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DATA-DRIVEN DECISION SUPPORT FOR CONSTRUCTION METHOD SELECTION IN LINEAR INFRASTRUCTURE PROJECTS: A SYSTEMATIC REVIEW

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Abstract

The selection of construction methods is a critical factor in linear infrastructure projects, yet current practice remains largely experience-driven. As is evident from the extant literature, multi-criteria decision-making, rule-based and algorithmic approaches are applied to support method selection. The present systematic literature review analyses these approaches with respect to input parameters, output structures, and validation strategies. The findings indicate a predominance of project-level ranking models and limited spatial resolution. Key deficiencies identified include inadequate scalability, deficient integration of costs and restricted applicability to corridor-scale decision-making. The review identifies these gaps as central challenges for future data-driven decision-support systems.

Introduction

The accelerated expansion of energy transmission infrastructure is a key prerequisite for achieving climate and energy policy goals in many countries. In Germany, too, the expansion of transmission grids poses a particularly complex planning challenge. This complexity along underground transmission routes arises from heterogeneous environmental conditions, dense existing infrastructure and highly variable geotechnical conditions along the routes (Ahmels & Bruns, 2016; TenneT TSO GmbH, 2025). In particular, soil conditions, groundwater conditions, intersection types, access restrictions or environmental restrictions can change significantly over short distances. Consequently, the construction methods selected in response to these conditions along the corridor significantly influence costs and time, environmental impacts and technical risks. Inadequate choices can increase costs, prolong construction periods and intensify environmental-related constraints (Neuling, 2013). In this context, the selection of suitable construction methods, such as open-cut excavation or horizontal directional drilling (HDD), plays a decisive role in project execution. Linear infrastructure projects are typically realised along extended corridors with spatially varying boundary conditions, where construction-related constraints may change over short distances. As a result, construction method selection is not a single project-level decision but a sequence of locally constrained choices made along the corridor. Figure 1 illustrates such a construction context by showing an open-cut excavation along a linear infrastructure corridor. Furthermore it highlights the spatial setting in which construction method selection translates into locally constrained execution decisions along the route.

Figure 1: Open-cut construction method along a linear infrastructure corridor (source: Max Bögl Group)

Despite their relevance, the selection of construction methods for linear infrastructure projects is still predominantly based on expert judgement, experience-based heuristics, and manually prepared feasibility studies. While such approaches benefit from domain expertise, they are difficult to standardise, reproduce, or scale across long corridors with heterogeneous boundary conditions. In contrast, a data-driven construction method selection approach could have the potential to support spatially resolved, segment-oriented decision-making. Construction methods would be assessed locally along the corridor, enabling more transparent and reproducible decision-making.

Against this backdrop, digital planning tools are increasingly being explored to operationalise such spatially resolved decision-making in infrastructure projects. Therefore research and practice have made significant progress in the digitalisation of infrastructure planning. Geographic information systems (GIS) have become a core technology for the integration and analysis of spatial data in corridor and route planning, enabling the systematic consideration of environmental constraints, topography and existing infrastructure (Schito & Grassi, 2015).

GIS-based approaches are widely used for route optimisation, spatial conflict analysis, and corridor evaluation, often in combination with resistance-based models or multi-criteria decision analysis (MCDA) (Malczewski, 2006; Steuer & Donaubauer, 2012). Within the context of digital construction, these developments form part of a broader convergence of geospatial modelling and simulation-based planning and increasingly shape research in construction informatics (Linner, 2024). They primarily address the question of *where* infrastructure should be located, while higher levels of automated or algorithmic decision support for construction-related decisions remain limited in practice (Pan M. et al., 2018).

However, once a route has been determined due to approval decisions, land use restrictions or agreements with stakeholders, the focus of planning shifts from route selection to construction. At this stage, the key question is *how* the infrastructure should be built along heterogeneous corridor segments. While tunnel construction and microtunnelling research has extensively addressed method and machine selection under geological uncertainties, the systematic transfer of such decision-making concepts to corridor-based linear infrastructure remains limited (Pan M. et al., 2020; Borrmann, 2024). Existing GIS-based planning tools and digital planning environments predominantly support data management, visualisation, and documentation of route alignments, while providing limited support for the automated derivation of construction methods or execution variants (Pan M. et al., 2020; Borrmann, 2024). Similarly, BIM and simulation-based approaches increasingly enable detailed modelling of construction processes, but they often lack integration with large-scale geodata sets or the segment-by-segment decision logic required for long linear projects (Borrmann A. et al., 2015; Borrmann, 2024; Arashpour, M. et al., 2025). Consequently, planning and execution data remain fragmented, and decisions about construction methods are rarely supported by transparent, reproducible, and data-driven models that work along entire corridors.

Recent research highlights the growing potential of integrated, model-based decision support systems that link geospatial data, geotechnical information and execution-related parameters within a unified analytical framework (König, M. et al., 2021; Pache, Scharun, & Hochmuth, 2024). At the same time, several authors emphasise the ongoing challenges associated with data heterogeneity, expert dependency and limited interoperability between planning and execution models (Schito & Grassi, 2015; Arashpour, M. et al., 2025). These limitations are particularly evident in the selection of construction methods, which remains one of the least standardised and most experience-driven steps in linear infrastructure planning. Against this backdrop, a systematic understanding of existing data- and model-based approaches to the selection of construction methods is needed.

On the one hand, individual studies propose decision support models based on multi-criteria evaluation, rule-based logic or hybrid algorithmic approaches. On the other hand, there is still a lack of a consolidated overview of these methods, their input specifications and output structures, and their validation strategies.

This study addresses this need by conducting a systematic literature review and deriving a structured taxonomy of decision-support approaches for construction method selection in linear infrastructure projects.

Building on the identified gaps, ongoing research aims to develop GIS-based, segment-oriented decision-support workflows that translate corridor-scale constraints into transparent method assignments and link them to cost and schedule evaluation.

Research Objective and Questions

The objective of this systematic literature review is to identify data- and model-based approaches for selecting construction methods in linear infrastructure projects. These approaches will then be classified and summarised. The review focuses on methodological contributions that support the selection of construction methods under heterogeneous segment conditions. Beyond identifying families of methods, the overview aims to systematically consolidate the types of input parameters used for decision-making. Moreover, the different forms in which decision results are provided in the existing approaches are consolidated. In the final step, validation strategies and frequently reported limitations are to be evaluated.

To achieve this goal, three specific research questions were formulated.

RQ1: Which data- and model-based approaches for the selection of construction methods in linear infrastructure projects are described in the scientific literature?

RQ2: Which input parameters (e.g. geotechnical, geometric, ecological or economic factors) and which output structures (e.g. rankings, suitability assessments, cost or time indicators or method assignments) are used in these approaches?

RQ3: How are the proposed decision models validated and what methodological limitations are discussed in literature?

Methodology – Systematic Review Design

In order to address the research objective and the three research questions defined in Chapter 2, a systematic literature review was conducted. The methodological design enables a structured and transparent analysis of data- and model-based approaches to construction method selection in linear infrastructure projects. It further ensures the reproducibility of both the synthesis and the underlying selection process. The review follows established guidelines for systematic reviews in civil engineering research and is aligned with the PRISMA framework (Page, M. et al., 2021).

Review Protocol and Analytical Framework

The methodological workflow of the review is divided into five consecutive phases: definition, search, selection, analysis and synthesis. Figure 2 provides an overview of the analytical workflow used in this study.

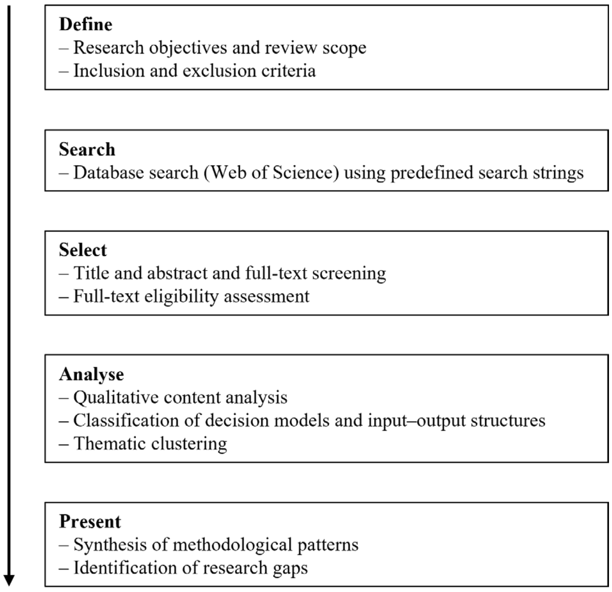

Figure 2: Methodological workflow of the systematic literature review

Literature Search Strategy

The literature search followed a transparent and reproducible procedure in accordance with the PRISMA framework and comprised literature identification, scope restriction, full-text eligibility assessment, and qualitative synthesis. The search was performed using the Web of Science Core Collection and limited to peer-reviewed journal articles and conference proceedings published in English between 2016 and January 2026.

Web of Science was selected as the primary database due to its structured indexing and broad coverage of engineering and construction-related outlets, supporting a consistent and reproducible review process.

Grey literature, such as technical reports or non-peer-reviewed project documentation, was not systematically included.

A predefined search strategy was applied on 12 January 2026 using three thematic keyword groups addressing (i) construction method selection, (ii) decision-support approaches, and (iii) linear infrastructure contexts. Keywords were combined using Boolean operators (OR within groups; AND between groups).

The search query was conducted using a topic search (TS), covering title, abstract, and author keyword fields. All search terms are summarised in Table 1. On top, subject-category filters were defined to restrict the results to relevant research fields. The selected categories included Engineering Civil, Construction & Building Technology, Materials Science Multidisciplinary, Physics Applied, Environmental Sciences, Computer Science Information Systems, Engineering Multidisciplinary and Geosciences Multidisciplinary. These categories were deliberately defined beyond the core field of civil engineering to ensure a broader coverage of related research domains and to capture potentially relevant methodological approaches from adjacent disciplines. Additional records were assigned to further categories but were not explicitly considered as primary filters.

After applying these filters, 177 publications remained from the initial 284 records for further screening.

Table1: Keyword groups and associated search terms used for the literature search

Keyword group	*Associated keywords*
Construction method selection	*construction method; construction technique; method selection; installation method; trenchless; horizontal directional drilling; HDD; tunnell; TBM selection*
Decision-support approaches	*decision support; select; multi-criteria; multicriteria; MCDA; MCDM; AHP; TOPSIS; ELECTRE; PROMETHEE; fuzzy; rule-based*
Linear infrastrucure context	*linear infrastructure; corridor; route; alignment; pipeline; cable; utility; underground infrastructure; transmission line*

This was followed by a two-stage screening process. First, titles and abstracts were reviewed for thematic relevance. Records that did not relate to civil engineering or construction or that did not focus on construction methods or processes were excluded at this stage. The full-text articles were then reviewed for suitability in terms of their methodological relevance. Studies were excluded in the full-text phase if they did not contain an explicit selection or comparison of construction methods, did not have a formal decision-making or evaluation model, or were purely descriptive case studies without transferable methodological contributions. The entire screening and selection process is summarised in the PRISMA flow diagram shown in Figure 3.

Data Extraction and Synthesis Approach

A structured data extraction scheme was used for the final selection of the included studies. Each publication was analysed with regard to (i) the type of decision support approach, (ii) the input parameters considered, (iii) the structure of the decision results, and (iv) the validation strategy applied. The extracted information was summarised using qualitative content analysis and thematic clustering. This process enabled the classification of decision support methods into methodological families, the identification of frequently used parameter categories, and the evaluation of validation practices and methodological limitations.

Results – Classification and Synthesis of Approaches

This section synthesises the results of the systematic review in accordance with the three research questions. The included studies were analysed with respect to their underlying decision-support approaches (RQ1), considered input parameters and output structures (RQ2), and applied validation strategies and methodological limitations (RQ3).
Table 2 provides an overview of the studies included in the qualitative synthesis.

Types of Decision-Support Approaches (RQ1)

The reviewed literature reveals three dominant families of decision-support approaches for construction method selection in linear infrastructure projects: (i) multi-criteria decision-making (MCDA) methods, (ii) rule-based and knowledge-based models, and (iii) hybrid or algorithmic decision approaches (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Parka, A. et al., 2020; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025).

In terms of digital decision support, the identified method families can be interpreted as distinct digital decision-support paradigms, ranging from expert-driven rule-based knowledge models to algorithmic and hybrid approaches with increasing degrees of automation (Pan M. et al., 2018; Pan M. et al., 2020).

MCDA-based approaches constitute the largest group of identified methods. These studies typically employ established techniques such as the Analytic Hierarchy Process (AHP), the Analytic Network Process (ANP) or fuzzy extensions to rank alternative construction methods based on weighted evaluation criteria (Aschilean & Giurca, 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023). MCDA approaches are predominantly applied at the project level and aim to support early-stage decision-making under multiple, often conflicting criteria.
While these methods provide transparent and structured rankings, they generally rely on predefined weights and are sensitive to expert judgement (Aschilean & Giurca, 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023).

Rule-based or expert-driven approaches formalise expert knowledge in the form of deterministic rules or decision trees (Matthews J. et al., 2018; Parka, A. et al., 2020). These models are commonly applied in more detailed planning or design stages and focus on technical feasibility and constraint satisfaction (Marinos V. et al., 2018; Parka, A. et al., 2020). Although such approaches enable consistent decision logic, their transferability is often limited by context-specific rule sets (Marinos V. et al., 2018; Parka, A. et al., 2020).

Hybrid and algorithmic approaches combine rule-based feasibility checks with optimisation or simulation techniques (Matthews J. et al., 2018; Leu, S.S. et al., 2025). These models are typically applied at a segment based decision level and explicitly account for spatial variability along linear infrastructure corridors (Matthews J. et al., 2018; Leu, S.S. et al., 2025).

Compared to purely MCDA-based methods, hybrid approaches allow the assignment of different construction methods to individual segments and thus offer a higher degree of operational realism (Matthews J. et al., 2018; Leu, S.S. et al., 2025).

Input Parameters and Output Structures (RQ2)

Across the reviewed studies, input parameters can be grouped into four main categories: geological and geotechnical conditions, geometric characteristics, economic factors, and environmental or social aspects (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Alinizzi, M. et al., 2020; Ma, P. et al., 2023; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025).

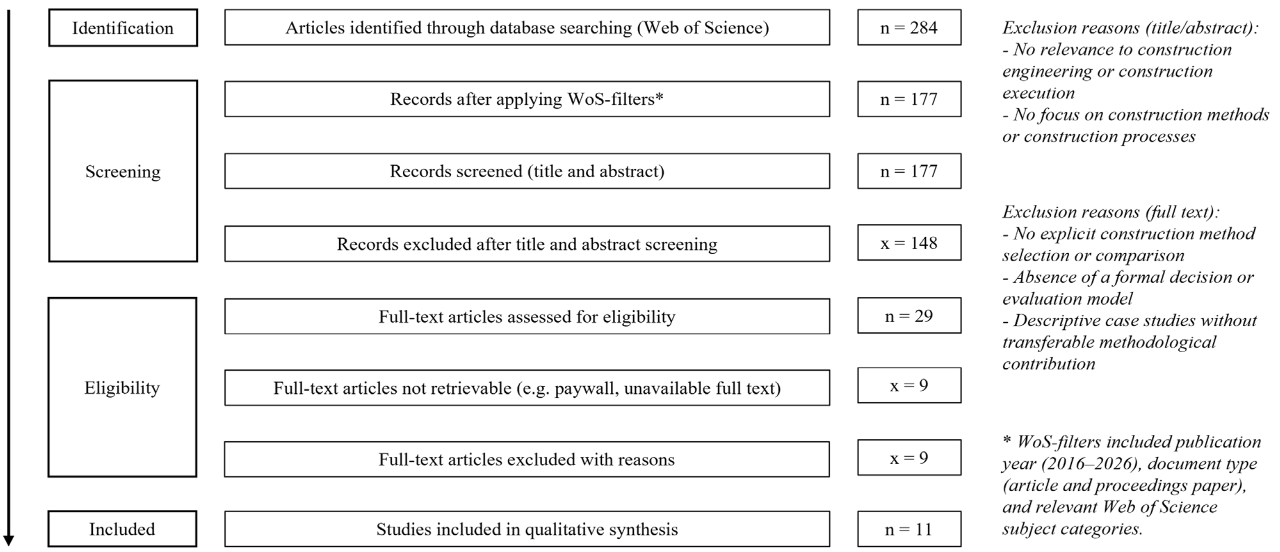

Figure 3: PRISMA flow diagram illustrating the literature search, screening, and study selection process

Geological and geotechnical parameters, such as soil type, groundwater conditions, and geomechanical properties, are considered in the majority of technically oriented models (Marinos V. et al., 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Ma, P. et al., 2023; Leu, S.S. et al., 2025).

Geometric inputs typically include pipeline diameter, installation depth, alignment length, and crossing conditions (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Ma, P. et al., 2023; Lin, S.S. et al., 2023).

Economic parameters, including construction cost and duration, are widely used across all methodological families (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Parka, A. et al., 2020; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025). Environmental and social criteria, such as emissions, traffic disruption, or societal impacts, are incorporated less consistently and are mainly addressed in sustainability-oriented MCDA studies (Zwierzchowska & Kuliczkowska, 2019; Alinizzi, M. et al., 2020; Rokstad, M. et al., 2025).

Regarding output structures, most approaches generate ranked lists or suitability scores for alternative construction methods (Aschilean & Giurca, 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023). Some studies provide a single recommended method, while others report relative performance indicators or Pareto-optimal solutions (Marinos V. et al., 2018; Parka, A. et al., 2020; Leu, S.S. et al., 2025). Only a limited number of models explicitly assign construction methods at a segment level along a predefined alignment (Matthews J. et al., 2018; Leu, S.S. et al., 2025).

The findings highlight a clear dominance of ranking-based outputs and a lack of models that produce directly implementable, spatially explicit construction method assignments (Aschilean & Giurca, 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025).

Validation Strategies and Methodological Limitations (RQ3)

Validation strategies across the reviewed literature predominantly rely on illustrative case studies and scenario-based analyses (Aschilean & Giurca, 2018; Marinos V. et al., 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Parka, A. et al., 2020; Alinizzi, M. et al., 2020; Ma, P. et al., 2023; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025). Many studies demonstrate their proposed methods using single real-world projects or hypothetical examples (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Parka, A. et al., 2020; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025).

Simulation-based validation is applied in algorithmic and risk-oriented approaches, whereas sensitivity analyses are commonly used in MCDA-based models to assess robustness against weighting assumptions (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Kwast-Kotlarek & Hełdak, 2019; Leu, S.S. et al., 2025).

Despite these validation efforts, several methodological limitations are recurrent. A strong dependence on expert input remains a key challenge, particularly in weighting criteria and defining rule sets (Aschilean & Giurca, 2018; Zwierzchowska & Kuliczkowska, 2019; Kwast-Kotlarek & Hełdak, 2019; Parka, A. et al., 2020; Lin, S.S. et al., 2023). Data availability and quality constraints limit the applicability of many models beyond their original case contexts (Marinos V. et al., 2018; Matthews J. et al., 2018; Ma, P. et al., 2023; Leu, S.S. et al., 2025).

Furthermore, most approaches lack integration with scheduling, cost control, or digital planning systems, which restricts their practical adoption in real-world project environments (Aschilean & Giurca, 2018; Matthews J. et al., 2018; Alinizzi, M. et al., 2020; Lin, S.S. et al., 2023; Leu, S.S. et al., 2025).

Table 2: Overview of studies included in the qualitative synthesis

ID	Author(s)	Year	Title (short)	Infrastrucure context
01	Aschilean et al.	2018	Sewer pipe rehabilitation (ANP)	Water pipelines
02	Marinos et al.	2018	TBM selection for microtunnelling	Microtunnelling
04	Matthews et al.	2018	Multi-segment trenchless method selection	Pipelines
05	Zwierzchowska et al.	2019	Fuzzy trenchless technology selection	Pipelines
06	Kwast-Kotlarek et al.	2019	HDD vs. open-cut method selection (AHP)	Gas pipelines
07	Parka et al.	2020	Rule-based pressure pipe lining selection	Water pipelines
09	Alinizzi et al.	2020	Fuzzy-QFD pipeline construction assessment	Large-diameter pipelines
11	Ma et al.	2023	Empirical analysis of pipe jacking practice	Pipe jacking
12	Lin et al.	2023	Optimal construction method evaluation	Underground infrastructure
15	Rokstad et al.	2025	Adoption of trenchless technologies	Water infrastructure
18	Leu et al	2025	Risk-based microtunneling machine selection	Microtunneling

Discussion

Interpretation of Results and Methodological Trends

The results of the systematic review show that research on data- and model-based construction method selection for linear infrastructure projects is methodologically diverse but limited in operational depth. Although numerous decision-support approaches have been proposed, most outputs remain project-level rankings or suitability assessments.

They primarily support the decision-making process in the early stages and rarely reflect the spatial variability of real-world corridors. Multi-criteria decision-making approaches dominate the literature, offering transparent evaluation structures and enabling the integration of technical, economic, and environmental criteria. Their outcomes strongly depend on expert-defined weights and project-specific assumptions.

Rule- and knowledge-based models provide more detailed feasibility assessments but often suffer from limited transferability due to context-specific rule sets. Against this background, a small number of core contributions represent a methodological advancement by addressing construction method selection at a segment or corridor level. Matthews J. et al. (2018) demonstrate how rule-based feasibility constraints combined with optimisation logic enable differentiated method assignment along pipeline corridors. Leu, S.S. et al. (2025) extend this perspective by incorporating risk and robustness considerations through Pareto-optimal solution spaces. In contrast, Alinizzi, M. et al. (2020) and Lin, S.S. et al. (2023) provide structured multi-criteria assessment frameworks that largely remain within ranking-based decision paradigms.

Identified Research Gaps

In spite of these advances, several persistent research gaps emerge from the synthesis.

First, construction method selection is rarely conceptualised as a spatially distributed decision problem along predefined alignments. Most approaches abstract from corridor geometry and do not provide explicit segment-level method assignments.

Second, a gap exists between the availability of detailed geospatial and geotechnical data and their systematic integration into decision-support models. Although such data are frequently cited as inputs, they are seldom combined within modular, rule-based frameworks that enable automated and consistent method selection along entire corridors.

Third, the operational integration of decision models remains limited. Most studies provide rankings or qualitative recommendations without translating them into quantitative indicators for cost, duration, or resource demand, thereby constraining their applicability within scheduling, cost control, or digital planning systems.

When interpreted through an AI and digital construction lens, the reviewed approaches distinguish between knowledge-driven decision-support models, such as rule-based systems, and more data-driven or algorithmic approaches. Whereas knowledge-based models offer transparency and traceability, they exhibit limited scalability and adaptability to changing boundary conditions. Automated and hybrid approaches remain rare and are often constrained by data availability, interoperability challenges, and limited uncertainty handling (Pan M. et al., 2020; Linner, 2024). This highlights construction method selection as a promising yet underexplored application field for AI-enabled decision-support within integrated digital construction workflows.

Although this review focuses on peer-reviewed journal articles and conference proceedings to ensure methodological transparency and reproducibility, practice-oriented knowledge documented in grey literature is not systematically reflected. Technical guidelines, industry reports, and project documentation often contain detailed procedural knowledge on construction method selection.

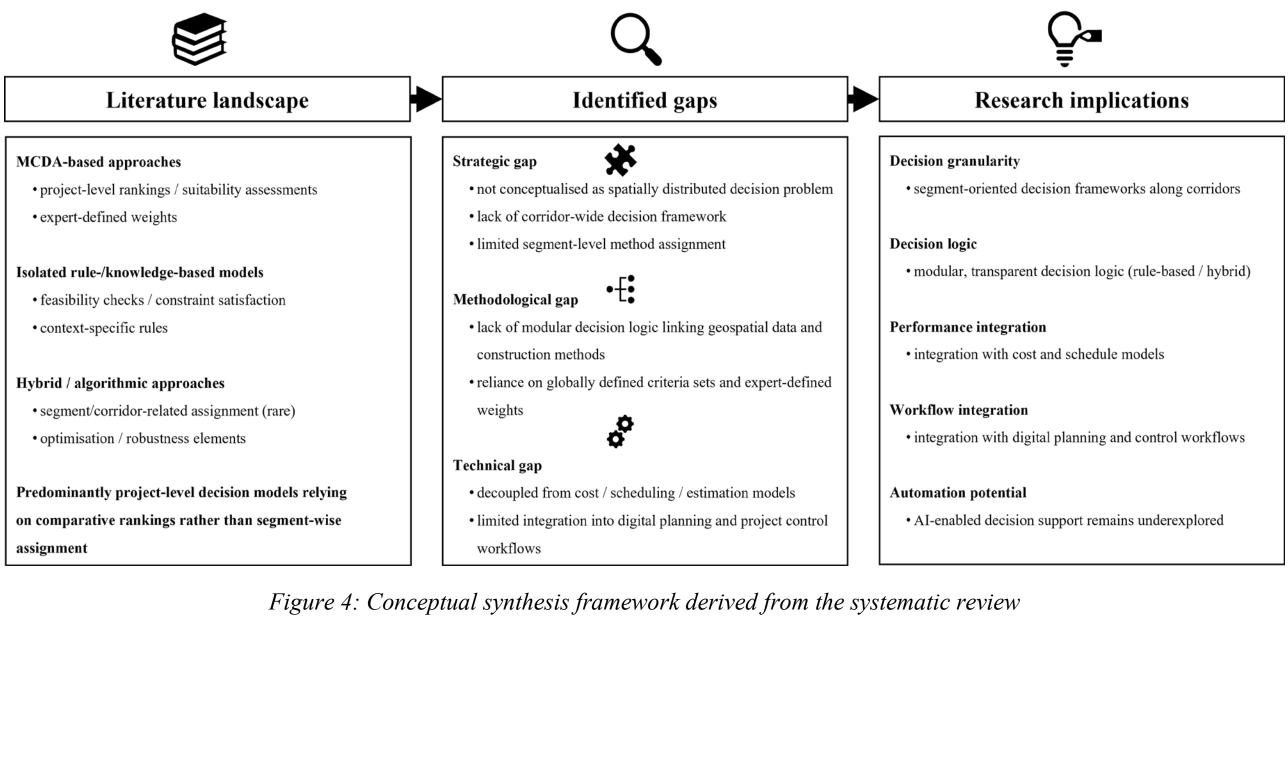

Figure 4: Conceptual synthesis framework derived from the systematic review

However, heterogeneous quality, limited traceability, and a lack of formal validation complicate systematic synthesis. From a scientific perspective, grey literature could be incorporated in complementary research designs, such as structured expert elicitation or qualitative case studies. While such approaches may support the transfer of practice-driven knowledge into reproducible decision-support models, they fall outside the scope of this systematic literature review.

Furthermore, another methodological limitation of this review lies in the restriction of the literature search to a single bibliographic database. While this supports consistency and reproducibility, relevant studies indexed exclusively in other databases (e.g., Scopus or Engineering Village) may not be fully captured. Future reviews could extend the search to additional databases and, where appropriate, complement peer-reviewed sources with structured evidence from practice-oriented outlets.

Methodological Implications for Decision-Support Approaches

Figure 4 summarises the review synthesis by linking the identified families of decision-support approaches, recurring limitations, and resulting methodological implications. Based on the findings of this systematic review, decision-support approaches for corridor-based projects should

(1) treat construction method selection as a segment-oriented decision problem with explicit spatial granularity rules,
(2) operationalise reusable and transparent decision modules linking ground and crossing conditions to feasible methods, and
(3) connect method assignment to cost, schedule, and resource evaluation through consistent data interfaces.

Building on these implications, the author’s ongoing research focuses on integrating spatial segmentation, modular decision logic, and quantitative evaluation within a GIS-enabled framework. Accordingly, validation needs to extend beyond single-case demonstrations and include sensitivity analyses and validation against empirical project data to assess model behaviour under varying boundary conditions.
Complementing this, Figure 5 positions the systematic review within an end-to-end decision-support workflow.

Conclusions and Outlook

By categorising existing decision-support approaches and analysing their input parameters, output structures, and validation strategies, the review establishes a transparent reference framework for comparative analysis and future research. The synthesis identifies a central structural limitation in current research: construction method selection is predominantly addressed through project-level or ranking-oriented models and remains weakly integrated with geospatial information and quantitative cost or scheduling perspectives. As a result, decision-support concepts are often fragmented and offer limited applicability for corridor-scale, segment-oriented planning.

Overall, the findings underline that construction method selection represents a critical yet underdeveloped component of digital infrastructure planning. Addressing the identified integration deficit is essential for improving transparency and reproducibility in the planning and execution of linear infrastructure projects. In this context, the review provides a structured foundation for the author’s research, which develops a modular hierarchy for construction method selection (e.g., open-cut and trenchless families and module types derived from soil and terrain conditions) and translates corridor constraints into reproducible module-based outputs (e.g., €/m and production rates). Such a framework aims to enable scalable, auditable, and quantitatively informed decisions along the entire alignment and to facilitate integration with downstream cost and schedule evaluation in digital planning workflows.

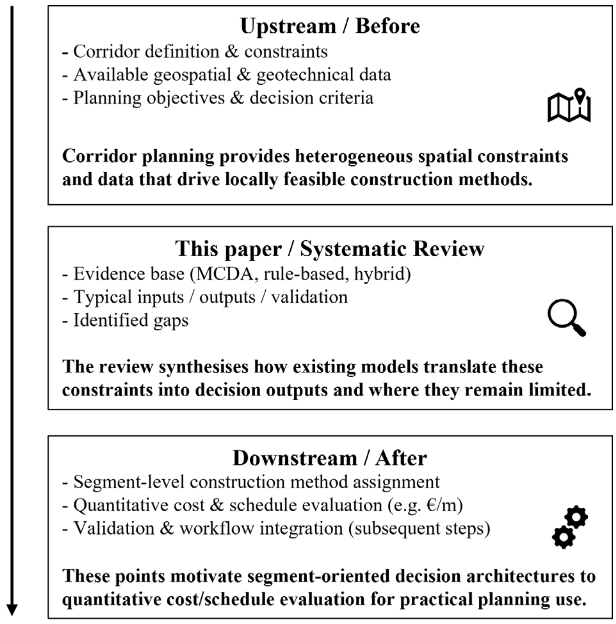

Figure 5: Systematic review positioned in an end-to-end corridor decision-support workflow.

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