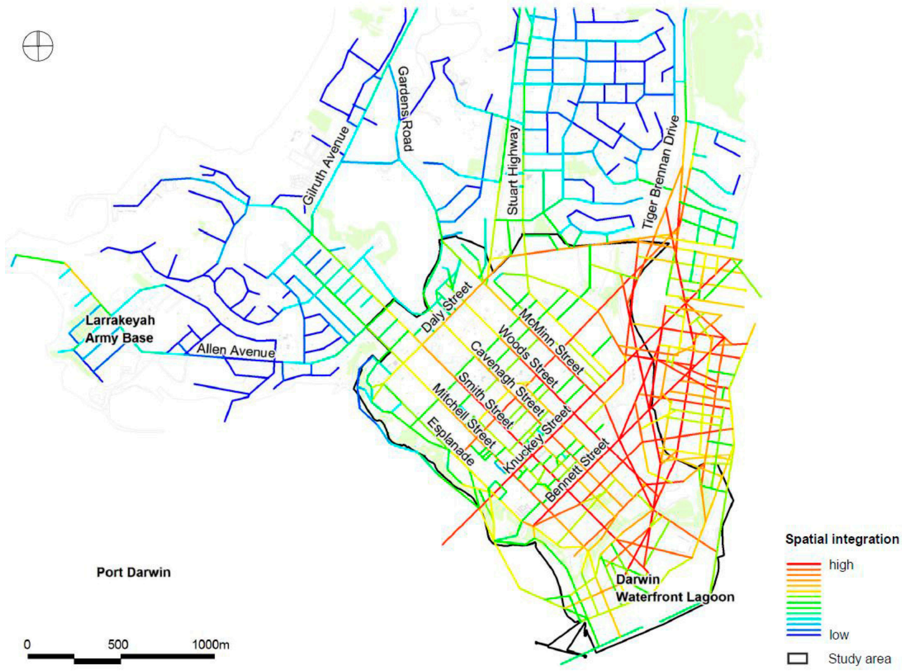

Figure 2. Proposed spatial configuration for the expansion of the city which is structured around forecast model that cohesively improves numerous parameters [36].

The process commenced with the establishment of key design objectives, informed by an evaluation matrix built on relevant precedents and disciplinary knowledge. This matrix served as a framework that shaped the subsequent stages of analysis and design development. Central to the design approach was an effort to work with the city's distinct geographical and environmental characteristics. There was an emphasis on contextually grounding the proposals by leveraging natural features and existing urban form. These attributes led towards a hybrid spatial modelling approach that enabled reviewing of options reflecting the complex nature of the project.

A significant focus of the project was the enhancement of street connectivity and urban density within the Central Business District (CBD). To achieve this, spatial models were developed to simulate both pedestrian and vehicular movement across the network. These models were used for testing of multiple configurational scenarios, allowing the design team to assess the opportunities and constraints associated with each option. Through this process, the analysis informed the refinement of the proposed urban structure. Beyond spatial analysis, the project introduced an evaluative dimension by constructing an 'urban performance index'. This index assessed the effectiveness of the proposed interventions against the project's strategic goals. Additionally, a 'profit index' was developed through correlation analysis, enabling the evaluation of the economic viability of the proposed changes. These analytical tools provided a dual lens, spatial and financial, through which design options could be assessed.

The Darwin City Centre project methodology aimed to links urban design objectives with spatial and economic modelling. By structuring the process around testing and multi-dimensional evaluation, the project provided a decision-support framework for prioritising development options and aligning these with strategic planning goals.

A summary of the comparative analysis of the project processes is presented in Table 4.

Table 4. Comparative Analysis, Darwin City Centre Project.

Aspect	Details
A. Project Vitals and Context	
Project Identification	Darwin City Centre Project [36]. Client: City of Darwin. Partners: Design Urban, Urbacity et al. Analyst and planning advisor: Space Syntax Limited.
Scale of Intervention	City Centre/Central Business District (CBD) Masterplan.
Primary Objective	Guide strategic extension of the city centre by enhancing asset utilisation, improving connectivity, encouraging mixed-use density, and fostering a local high street.
Key Constraints	The city's unique geographical and environmental conditions acted as primary guiding principles for the design.
B. The EBDP Workflow in Action	
Clarification & Objectives	Established key design objectives structured within an evaluation matrix, developed from precedent studies and disciplinary knowledge, which served as the project's foundational framework.
Analysis & Modelling	Developed spatial models simulating pedestrian and vehicular networks. Introduced two new evaluative tools: an urban performance index (measuring proposals against strategic goals) and a profit index (assessing economic viability).
Design & Option Generation	Explicitly supported the generation and iterative testing of multiple configurational scenarios. Comparison of scenarios directly informed refinement of the urban structure.
Evaluation & Decision-Making	Conducted multi-dimensional evaluation, combining spatial performance models (movement) with financial metrics (profit index). Provided decision-makers with a dual framework for prioritising options.
C. Iteration and Feedback Loops	
Presence of Iteration	Iteration was a central methodological feature, emphasised as "iterative testing" of scenarios.
Trigger for Iteration	Driven by systematic assessment of opportunities, constraints, and performance (spatial and economic) of each option.
Nature of the Loop	Strong cyclical feedback loop across all stages, particularly between Stage 3 (Design) and Stage 4 (Evaluation).

3.1.3. Evidence Informed, Adaptable, Implementation Frameworks for Jeddah's Unplanned Settlements

The Strategic Upgrading Framework for Jeddah's Central Unplanned Areas was developed as a continuation of an earlier initiative aimed at the incremental upgrading of informal settlements through enhanced accessibility commissioned by the Municipality of Jeddah in 2009. This phase sought to refine and operationalise an evidence-based methodology for spatial intervention, with a particular emphasis on aligning localised upgrades with broader city-wide strategic planning efforts (Figure 3)..

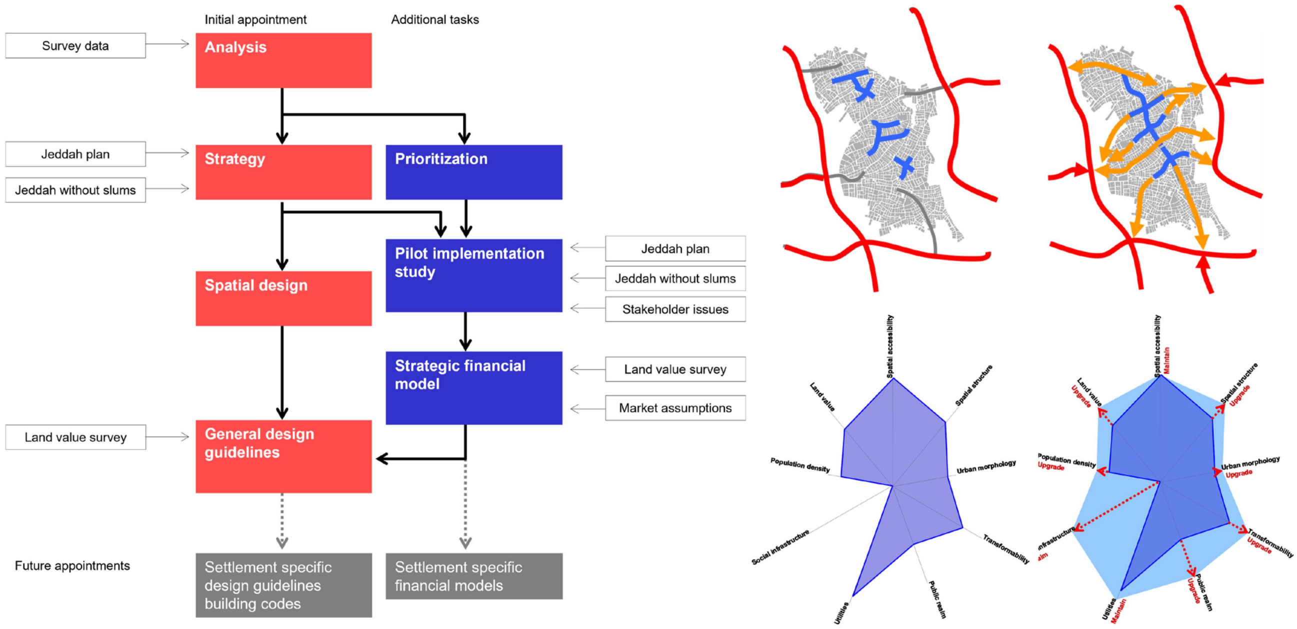

Figure 3. Development of a spatial network scenario for the development framework of Jeddah [37].

Building on the foundational work in preceding projects, the framework was designed to reconnect Jeddah's Central Unplanned Areas with adjacent formal neighbourhoods and integrate them into the larger urban system, including the City Centre and Historic Core. The approach focused on developing optimal spatial configurations—redesigning street networks, urban block structures, and public realm interfaces—through a structured process involving data collection, multi-scalar analysis, strategic planning, and design synthesis.

The project began with an in-depth profiling of each settlement, encompassing both physical and socio-economic indicators. This diagnostic phase enabled the formulation of bespoke strategies tailored to the specific needs and transformation potential of each area. Using an integrated approach, a model combining varied streams of information was produced which resulted in key indices, including an Urban Morphology Index, Transformability Index, and measures of public realm quality, utility provision, and social infrastructure. These indices were used to rank settlements by priority, identifying both their need for intervention and their capacity to accommodate change.

Strategic design interventions were then elaborated based on the above-mentioned rankings, with the aim of minimising displacement while maximising spatial and socio-economic impact. The resulting spatial proposals included reconfigured street hierarchies, revised block layouts, and adaptive design typologies that could be locally interpreted. In tandem, detailed design guidelines were developed to inform subsequent architectural and infrastructural interventions, ensuring consistency across scales while allowing for contextual flexibility.

A pilot study phase was introduced to assess the practical coordination of strategies among key stakeholders, including Happold Consulting, JDURC (Jeddah Development and Urban Regeneration Company), and the Jeddah Municipality. This stage also tested the communicative value of design alternatives, offering financially grounded options that helped clients to make decisions. The pilot process underscored the challenges of applying analytical tools in professional practice, pointing to the need for clearer justifications and demonstrations of utility.

The project produced a prioritisation model that sequenced implementation based on settlement scores derived from composite indices. This provided a phased pathway for rolling out interventions and aligning technical evidence with strategic governance decisions.

The 2009 Strategic Upgrading Framework advanced an integrated methodology for the spatial and socio-economic transformation of unplanned settlements in Jeddah. By synthesising analytical tools with strategic design and stakeholder coordination, the project aimed to generate context-sensitive and financially viable upgrades bridging local needs with broader urban objectives.

A summary of the comparative analysis of the project processes is presented in Table 5.

Table 5. Comparative Analysis, Evidence informed, adaptable, implementation frameworks for Jeddah's unplanned settlements.

Aspect	Details
A. Project Vitals and Context	
Project Identification	Strategic Upgrading Framework for Jeddah's Central Unplanned Areas [37]. Client: Municipality of Jeddah. Partners: Happold Consulting, JDURC. Analyst, planner and urban designer: Space Syntax Limited.
Scale of Intervention	Multi-Settlement/District-level Urban Upgrading.
Primary Objective	Develop a replicable methodology for incremental upgrading of informal settlements, reconnecting them to the formal city grid, integrating them into the broader urban system, and aligning local interventions with city-wide strategies.
Key Constraints	Social: minimising resident displacement. Methodological: challenges in communicating and justifying advanced analytical tools to stakeholders.
B. The EBDP Workflow in Action	
Clarification & Objectives	Began with a diagnostic phase profiling each settlement using physical and socio-economic indicators. Aimed to create bespoke, settlement-specific upgrading strategies.
Analysis & Modelling	Developed custom indices—including an Urban Morphology Index, Transformability Index, and metrics for public realm and infrastructure quality. These indices produced a data-driven prioritisation model for sequencing interventions.
Design & Option Generation	Strategic interventions derived from rankings, spanning multiple scales: reconfigured street networks, revised block layouts, adaptive design typologies, and design guidelines. Pilot phase introduced financially grounded design options.
Evaluation & Decision-Making	A formal pilot study tested stakeholder coordination and communicative clarity of design proposals, providing empirical feedback to refine the framework before city-wide rollout.
C. Iteration and Feedback Loops	
Presence of Iteration	Iteration explicitly structured via the pilot study, serving as a feedback mechanism for validation.
Trigger for Iteration	The need to test feasibility, stakeholder coordination, and financial viability before full-scale application.
Nature of the Loop	Operated at a meta-level: findings from Stage 4 (Evaluation) fed back into Stages 1–3, refining the framework for broader application.

3.1.4. City of Astana (Nur-Sultan at the Time) Master Plan

Commissioned by the City of Nur-Sultan (Formerly and presently Astana), and in partnership with Expedition Engineering, Gustafson Porter + Boman, and Mobility in Chain, the Nur-Sultan Master Plan (for the city now renamed Astana) was developed to enhance urban conditions through a structured, evidence-based planning framework in 2019 (Figure 4). The approach employed a four-stage methodology designed to guide the city's development and ensure that proposals addressed both current challenges and long-term aspirations. The first stage, the Vision Stage, involved a comprehensive review of existing development documentation to identify key performance indicators (KPIs) and relevant international precedents. This stage established a foundational understanding of the desired urban outcomes and served to articulate the project's overarching ambitions.

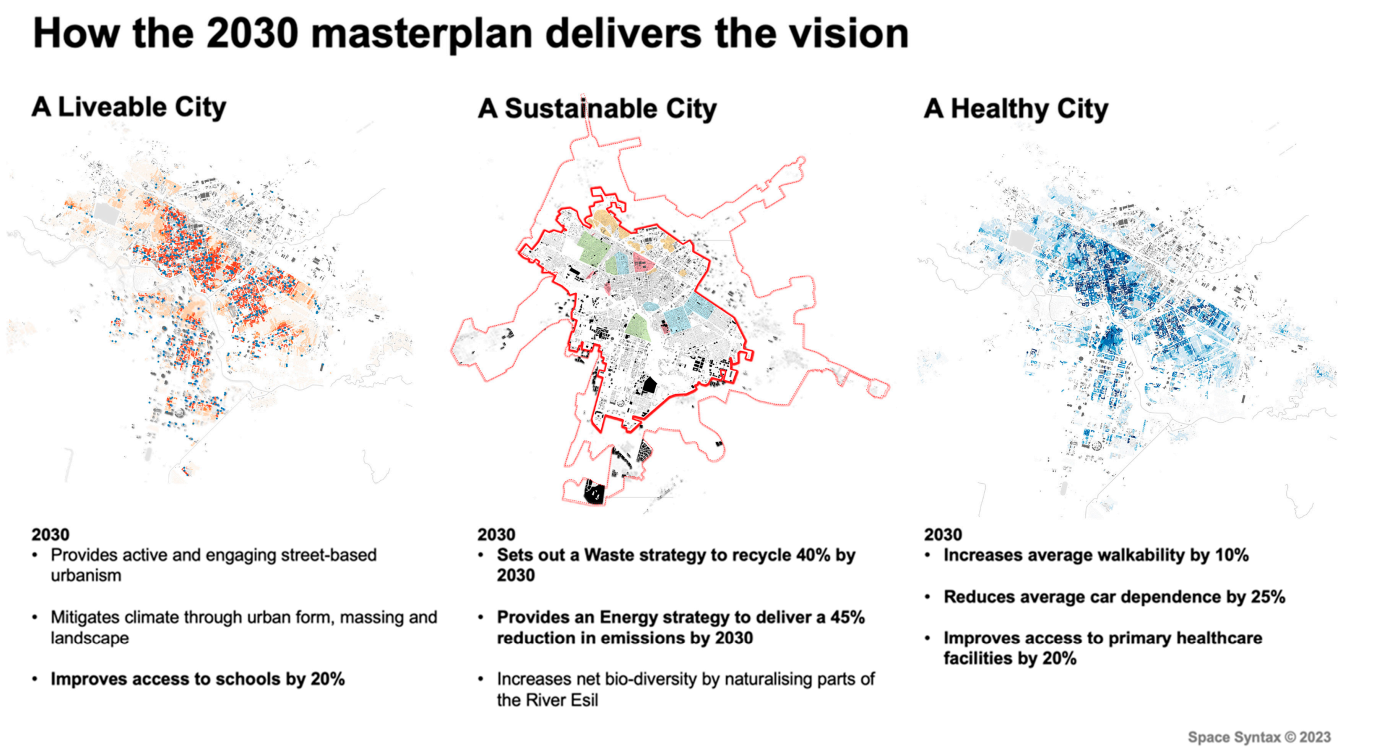

Figure 4. A map of walkability in the proposed masterplan for Nur-Sultan created using a combination of evidence including the spatial configuration [38].

The second stage, the Baseline Analysis, focused on assessing the city's current conditions against the indicators identified in the vision phase. This was achieved through the implementation of an Integrated Urban Model (IUM), which enabled the team to measure a range of urban metrics and establish evidence-based benchmarks. The resulting analysis formed a robust problem definition and clarified the areas requiring strategic intervention. In the Strategy Stage, the third phase of the framework, design solutions were developed to address the identified deficiencies, particularly in terms of social infrastructure and spatial connectivity. Multiple spatial configurations were evaluated and refined within this phase, informed by the Integrated Urban Modelling (IUM), and aligned with the overarching vision.

The final stage, the Masterplan and Continuous Testing phase, involved the formulation of detailed urban proposals, supported by environmental assessments and aligned with local planning regulations. At this point, the IUM was updated to reflect the new proposals and assess their performance against the established KPIs. Continuous testing and feedback loops allowed for the refinement of strategies and facilitated communication with stakeholders, supporting transparency and adaptability throughout the planning process.

This continuous process, based on both quantitative analysis and strategic visioning, allowed the Nur-Sultan Master Plan to move towards a dynamic, performance-driven planning framework. By continuously evaluating and refining interventions against measurable outcomes, the project deployed an integrated, model-based approach to support the formulation of responsive and resilient urban strategies.

A summary of the comparative analysis of the project processes is presented in Table 6.

Table 6. Comparative Analysis, Nur-Sultan (Astana) Master Plan.

Aspect	Details
A. Project Vitals and Context	
Project Identification	Nur-Sultan Master Plan [38]. Client: City of Nur-Sultan. Partners: Expedition Engineering, Gustafson Porter + Boman et al. Analyst, masterplanner, urban designer: Space Syntax Limited.
Scale of Intervention	City-wide Masterplan.
Primary Objective	Develop a structured, evidence-based framework to guide long-term development while addressing current challenges and strategic ambitions.
Key Constraints	Limited availability of data and restrictions on conducting first-hand field observations.
B. The EBDP Workflow in Action	
Clarification & Objectives (Vision Stage)	Comprehensive review of existing planning documents and international precedents. Defined Key Performance Indicators (KPIs) that expressed desired city outcomes and established project ambitions.
Analysis & Modelling (Baseline Analysis Stage)	Assessed current conditions against KPIs. Implemented the Integrated Urban Model (IUM) to measure urban metrics, set evidence-based benchmarks, and establish a robust problem definition.
Design & Option Generation (Strategy Stage)	Developed solutions to address deficiencies (e.g., social infrastructure, connectivity). Generated and refined multiple spatial configurations using the IUM to align strategies with the project vision.
Evaluation & Decision-Making (Masterplan & Continuous Testing Stage)	Formulated detailed proposals and evaluated them by updating the IUM to test performance against KPIs. Supplemented analysis with environmental assessments. The IUM served as a tool for continuous testing and transparent stakeholder communication.
C. Iteration and Feedback Loops	
Presence of Iteration	Iteration was a central feature, explicitly described as "continuous testing and feedback loops."
Trigger for Iteration	Driven by the refinement of design configurations in the Strategy Stage and evaluation of final proposals against KPIs.
Nature of the Loop	Included two key loops: (1) internal refinement within the Strategy Stage (Stage 3); (2) a broader loop connecting final Masterplan testing (Stage 4) back into the design process.

3.2. A Review of Selected Projects from SOCIETY and Urban Form (SURF) Lab—University of Cyprus

3.2.1. Design Improvements Supporting Active Travel Around Secondary Schools (DESIRE)

This project focused on analysing and improving active travel and micromobility conditions around secondary schools in Nicosia, Cyprus, with the aim of enhancing student safety and promoting sustainable urban mobility. Employing a four-stage approach, the study began with comprehensive data collection and spatial modelling. Accident data from 2018 to 2023 was mapped in relation to the city's road network, school locations, and existing pedestrian infrastructure. This enabled the development of a spatial network model that identified baseline conditions and highlighted schools located near recurring accident hotspots (Figure 5). The analysis extended to the spatial characteristics of the urban street network and the detailed distribution of pedestrian infrastructure across the city.

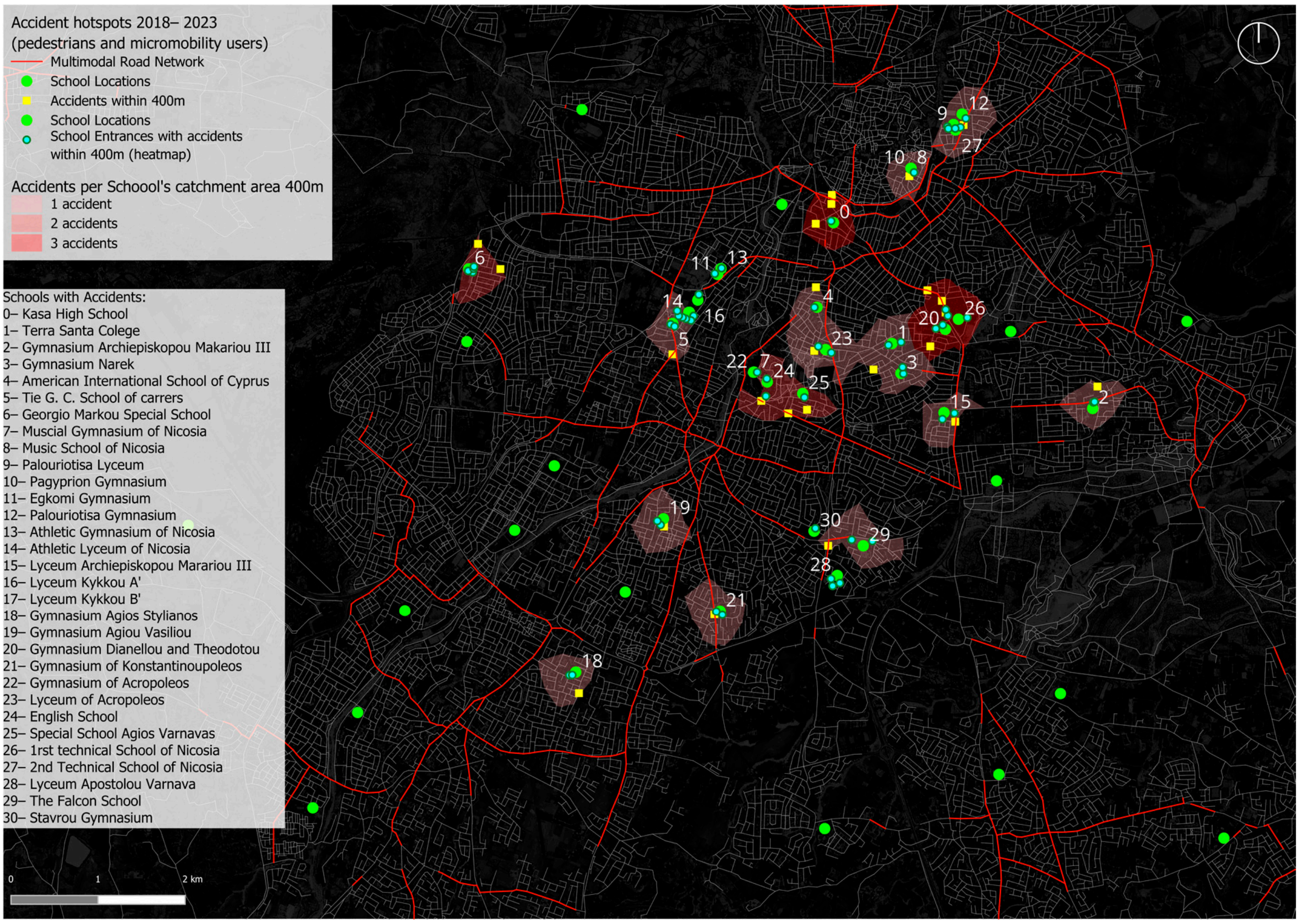

Figure 5. Accidents hotspots within schools' 400 m catchment areas in relation to the multimodal network.

The second stage examined existing safety measures, evaluating the effectiveness of speed limits, pedestrian crossings, and traffic-calming interventions in proximity to schools. This provided insight into the strengths and deficiencies of current road safety provisions. Based on this analysis, the third stage proposed targeted interventions, such as improved pedestrian crossings and the expansion of pedestrian and cycling infrastructure that directly addressed the identified risk factors.

In the final stage, these proposed measures were evaluated for their potential impact, forming the foundation for a policy framework that integrates safety improvements into broader urban planning strategies.

A summary of the comparative analysis of the project processes is presented in Table 7.

Table 7. Comparative Analysis, DESIRE Project.

Aspect	Details
A. Project Vitals and Context	
Project Identification	Design Improvements Supporting Active Travel Around Secondary Schools (DESIRE, 2024–2025). Location: Nicosia, Cyprus. Analyst: Society and Urban Form (SURF) Lab.
Scale of Intervention	Thematic/Multi-location analysis, focusing on catchment areas of secondary schools across the city.
Primary Objective	Analyse and improve active travel and micromobility conditions around secondary schools, aiming to enhance student safety and promote sustainable mobility.
Key Constraints	Not explicitly specified.
B. The EBDP Workflow in Action	
Clarification & Objectives	Initiated with comprehensive data collection to define the problem scope. This included mapping accident data (2018–2023) in relation to the road network, school locations, and pedestrian infrastructure.
Analysis & Modelling	Developed a spatial network model to establish baseline safety conditions. Identified schools near accident hotspots and assessed street network characteristics and existing safety measures (e.g., crossings, speed limits) to pinpoint deficiencies.
Design & Option Generation	Proposed targeted physical interventions, including improved pedestrian crossings and expanded walking/cycling infrastructure to mitigate risks.
Evaluation & Decision-Making	Evaluated potential impacts of proposed interventions. Produced a policy framework to integrate improvements into broader urban planning strategies.
C. Iteration and Feedback Loops	
Presence of Iteration	Iteration not explicitly detailed; process presented as sequential, though implied during option testing.
Trigger for Iteration	Testing of design options for policy integration.
Nature of the Loop	Refinement of models and proposals between Stage 3 (Design) and Stage 4 (Evaluation).

3.2.2. Assessing Accessibility and Connectivity to Greenspaces (Nicosia Linear Park) at Urban Scale

This study evaluated the accessibility and connectivity of the Pedieos Linear Park in Nicosia through a mixed-methods approach, aiming to understand existing spatial conditions and assess the potential impact of a proposed masterplan (Figure 6). The research began with a qualitative component centred on community engagement through focus group sessions with residents, stakeholders, and local organizations. These sessions captured the needs and aspirations of various user groups, resulting in forty-three initial proposals that were refined and prioritised to offer valuable user-centred insights.

Building on this qualitative foundation, a spatial analysis was conducted to assess the park's current accessibility and its relationship to surrounding amenities. Quantitative data was collected to evaluate population reach within defined accessibility radii and proximity to key facilities from and within the park. This established a baseline for comparison. To incorporate future scenarios, proposed elements from the park's masterplan, such as new entrances, pedestrian bridges, and extended pathways, were manually integrated into the existing street network using Geographic Information Systems (GIS), allowing for a comparative spatial analysis between current and proposed conditions.

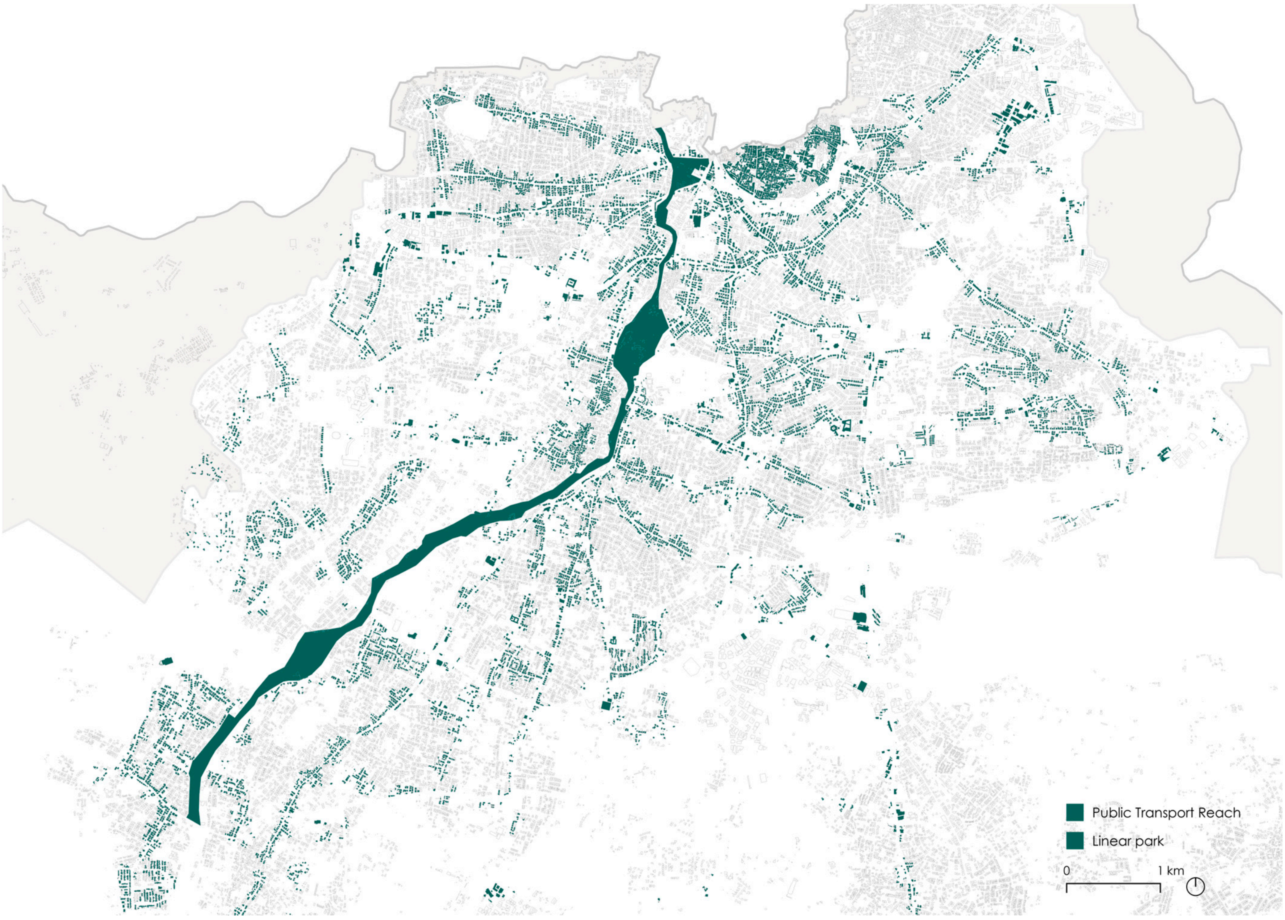

Figure 6. Assessing accessibility to the Linear Park using public transportation.

Further extending the analytical scope, external points of interest were sourced from OpenStreetMap to facilitate a multi-scalar assessment of accessibility and connectivity within the broader urban context. This integrated methodology enabled a comparison of present and future states, highlighting how the proposed interventions could enhance urban inclusivity and network integration. The study uses an iterative design evaluation process to combine participatory qualitative input with quantitative spatial modelling to inform strategic urban planning and park development. A summary of the comparative analysis of the project processes is presented in the Table 8:

Table 8. Comparative Analysis, Nicosia Linear Park Accessibility.

Aspect	Details
A. Project Vitals and Context	
Project Identification	Assessing Accessibility and Connectivity to Greenspaces (Nicosia Linear Park, 2024–2025). Location: Nicosia, Cyprus. Analyst: Society and Urban Form (SURF) Lab.
Scale of Intervention	Urban park/greenspace network analysis.
Primary Objective	Evaluate existing accessibility and connectivity of the Pedieos Linear Park and assess the potential spatial impact of a proposed masterplan for its development.
Key Constraints	Not explicitly specified.

Table 8. *Cont.*

Aspect	Details
B. The EBDP Workflow in Action	
Clarification & Objectives	Began with a participatory phase using community engagement (focus groups with residents, stakeholders, local organisations). These sessions captured user needs and produced user-centred proposals for the park.
Analysis & Modelling	Conducted quantitative spatial analysis to establish baseline accessibility. Calculated population reach within radii and proximity to key facilities. Enhanced model with OpenStreetMap points of interest for multi-scalar assessment.
Design & Option Generation	Focused on design evaluation rather than generation. The existing masterplan was modelled into the GIS network by manually integrating proposed elements (new entrances, bridges, etc.) for scenario testing.
Evaluation & Decision-Making	Performed comparative spatial analysis between baseline (current) conditions and modelled future scenario. Provided evidence on how proposed interventions could improve inclusivity and connectivity, informing strategic planning.
C. Iteration and Feedback Loops	
Presence of Iteration	Iterative design evaluation was present.
Trigger for Iteration	Community engagement (Stage 1) shaped the scope of spatial analysis and evaluation (Stages 2 & 4).
Nature of the Loop	Connected participatory input with quantitative modelling. Qualitative priorities guided spatial analysis, while quantitative outputs benchmarked the effects of proposals, informing future iterations of the masterplan.

4. Generalisation and Synthesis

4.1. Generalisation

The comparative framework provides an overview of how EBDP materialises in the context of practice. Table 9 synthesises and summarises these findings across the projects, highlighting shared elements and the respective progression of workflows.

Figure 7 illustrates the sequence of development processes across the six studied projects, organised by their respective scales. A comparative reading of these timelines reveals patterns in how analytical methods are implemented at different scales of planning and design. Notably, as the scale of the project increases, there is a more pronounced adoption of a pre-development phase focused on clarification of the brief, data gathering, and the formulation of an evidence-based methodological framework. This contrasts with smaller-scale projects, where the formulation of design questions often remains more narrative-driven and linked to contextual interpretations.

By comparing these sequences, recurring stages can be observed that provide a structure supporting workflows for evidence-based design and planning (EBDP). A pattern emerges where projects typically begin with a phase of clarification of the brief and understanding the problem context, followed by an analysis phase where spatial evidence is generated. This evidence is then consumed in a subsequent stage to inform the generation of design options. These options are further evaluated and refined, often through continuous evaluation and feedback loops.

For larger projects, the analysis stage tends to transition into a more clearly articulated design strategy, which acts as a guiding framework for exploring multiple design scenarios. In contrast, smaller-scale projects often exhibit a tighter coupling between the problem definition and option development phases, with fewer intermediate steps.

Table 9. Comparative analysis of the projects based on their development rationale.

Project	Clarification & Objectives	Analysis & Modelling	Design & Option Generation	Evaluation & Decision-Making	Feedback Loops
Trafalgar Square Redevelopment	Combined systematic pedestrian observation with qualitative study of the square's historical and social roles.	Used early space syntax axial modelling to test spatial implications and predict pedestrian flows.	Analysis refined a central design concept rather than generating multiple alternatives.	Public consultation through surveys and exhibitions influenced final decisions.	Targeted iteration between analysis and design stages, driven by expert and community feedback.
Darwin City Centre Project (2013)	Defined objectives through an evaluation matrix informed by precedent and disciplinary knowledge.	Developed spatial models and introduced urban performance and profit indices to evaluate proposals.	Supported generation and comparative testing of multiple configurational scenarios.	Combined spatial performance and financial analysis for evidence-informed prioritisation.	Strong cycle across all phases, especially between design and evaluation.
Jeddah Central Unplanned Areas Framework (2009)	Conducted diagnostic profiling using physical and socio-economic indicators.	Created indices (Urban Morphology, Transformability, Public Realm) for data-driven prioritisation.	Developed multi-scalar interventions and tested pilot designs for upgrading settlements.	A pilot phase validated the analytical framework and stakeholder collaboration.	Feedback mechanism embedded through pilot feedback, refining framework before city-wide rollout.
Nur-Sultan Master Plan (2019)	Defined Key Performance Indicators (KPIs) expressing long-term urban outcomes.	Applied the Integrated Urban Model (IUM) to benchmark existing conditions and set measurable baselines.	Generated and refined multiple spatial strategies addressing key deficiencies.	Continuously updated IUM to evaluate proposals and communicate with stakeholders.	Feedback structured as continuous model-based testing linking analysis, design, and evaluation.
DESIRE Project—Active Travel (Nicosia, 2024–2025)	Defined objectives through spatial mapping of accident data and mobility patterns around schools.	Modelled spatial networks to identify safety and accessibility issues.	Proposed targeted physical interventions improving walking and cycling conditions.	Evaluated intervention impacts and integrated findings into policy guidance.	Implied feedback between testing and policy refinement, though less formally codified.
Greenspace Accessibility (Nicosia Linear Park, 2024–2025)	Used participatory engagement to define goals and user priorities.	Conducted accessibility modelling using demographic and facility data.	Tested proposed masterplan scenarios against baseline conditions.	Provided evidence for strategic planning and inclusivity improvements.	Feedback loop integrated qualitative engagement with quantitative analysis for continuous refinement.
Conclusion of the comparative studies: synthesis and Future Implications	EBDP clarification stages are shifting from expert-led diagnosis to participatory, data-informed goal setting, emphasising transparency and co-definition of objectives.	Analytical methods have evolved from isolated spatial modelling to integrated, multi-dimensional systems combining social, economic, and environmental metrics.	Design generation is becoming more informed, supported by simulation and scenario testing rather than fixed concept refinement.	Evaluation increasingly serves as both a testing and communication platform, linking technical evidence to policy and stakeholder dialogue.	Future EBDP practice should institutionalize continuous feedback cycles, supported by adaptive digital tools and participatory mechanisms, ensuring that evidence remains actionable, reflective, and responsive throughout the design process.

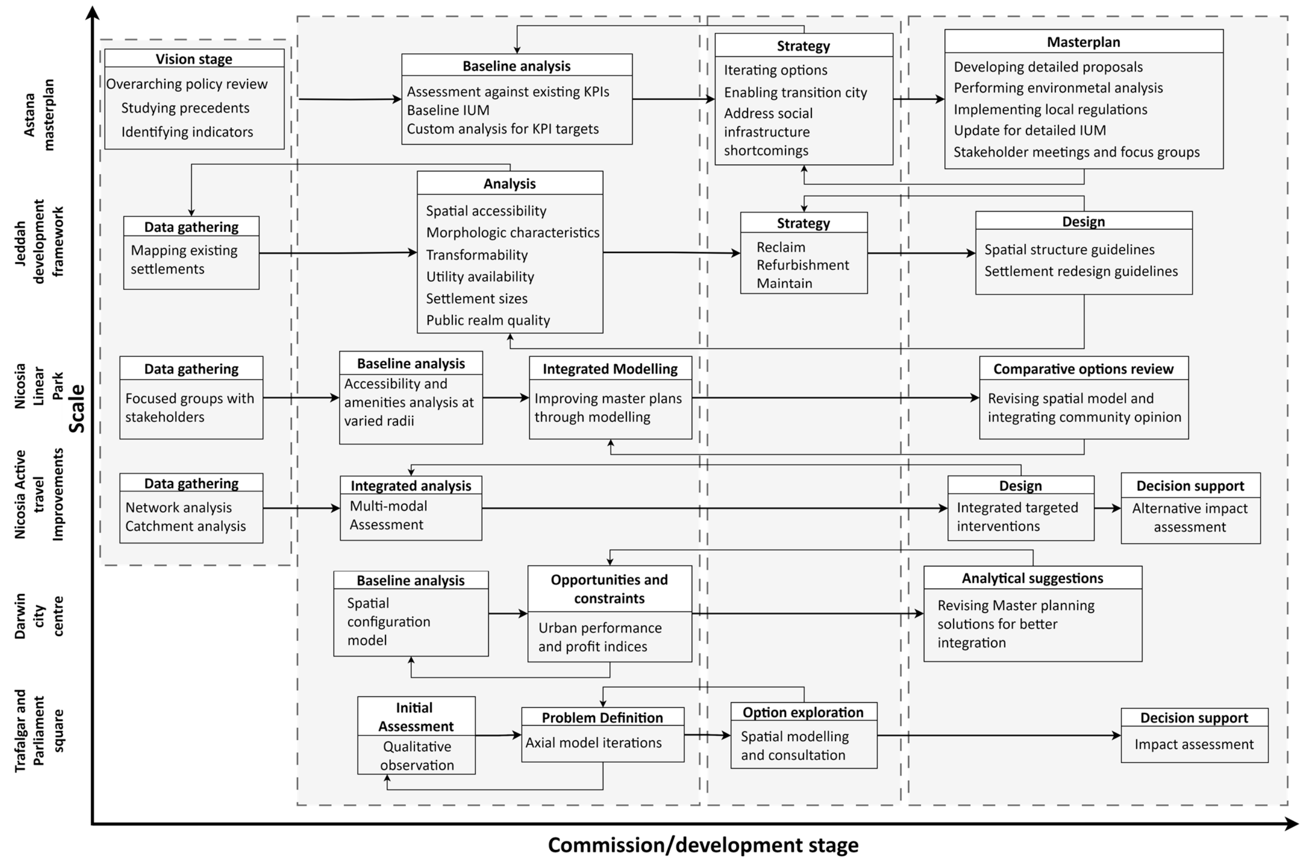

Figure 7. Project implementation process as per logistical stages.

4.2. Synthesis

The examination of the projects indicates that an EBDP process is not a rigid and linear process, but an adaptive framework. This framework typically generalises into distinct but interlinked phases that guide the synthesis, generation, and application of evidence:

- Clarification and Objective Setting: Focuses on defining the core problem, understanding the context, and establishing clear project goals and performance criteria, often in collaboration with clients and stakeholders.
- Analysis and Modelling: An evidence base is generated through spatial modelling and data analysis, and empirical literature or site studies where relevant and available. In this stage the emphasis is on diagnosing existing conditions, identifying key performance indicators, and providing objective information to guide the design process.
- Design Generation and Synthesis: Guided by the evidence base, this phase involves the creation of design options or strategic proposals. It is a synthetic process where designers respond to the diagnosed problems within the project's practical constraints.
- Evaluation and Refinement: Proposed designs are evaluated and assessed against the objectives framed in Stage 1 and formalised in Stage 2. This phase involves critical discussion among experts, stakeholders, and clients, and can often lead to further design refinement or may trigger a new cycle.

The workflow is organised around feedback loops, where new data or feedback can trigger the refinement of earlier steps, ensuring the process remains responsive to different project and data contexts or to evolving project needs. Iteration is the engine of this framework and occurs in two primary ways. Firstly, intra-stage cycle happens within a single phase, such as when refining an analytical model with new datasets or exploring multiple design variations. More significantly, inter-stage feedback cycle occurs when findings from a later stage prompt a return to an earlier one. For example, results from the Evaluation phase may trigger revised Objectives or a renewed cycle of Analysis and Design, ensuring the final output is robust and well-justified.

4.3. Elaboration

4.3.1. Clarification and Objective Setting

The first stage centres on developing a grounded understanding of the design brief and its broader context. This begins with a critical clarification of the project brief, which is examined in relation to existing strategic documents, planning regulations, and overarching policy frameworks. This process is necessary for setting and aligning project objectives with institutional priorities, spatial constraints, and stakeholder expectations. It also involves identifying key questions and establishing the feasibility of different approaches for moving forward. At this stage, the objective is not to define fixed solutions, but to articulate a coherent and informed framing from which the EBDP process can be further developed.

4.3.2. Analysis—Building a Comprehensive Evidence Base

Following the initial framing and clarification of objectives, the analysis stage marks the point at which the planning problem is systematically unpacked using diverse forms of evidence. At this stage, multiple layers of data can be incorporated to build a rich understanding of current conditions [39,40]. These datasets, ranging from qualitative site observations to large-scale quantitative sources, often come in heterogeneous formats and must be organised, cleaned, and pre-processed prior to modelling [41].

Models at this stage function as structured abstractions of reality [42], enabling planners to make sense of complex urban dynamics by organising information into coherent analytical frameworks [43]. However, working with dynamic urban systems presents significant challenges. As Cheylan and Lardon [44] note, information in such contexts is often unstable, changing in form, definition, or relevance over time. As such, the modelling process is inherently iterative: insights gained from preliminary modelling frequently reveal gaps or misalignments, prompting further rounds of data collection, reinterpretation, and refinement. This cycle not only enhances model precision but also deepens the understanding of the spatial and social dimensions of the issue. Figure 8 illustrates this process.

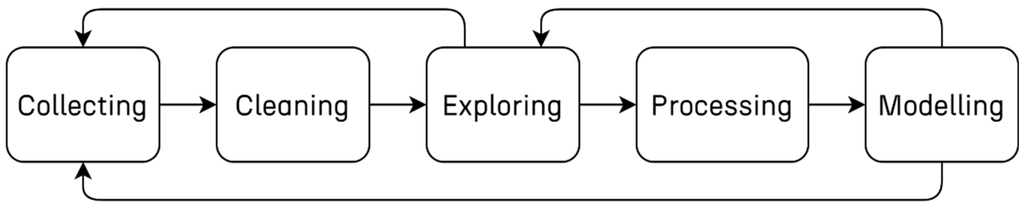

Figure 8. General EBDP data collection pipeline. Adapted from Jordan [45].

Table 10 presents a high-level classification of analytical approaches used in Evidence-Based Design and Planning (EBDP). These approaches can be broadly grouped into two categories: empirical and quantitative. Each category differs in terms of input data types, methodological techniques, scale of application, and the nature of the questions they are best suited to address.

The selection and application of these approaches are largely shaped by project-specific constraints such as scale, budget, data availability, and computational capacity. Empirical methods are typically applied to high-resolution, context-specific challenges that require detailed technical analysis. In contrast, quantitative approaches are more suitable for addressing lower-resolution, strategic issues that span broader spatial or thematic scales. The choice between these methods is therefore contingent on the specific aims and limitations of each project.

Table 10. Analytical approaches employed in evidence-based design and planning.

	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 methods, participatory methods, evaluation, and feedback loop	Spatial statistics, mathematical modelling, geostatistics, machine learning

From a modelling perspective, a range of modelling approaches may be employed, falling broadly into conceptual and data-intensive categories. Conceptual models establish logical linkages between selected indicators and the phenomena under investigation, while data-intensive models structure large volumes of thematic and geometric data. These can be formalised through several analytical strategies, such as GIS, statistical modelling using probabilistic methods [46], dynamic models capturing emergent spatial behaviours [47,48], and computational simulations such as cellular automata [49] and agent-based models [50] that explore multi-scalar interactions within urban systems.

Since individual layers of data or analysis (e.g., spatial, statistical, experiential, or contextual) offer an only partial view, relying on a single data source or form of analysis may fail to support complex design decision-making. Diverse data inputs are therefore often synthesised into a more rounded modelling strategy to inform a hybrid spatial modelling approach. A ‘hybrid model’ integrates multiple modelling techniques and data types to compare and interpret relationships between varied forms of evidence. As evidence is introduced or assumptions are challenged, the model can be updated, reconfigured, or extended, supporting continuous cycles of analysis, design exploration, and evaluation. In this way, hybrid modelling can support design iteration as questions and responses are refined throughout the design process.

4.3.3. Design—Evidence Informed Options Exploration

The third stage of the EBDP process facilitates the integration of design ideas and options in a way that creatively and strategically addresses the objectives. In EBDP, this is not strictly a technical exercise in model optimisation, but a design-led process in which contextual insight and interpretive expertise are used to generate sets of distinct, well-informed alternatives. The intention is for these to remain grounded in evidence-informed objectives and analysis while being shaped by the designer’s capacity to prioritise constraints, interpret evidence, and imagine plausible future interventions.

Different techniques can support this process by varying input parameters to explore a range of outcomes. These range from simple sketching to more advanced tools such as evolutionary optimisation methods [51], parametric modelling [52], and generative workflows [53,54], including the more recent emergence of generative AI-based approaches. Hybrid models combine spatial analysis with generative and optimisation processes, for example, Koenig et al.’s [54] integration of urban analysis and evolutionary design, Celani et al.’s [55] application of shape grammar and genetic algorithms, Acharya et al.’s [56] integrated urban modelling (IUM), and Motieyan and Mesgari’s [57] use of agent-based modelling to optimise land use and transport strategies

Constraints on data availability, computational power, or institutional flexibility may limit the range and resolution of options. Furthermore, balancing multiple design objectives remains a known challenge. As Von Winterfeldt and Fischer [58] highlight, the absence of clearly defined objective-weighting models complicates multi-attribute decision-making. To address this, approaches such as the multi-criteria average-weighted model [59] offer adaptable frameworks for evaluating trade-offs across competing priorities. Although originally developed outside the spatial domain, these models can be repurposed to support decision-making in complex urban design contexts.

To clarify, data and analysis tools do not produce solutions autonomously, and their use should not be seen to replace integrative design thinking: narrowly defined generative algorithms, though complex, may divert attention from wider, complex, or nuanced priorities if not critically applied. EBDP represents an approach that can assist designers in navigating and articulating a spectrum of plausible scenarios that are distinct in emphasis, trade-offs, and outcomes, while remaining anchored the objectives and informed by evidence as defined in prior stages.

This stage presents a bridge from preceding objectives and analysis to the next stage, where a range of differentiated options can be used to support the evaluation and feedback process.

4.3.4. Evaluation and Feedback

The final stage of the evidence-based design and planning (EBDP) cycle involves the evaluation of the design options, with feedback from external experts, public audiences, policy officials, clients, and other stakeholders. The aim is to assess the validity, feasibility, and desirability of each proposal within its broader social, political, and functional context while remaining grounded in evidence informed context.

Given the inherent complexity of urban systems [60], and the multiplicity of analytical outputs produced through modelling and spatial evaluation, this feedback process can be highly intricate. Diverse formats of data must be communicated to stakeholders with varying levels of technical expertise and interest. Budgetary constraints, political agendas, and institutional frameworks further complicate this landscape. As a result, the evaluation process must be approached as a dynamic, multi-scalar system in itself, where feedback loops enable progressive refinement of proposals through structured deliberation and integration of evidence [10,12,27].

5. Towards a Conceptual Model for Operationalising Evidence-Based Design and Planning: An Analytical, Multi-Scalar and Iterative Framework

This study was carried out to address the challenge of framing Evidence-Based Design and Planning (EBDP) for professional practice. While EBDP is increasingly recognised for its potential, its practical uptake remains constrained. The framework presented in this article draws on earlier EBDP studies to compare evidence-based workflows across a selection of real-world projects. From this review, a structured yet adaptable framework is proposed, integrating multiple forms of evidence across four phases: clarification and evidence-based project definition; preparation of an evidence base through analysis and modelling; generation of options synthesising diverse evidence; and evaluations to guide adaptation and decision-making.

We propose that these stages are anchored and interlinked more deeply by what can be termed as a Hybrid Spatial Model (Figure 9), which provides both the conceptual foundation and analytical backbone of the framework.

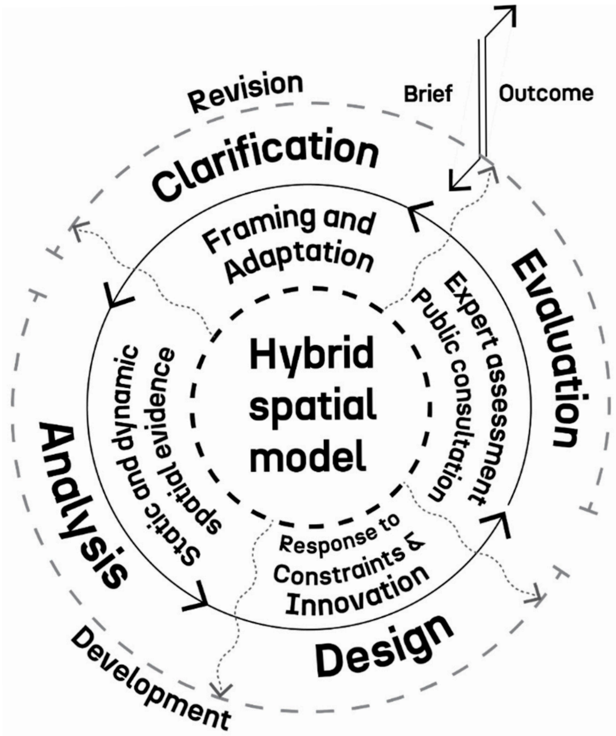

Figure 9. A conceptual model for evidence-based design and planning.

The Hybrid Spatial Model brings together diverse streams of knowledge, quantitative data and analysis, qualitative insights, disciplinary expertise, and stakeholder perspectives. These are synthesised into a unified and spatially coherent structure. Importantly, links are established between the Hybrid Spatial Model and all phases of clarification, analysis, design, and evaluation. The design process is thereby informed by the evidence base while in turn remains responsive to evaluations considering the project's intended outcomes.

A defining feature of the framework is its emphasis on feedback loops. This feature is embedded both within and across stages, allowing earlier phases to be revisited and reframed as new evidence emerges. This approach resonates with Zeisel's [10] cyclical model, extends Carmona's [12] progression by embedding continuous refinement more deeply, and aligns closely with Karimi's [27] configurational methodology. However, this model advances earlier framing by situating a unified Hybrid Spatial Model at the centre. The significance of this explicitly unified framing is twofold. Firstly, the model serves as an integrative mechanism, assimilating heterogeneous evidence into a system that can be interrogated, compared, and refined. Without this, EBDP risks fragmentation with isolated datasets and uncoordinated insights. Secondly, the model acts as a generative engine that produces new knowledge through testing, simulation, and continuous evaluation. In this sense, it not only synthesises information but also drives the design process itself, linking clarification, analysis, and design through informed evaluation.

A limitation here is that the framework has been developed from a limited number of case studies drawn from Space Syntax Limited and the SURF Lab, both of which represent specific institutional and methodological traditions. Although these cases vary in scale and focus, further testing across a broader range of geographical, cultural, and organisational contexts is required to validate or improve the framework's generalisability. In addition, while the Hybrid Spatial Model successfully integrates multiple evidence types, it remains data-dependent and its effectiveness may be constrained in data-scarce environments or where technical capacity is limited. Therefore, future work should explore lightweight, open-source modelling tools and standardised benchmarks to enhance accessibility and transferability across diverse planning contexts.

A potential direction for future exploration for extending this framework lies in the integration of Artificial Intelligence (AI) within the EBDP workflow. Recent research highlights AI as a major catalyst for advancing evidence-based planning, expanding the ability of planners to handle complex, dynamic, and data-rich urban systems [61,62].

AI offers distinct opportunities to enhance each stage of the EBDP process. In the clarification phase, machine learning can synthesise vast datasets—such as demographic, environmental, and mobility data—to identify spatial inequalities and prioritise interventions [63,64]. In analysis and modelling, AI-driven predictive tools improve the capacity to simulate urban systems, supporting adaptive and scenario-based planning [65–67]. During design exploration, generative algorithms can test multiple spatial configurations, optimising social, economic, and environmental performance [68,69]. Finally, in evaluations, AI-enabled decision-support systems promote continuous feedback and transparency between planners, policymakers, and communities [61].

Nonetheless, the literature cautions that these opportunities are accompanied by technical, social, and ethical challenges, including data quality, algorithmic biases, transparency, and institutional capacity [17,70]. Future research should therefore prioritise participatory, transparent, and interdisciplinary AI integration to ensure that automation enhances, rather than replaces, human judgment and contextual understanding. By providing a model for how AI could be embedded into the logic of EBDP workflows, the framework can evolve toward enhanced versions where empirical reasoning, stakeholder knowledge, and algorithmic intelligence combine to produce more adaptive, equitable, and sustainable solutions.

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Data Availability Statement: No specific datasets were used in this study. The project documentation reviewed was partly publicly available and partly provided through the TWIN2EXPAND project consortium. The publicly available project materials can be accessed at https://spacesyntax.com/cities-regions/cities-regions-landing-page/, accessed on 1 September 2024. Detailed documentation for projects that are not publicly accessible cannot be provided openly owing to client confidentiality agreements, but can be made available from the authors upon reasonable requests.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EBDP	Evidence-Based Design and Planning
RID	Research Informed Design
DDD	Data Driven Design

GIS	Geographic Information System
SSL	Space Syntax Limited
SURF	Society and Urban Form Lab
IUM	Integrated Urban Model
KPI	Key Performance Indicators
AI	Artificial Intelligence
DESIRE	Design improvements Supporting Active Travel Around Secondary Schools

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