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A conceptual framework for realising ESG-centred project value in modern methods of construction

Zixin Lu, Xiaohua Jin, Robert Osei-Kyei and Sepani Senaratne
School of Built Environment and Design, Western Sydney University, Penrith Campus, Kingswood, Australia

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Abstract

Purpose – Sustainability research on modern methods of construction (MMC) has predominantly conceptualised sustainability through assessed performance outcomes, particularly environmental indicators. While this literature demonstrates the sustainability potential of MMC, it offers limited explanation of how sustainability-oriented value is realised during project delivery. This study aims to develop a project-level conceptual framework to explain how environmental, social and governance (ESG)-centred project value is realised in MMC projects.

Design/methodology/approach – This study adopts a qualitative conceptual research approach focused on framework development. Insights from project value research, delivery-oriented perspectives and project capability literature are integrated with existing MMC sustainability research to inform the development of a project-level conceptual framework.

Findings – Existing MMC sustainability research is dominated by an outcome-oriented focus with limited attention to project delivery execution and implementation conditions. In response, this study develops an ESG-centred capability-focused conceptual framework that conceptualises sustainability as ESG-centred project value realised through ESG-centred project delivery execution across the MMC project life cycle and enabled by ESG-centred project team capability. The framework provides a project-level explanation of how ESG-centred project value is enacted in practice.

Research limitations/implications – As a conceptual study, the proposed framework has not yet been empirically tested.

Practical implications – The framework highlights the importance of embedding ESG priorities within project delivery execution and project team capability, rather than relying on technological adoption alone.

Originality/value – By shifting the analytical focus from performance measurement to value realisation through project delivery, the framework offers a novel project-level explanation of sustainability implementation in MMC.

Keywords Sustainability, ESG, Project value, Project management, Construction management, Modern methods of construction (MMC)

Paper type Conceptual paper

1. Introduction

Modern methods of construction (MMC), including off-site construction and prefabrication, are widely promoted as a promising approach to addressing industry challenges and supporting sustainability objectives in the built environment (Pan and Sidwell, 2011).

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Because MMC shift substantial work from site-based assembly to factory-based production and subsequent on-site installation, they have been associated with improved environmental performance across life cycle stages, including reductions in material waste and emissions (Kamali and Hewage, 2016). Consequently, project-level environmental evidence on MMC has often been generated through approaches such as life-cycle assessment (LCA), embodied carbon calculations, waste analysis and material efficiency assessments, typically framed as comparative evaluations against traditional construction methods (Kamali and Hewage, 2016; Jaillon and Poon, 2014).

As the sustainability evidence on MMC has expanded, research has remained predominantly outcome-oriented. Existing reviews indicate that sustainability research on MMC has generated substantial knowledge on what outcomes may be achieved, while offering more limited insight into how these outcomes are realised during project delivery (Jin *et al.*, 2020; Kamali and Hewage, 2016). Implementation processes are seldom examined explicitly, and sustainability outcomes are often analysed without attention to the project-level mechanisms through which they are produced. This analytical orientation constrains the ability of current research to explain why projects employing similar MMC configurations often exhibit markedly different sustainability results. MMC project delivery involves complex interactions among design coordination, off-site production, logistics and on-site assembly that unfold across the project lifecycle and require coordination among temporary multi-organisational project teams (Goodier and Gibb, 2007). Without an explicit conceptualisation of implementation processes, existing research struggles to translate sustainability evidence into actionable guidance for project teams.

Addressing this limitation requires a shift in analytical perspective. Rather than conceptualising sustainability solely as a set of performance outcomes, this study adopts a project value perspective that treats sustainability as something to be realised through project delivery. A value lens enables sustainability to be understood not only in terms of what is achieved, but also in terms of what is prioritised, negotiated and conducted throughout the project life cycle. However, sustainability as a project value remains selectively specified in existing research, with its articulation largely dominated by environmental concerns and offering limited clarity on other dimensions (Jaillon and Poon, 2014; Kamali and Hewage, 2016).

To address this problem, the study draws on environmental, social and governance (ESG) dimensions to conceptualise sustainability-oriented project value. ESG offers more than a set of performance indicators; it is used here as a value-structuring lens that captures the multidimensional nature of sustainability and reflects how sustainability priorities are increasingly framed in contemporary governance, investment and decision-making contexts (Eccles *et al.*, 2014; Global Reporting Initiative, 2021). In this study, ESG is treated as an analytical lens that structures how sustainability-related project value is interpreted and operationalised in project delivery. Although ESG has traditionally been applied at the organisational level, its underlying logic is highly relevant to projects, particularly MMC projects characterised by fragmented responsibilities, inter-organisational coordination and life cycle-spanning decisions (Davies and Hobday, 2009; Pan *et al.*, 2012; Söderlund and Tell, 2009). Recent studies have also begun to explore ESG considerations in relation to sustainability governance and value delivery in complex construction projects (Kim and Chang, 2022).

Outcome-based sustainability assessments remain important for evaluating environmental performance in MMC projects. However, such approaches primarily articulate sustainability through measurable results (Finnveden *et al.*, 2009; Gibson *et al.*, 2013). In this study, sustainability is conceptualised more broadly as ESG-centred project

value, which situates outcome-oriented sustainability within a wider project-level value structure encompassing ESG considerations. Figure 1 illustrates this relationship.

Conceptualising sustainability as ESG-centred project value raises a further analytical question regarding how such value is realised in MMC projects. It is not embedded in MMC technologies by default, nor is it automatically achieved through design intentions alone. Instead, it is realised through ESG-centred project activities conducted across the project life cycle (Martinsuo *et al.*, 2019; Zwikael and Smyrk, 2015). The consistent implementation of such activities depends on the collective ability of project teams to coordinate life cycle decisions, manage trade-offs and align actions across multiple organisational actors. This collective ability is conceptualised in this study as project team ESG-centred capability.

Building on these premises, this study develops a conceptual framework explaining how ESG-centred project value is realised in MMC projects through the interaction between ESG-centred project activities across the MMC project life cycle and project team ESG-centred capability. By making these relationships explicit, the framework provides a project management (PM) perspective on how sustainability-oriented value is achieved during MMC project delivery and offers a basis for explaining variation in sustainability outcomes across MMC projects.

2. Literature review

2.1 MMC research on outcome-oriented sustainability at project's level

Research on the sustainability performance of MMC, including modular and off-site construction, has expanded rapidly over the past decade, as evidenced by multiple critical and systematic reviews synthesising a growing body of project-level environmental studies (Jin *et al.*, 2020; Kamali and Hewage, 2016). Existing studies primarily quantify environmental performance through life cycle indicators such as carbon emissions, material efficiency and waste reduction.

A major direction in this literature focuses on building- or project-level life cycle comparisons between prefabricated/modular systems and conventional construction. These studies typically aim to quantify the magnitude of environmental improvement and to identify life cycle hotspots. For example, Pervez *et al.* (2021) report significant reductions in construction-phase greenhouse gas emissions for modular housing compared with conventional masonry construction. Similarly, Tian and Spatari (2022) conduct a cradle-to-site multi-indicator LCA comparing prefabricated and cast-in-situ projects in China, reinforcing the stage-based quantification logic characteristic of this stream.

A second group of studies shifts the analytical focus from whole buildings to components, materials or discrete processes to isolate embodied and installation-stage impacts. Xu *et al.* (2021), for instance, quantify emissions associated with production, transport and installation of prefabricated composite beams, demonstrating the dominant contribution of production-stage emissions and the sensitivity of transport impacts to logistics conditions. In

Figure 1. Conceptual positioning of ESG-centred project value in sustainability research on MMC
Source: Authors' own work

timber-based prefabrication, Smith *et al.* (2018) compare stick-built, panelised and modular timber systems, highlighting embodied carbon impacts and carbon storage effects across alternative construction systems.

A third strand adopts method-driven approaches that further consolidate this outcome-oriented orientation, including Building Information Modelling (BIM)-enabled LCA automation, multi-criteria decision-making methods and integrated LCA/LCC/S-LCA frameworks. Examples include automated BIM–LCA workflows for modular buildings (Ansah *et al.*, 2021), carbon comparisons of industrialised building systems using environmental modelling tools (Balasbaneh and Bin Marsono, 2017), and integrated sustainability evaluation models using multi-criteria decision techniques such as AHP or TOPSIS (Balasbaneh and Ramli, 2020; Balasbaneh and Sher, 2021). While these approaches enhance analytical efficiency and comparability, they remain centred on quantified sustainability outcomes rather than delivery processes.

Taken together, this literature establishes robust environmental baselines for MMC and provides consistent evidence on typical performance ranges, life cycle hotspots and trade-offs. Sustainability is predominantly evidenced through aggregated environmental indicators and life cycle-stage decomposition, forming a coherent outcome-oriented research tradition that prioritises performance measurement over explanation.

While this body of research provides important environmental evidence, sustainability considerations in construction projects are increasingly discussed through broader ESG dimensions. Environmental aspects have received extensive empirical attention, yet project-level sustainability outcomes are also shaped by social and governance conditions embedded in how construction activities are organised and coordinated across project actors.

Social dimensions in MMC delivery relate primarily to workforce conditions and stakeholder impacts associated with the shift from craft-based site production to industrialised off-site manufacturing and assembly. Previous studies have highlighted the implications of prefabrication for workforce training, labour organisation and site safety management (Goodier and Gibb, 2007; Pan *et al.*, 2012). These social conditions are closely intertwined with project delivery arrangements, as the effectiveness of off-site manufacturing and on-site installation depends on the ability of project teams to coordinate safety practices, workforce collaboration and task sequencing across distributed production environments (Davies and Hobday, 2009; Söderlund and Tell, 2009).

Governance dimensions concern the coordination structures through which project stakeholders organise responsibilities, allocate decision authority and manage contractual interfaces across project delivery. Research on project governance highlights that accountability arrangements, decision rights and inter-organisational coordination mechanisms significantly influence outcomes in complex project systems (Too and Weaver, 2014; Winch, 2009; Miller and Hobbs, 2005). These governance issues are particularly salient in MMC projects due to their distributed production systems and strong interdependencies between designers, manufacturers, logistics providers and contractors (Davies and Hobday, 2009; Too and Weaver, 2014; Winch, 2009).

Despite the relevance of these broader ESG dimensions, empirical sustainability research in MMC remains predominantly centred on environmental performance measurement, leaving the social and governance conditions through which sustainability outcomes are realised during project delivery comparatively underexplored.

2.2 Silence on the implementation's side in empirical sustainability studies on MMC

Across this predominantly environmental and outcome-oriented evidence base, project delivery is rarely examined as an explanatory process. Sustainability outcomes are

commonly modelled as the result of predefined inventories, life cycle stages or scenario assumptions, while the organisational, managerial and operational processes through which those outcomes are realised are largely absent from empirical analysis.

This implementation silence is evident in project-level life cycle assessments comparing modular and conventional construction. For instance, Pervez *et al.* (2021) represent construction activities through material, transport and energy inventories, without examining how off-site manufacturing, logistics coordination or on-site assembly are planned and executed by project teams. Similarly, Li *et al.* (2022) quantify life cycle carbon emissions across five prefabricated high-rise projects using aggregated life cycle stages, but do not analyse the organisational arrangements or coordination mechanisms underpinning delivery. Tian and Spatari (2022) adopt a cradle-to-site LCA framework that decomposes emissions by stage while abstracting away from how activities are sequenced and managed across off-site and on-site contexts.

The same pattern appears in component- and process-focused assessments. Xu *et al.* (2021) demonstrate that transport-related emissions are highly sensitive to transport mode and distance, yet transport decisions are treated as scenario inputs rather than as outcomes of project planning, coordination or capability. Li *et al.* (2023) similarly quantify emissions across production and installation stages without analysing the delivery conditions under which alternative logistics or installation strategies would be feasible.

Across these studies, construction delivery is implicitly positioned as analytically neutral once MMC adoption and system boundaries are defined. Decisions concerning coordination between off-site production and on-site assembly, sequencing of activities and responses to project-specific constraints are not directly observed or theorised. This implementation silence reflects a structural feature of an outcome-oriented research tradition rather than a shortcoming of individual studies. While the literature is well equipped to estimate how much sustainability improvement may be associated with MMC, it provides limited insight into how project teams realise such improvements under varying project conditions.

2.3 Activity-level descriptions without capability theorisation

A smaller subset of sustainability research on MMC moves closer to implementation by explicitly examining project delivery activities that influence sustainability outcomes. These studies provide evidence that sustainability performance is sensitive to how project-level activities are organised and executed, particularly during installation and logistics stages where coordination between off-site production and on-site assembly becomes critical from both operational and governance perspectives. In this sense, sustainability outcomes in MMC projects are not only determined by technical system choices or life cycle characteristics, but also by how project teams organise, sequence and coordinate delivery activities under specific project conditions. However, while these studies highlight the importance of delivery activities, such activities are rarely theorised as manifestations of underlying project team capability.

Installation-stage workflow and site management activities are a prominent focus. Wu *et al.* (2013) investigate non-value-adding activities during precast concrete installation and identify multiple sources of avoidable emissions, including inefficient site layout, poor communication, inappropriate crane allocation and unnecessary handling. Building on this activity-level diagnosis, Peng (2015) quantify effective versus wasted emissions in precast column installation cycles and show that more than 70% of installation-stage emissions are attributable to workflow inefficiencies. These findings demonstrate that environmental performance is highly sensitive to how installation activities are configured and managed on site.

Logistics and transport-related activities also emerge as critical levers. Xu *et al.* (2021) show that transport emissions vary substantially with transport mode and distance, indicating the importance of logistics planning and delivery sequencing decisions. Li *et al.* (2023) similarly identify logistics and installation activities as non-negligible contributors to total emissions under certain project configurations. Across these studies, activities such as site layout planning, crane scheduling, just-in-time delivery coordination and installation sequencing repeatedly shape sustainability outcomes.

Despite this proximity to delivery practice, activities are predominantly framed as discrete optimisation measures or elements of operational efficiency, often within lean or workflow improvement perspectives. Even when coordination, supervision and communication are discussed, they are treated as operational factors rather than conceptualised as collective project team capabilities. As a result, while activity-level explanations demonstrate that sustainability outcomes are project-team-executable, the literature offers limited insight into the capability conditions under which such activities are consistently implemented, adapted and integrated across projects.

3. Methodology

This section describes the research design and analytical approach adopted in this study. It explains how the literature was identified, selected and analysed to support theory development.

3.1 Research design and scope

This study adopts a conceptual research design aimed at developing a framework to explain how ESG-centred project value is realised in MMC projects. Conceptual research of this type seeks to integrate insights from existing literature to clarify under-theorised relationships and to construct new analytical structures that explain observed phenomena.

The scope of the study focuses on ESG goals at the project level in MMC contexts. In particular, the analysis examines how sustainability considerations, increasingly articulated through ESG perspectives, are translated into project delivery processes and realised as project value. The study therefore concentrates on the relationships between project delivery processes, project team capability and ESG-centred project value realisation within MMC projects.

The conceptual framework was developed through a structured conceptual development process consisting of problem identification, literature identification and evidence base formation, conceptual analysis and synthesis and conceptual integration leading to framework development. This overall methodological procedure is illustrated in Figure 2, which summarises the stages through which the conceptual framework proposed in this study was developed.

3.2 Literature search strategy and data sources

To identify literature relevant to the conceptual development of the framework, a structured literature search was conducted. The search aimed to capture sustainability-related research in MMC projects, including studies examining environmental and broader sustainability outcomes as well as research addressing project-level delivery activities, implementation processes and organisational aspects of MMC projects. These studies provide the empirical and analytical basis for developing an ESG-centred conceptual framework in this study.

The search was conducted using Scopus and Web of Science. The search targeted journal articles published in English from 1 January 2010 to 28 October 2025. The review period was defined from 2010 onwards to capture the consolidation of sustainability research on

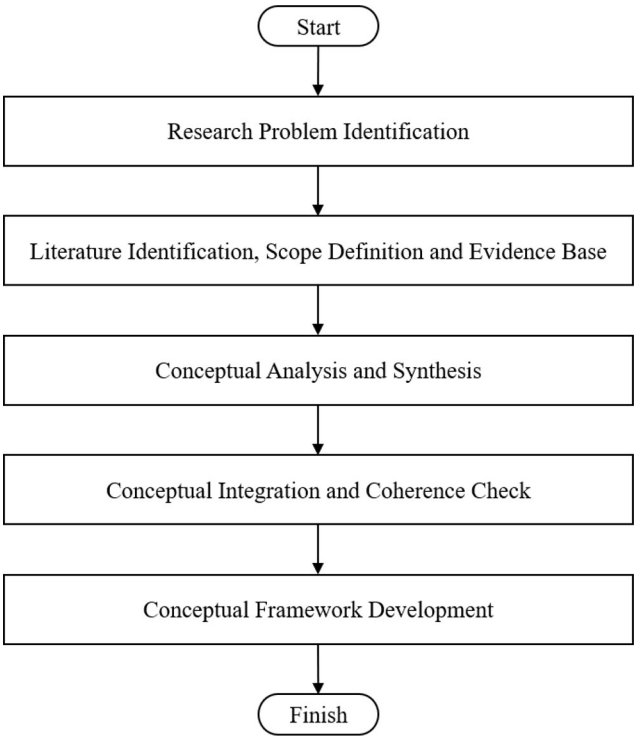

Figure 2. Methodology procedure of the conceptual framework development in this study
Source: Authors' own work

MMC projects. During this period, sustainability was increasingly examined in relation to project delivery, life cycle coordination and organisational processes (Silvius and Schipper, 2014; Jin *et al.*, 2020; Jaillon and Poon, 2014).

Search strings were developed to capture project-level sustainability research in MMC contexts by combining three groups of terms: (1) MMC-related construction methods, (2) sustainability and ESG-related outcomes and (3) project-level processes and implementation activities. Keyword clusters were developed for each domain. The first cluster included MMC-related terms (e.g. modern methods of construction, off-site construction, prefabrication, modular construction, industrialised building systems, PPVC and DfMA). The second cluster captured sustainability and ESG-related concepts (e.g. sustainability, environmental performance, ESG, life cycle assessment, low-carbon construction and resource efficiency). The third cluster focused on project-level and delivery-related concepts (e.g. project, activity, practice, process and implementation). These keyword clusters were combined using Boolean operators within the title, abstract and keyword fields.

This concept-driven search strategy was designed to capture studies addressing both sustainability outcomes and project delivery processes within MMC projects. The resulting records were subsequently screened to identify studies relevant to sustainability outcomes, life cycle stages, delivery activities and organisational aspects of MMC projects at the

project or building level. The screening results and final evidence base used for conceptual analysis are described in the following section.

3.3 Evidence base and screening results

The database search returned 1,213 records in total (Web of Science: 515; Scopus: 698). All records were exported to a reference management software for duplicate removal and screening. After removal of duplicates and screening of titles and abstracts for relevance to project- or building-level sustainability in MMC contexts, 169 articles were retained for full-text assessment.

Following full-text review, 60 empirical journal articles were identified as directly relevant to the study's focus. These studies explicitly examined sustainability outcomes, life cycle stages, delivery activities or organisational and project-related aspects of MMC at the project or building level. This final set of articles constitutes the evidence base for the literature review and the subsequent development of the conceptual framework presented in this paper.

3.4 Conceptual analysis and framework development

The retained literature was analysed through an interpretive conceptual synthesis aimed at identifying analytical patterns and conceptual relationships relevant to sustainability in MMC projects. The analysis focused on three aspects: how sustainability was conceptualised and assessed at the project level, how project delivery activities and processes were addressed in the literature and how organisational or project team capabilities were theorised in relation to sustainability outcomes.

Through iterative reading and comparison of the selected studies, analytical patterns in how sustainability was conceptualised, assessed and linked to project delivery processes were examined. Particular attention was given to how sustainability outcomes were evaluated at the project level, how project delivery activities were discussed in relation to sustainability performance and how organisational or project team capabilities were theorised within MMC contexts.

These analytical patterns informed the subsequent conceptual integration undertaken in this study. Insights from MMC sustainability research were therefore combined with perspectives from project value and project capability literature to develop an integrated conceptual structure explaining how sustainability considerations can be translated into project delivery activities and realised as ESG-centred project value. This synthesis formed the basis for the ESG-centred Activity–Capability–Value conceptual framework proposed in this study.

4. ESG-centred activity-capability-value conceptual framework

This section presents the ESG-centred Activity–Capability–Value conceptual framework, hereafter referred to as the ESG value realisation framework. It introduces its theoretical foundations and defines its core constructs.

4.1 Theoretical foundations

Project-based research has long recognised that project outcomes cannot be adequately explained by technological choices or performance indicators alone, but must be understood through the interaction of value orientations, delivery processes and organisational capabilities (Davies and Hobday, 2009; Morris, 2013). Within this body of literature, three research directions have contributed to understanding how value is defined, achieved and

sustained in projects: project value research, activity- and practice-based perspectives and project capability literature. While these strands have developed largely in parallel (Söderlund, 2004), together they provide a strong theoretical foundation for examining how sustainability-oriented project value can be realised through project delivery.

Firstly, project value research has shifted attention away from viewing value as a predefined or inherent attribute of project outputs, towards understanding value as something realised through project delivery. From this perspective, value emerges through decisions made across the project life cycle, reflecting how objectives are prioritised, negotiated and balanced in practice (Laursen and Svejvig, 2016; Zwikael and Smyrk, 2015). This line of research highlights that value is fundamentally processual and context-dependent, shaped by how projects are managed rather than by technical solutions alone (Martinsuo *et al.*, 2019). Such insights are particularly relevant for sustainability-oriented projects, where value cannot be reduced to a single performance dimension but involves balancing multiple, and often competing considerations over time (Martinsuo *et al.*, 2019; Silvius and Schipper, 2014).

Secondly, activity- and practice-based perspectives provide a complementary foundation by explaining where and how such value is achieved. These perspectives emphasise that project outcomes are produced through situated actions, routines and interactions embedded in everyday project work (Morris, 2013; Söderlund, 2004). Importantly, this strand of literature demonstrates that activities do not simply execute predefined objectives; they are processes through which trade-offs are negotiated and values are operationalised (Söderlund, 2004; Martinsuo *et al.*, 2019). This insight supports the view that sustainability-oriented project value must be realised through project delivery activities rather than assessed solely through outcome indicators.

Thirdly, project capability literature extends these insights by explaining why similar activities may lead to different outcomes across projects. Research on project capabilities and temporary organisations shows that projects rely on collective, emergent abilities to coordinate interdependent tasks, integrate diverse expertise and adapt to uncertainty (Brady and Davies, 2004; Turner and Müller, 2003). These capabilities are not reducible to individual skills or organisational resources, but arise from interaction across organisational boundaries and evolve throughout project delivery (Davies *et al.*, 2016; Davies and Hobday, 2009). In complex project settings, capability therefore conditions how project activities are performed, aligned and adjusted over time (Brady and Davies, 2004; Davies *et al.*, 2016). This strand of research provides a theoretical basis for understanding variation in project outcomes that cannot be explained by activity configurations alone.

Taken together, these three strands suggest an implicit but underexplored linkage between value, activities and capability at the project level. While existing sustainability research has largely focused on evaluating project outcomes, such outcome-oriented approaches provide limited insight into how sustainability-oriented value is actually realised during project delivery. In particular, they offer little explanation of the project-level processes through which sustainability considerations are translated into coordinated actions and operational decisions among project actors. Addressing this limitation requires analytical concepts that capture both the execution of project delivery activities and the capabilities of project teams that enable such activities to be coordinated and adapted across the project lifecycle.

This gap is particularly evident in sustainability research on MMC. While MMC studies have generated extensive evidence on sustainability performance outcomes, they have paid limited attention to how sustainability-oriented value is realised through project delivery and why similar MMC configurations produce divergent outcomes in practice. By drawing together project value, activity-based and capability-based perspectives, this study

establishes a theoretical foundation for examining sustainability implementation as a project-level value realisation process in MMC projects. Building on these insights, this study conceptualises ESG-centred project value as an outcome realised through project delivery activities across the MMC project life cycle, enabled by project team ESG-centred capabilities.

4.2 Core constructs and mechanisms

The proposed framework is built around three core constructs: ESG-centred project value, project team ESG-centred capabilities and project delivery activities across the MMC project life cycle. These constructs represent three analytically distinct but interrelated layers of the framework: the outcome of project delivery, the execution processes through which value is realised and the enabling conditions that shape how these processes unfold. Together, they provide a structured basis for explaining how sustainability-oriented intentions are translated into project-level value during MMC project delivery.

In this study, ESG-centred project value refers to sustainability-oriented value realised through project delivery in MMC projects. Drawing on project value research, project value is understood as an emergent outcome that reflects how project objectives are achieved and balanced throughout the project life cycle (Laursen and Svejvig, 2016; Zwikael and Smyrk, 2015). Within the proposed framework, this value is structured through an ESG-centred value orientation, which provides a lens for articulating the ESG dimensions of sustainability-oriented project outcomes. Rather than treating ESG solely as a reporting or performance measurement framework, the present study adopts ESG as a conceptual structure for defining the content and direction of project-level sustainability value. From this perspective, ESG-centred project value captures what sustainability means within the context of project delivery, reflecting how ESG considerations are incorporated into project decisions and practices across the project life cycle.

Project delivery activities refer to the concrete actions through which projects are planned, coordinated and implemented across the MMC project life cycle (Project Management Institute, 2017; Turner, 2014). In MMC projects, project delivery spans multiple interrelated life cycle stages including initiation, design, off-site manufacturing, transportation, on-site assembly, maintenance and recovery phases (Kamali and Hewage, 2016; Pan *et al.*, 2012). Within MMC project life cycle, these activities frequently involve coordination across multiple organisational interfaces, such as design coordination, off-site production planning, logistics scheduling and on-site assembly. ESG considerations are closely intertwined with project delivery processes in MMC projects, particularly because project delivery spans both off-site production systems and on-site construction environments and involves complex coordination among multiple project actors (Davies and Hobday, 2009; Kamali and Hewage, 2016; Pan *et al.*, 2012). In this context, ESG considerations influence how project activities are prioritised, coordinated and adapted during project delivery. Table 1 summarises how ESG dimensions typically manifest at the project level and how they may shape project delivery activities in MMC contexts.

Within the proposed framework, project delivery activities therefore represent the execution mechanism through which ESG-centred project value may be realised in MMC projects. These activities are not treated as a distinct set of ESG-specific practices; rather, they refer to conventional project delivery processes enacted under an ESG-centred value orientation.

Project team ESG-centred capabilities capture the collective ability of project actors to coordinate, adapt and integrate project delivery activities in pursuit of ESG-centred project value. Consistent with the project capability literature, such capabilities emerge from interactions among multiple stakeholders and organisational boundaries rather than residing

Table 1. Conceptual interpretation of ESG dimensions in MMC project delivery

ESG dimension	Typical project-level concerns in MMC delivery	Implications for project delivery activities	Illustrative assessment perspectives
Environmental	Resource efficiency, material waste, emissions associated with off-site production and logistics	Environmental considerations influence design–manufacturing coordination, material selection, prefabrication logistics and assembly sequencing	Life-cycle environmental performance, waste reduction practices, carbon and resource efficiency evaluation
Social	Workforce safety, skill development, labour conditions and stakeholder impacts across production and construction environments	Social considerations influence workforce coordination across off-site/on-site interfaces, safety management and training practices	Safety and workforce practice review, skills and training assessment, stakeholder impact consideration
Governance	Accountability, transparency and coordination of decision-making across project actors and supply chain interfaces	Governance considerations influence how project actors coordinate decisions, manage contractual relationships and structure project interfaces	Governance and coordination review, accountability and decision-process assessment, contractual/interface evaluation

solely within individual actors (Brady and Davies, 2004; Davies *et al.*, 2016; Söderlund and Tell, 2009). In MMC projects, where off-site production and on-site assembly are tightly coupled and organisational interdependencies are pronounced (Pan *et al.*, 2012), these capabilities become critical for enabling project actors to coordinate delivery activities and integrate ESG considerations across project interfaces.

Taken together, the three constructs form an integrated explanatory structure for understanding how ESG-centred project value may be realised in MMC projects. Within this structure, project delivery activities constitute the execution mechanism through which value is realised, while project team ESG-centred capabilities function as enabling conditions that shape how these activities are coordinated and enacted under an ESG-centred value orientation. Figure 3 illustrated this structure.

For empirical application, the constructs may be operationalised through dimensions such as coordination, sequencing and integration in project delivery activities, and coordination, learning and governance capabilities within project teams.

Based on this logic, the relationships among the constructs can be expressed as the following propositions:

P1. Project team ESG-centred capabilities positively influence the effectiveness with which project delivery activities are coordinated and enacted across the MMC project lifecycle.

P2. Project delivery activities positively influence the realisation of ESG-centred project value in MMC projects.

P3. The influence of project team ESG-centred capabilities on ESG-centred project value is mediated by project delivery activities.

Finally, the effectiveness of these relationships may vary depending on contextual conditions of the project environment. In MMC projects, factors such as project type, the maturity of MMC adoption, contractual arrangements and the level of supply chain integration may shape how project team capabilities translate into coordinated activities and how such activities ultimately contribute to ESG-centred project value.

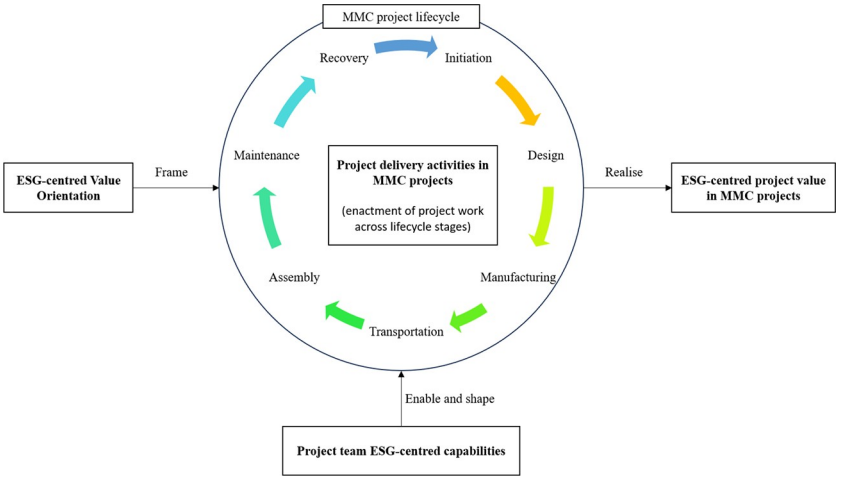

Figure 3. ESG-centred activity–capability–value conceptual framework for ESG-centred project value realisation in MMC projects

Source: Authors' own work

4.3 Positioning the framework within existing literature

The proposed ESG value realisation framework is positioned within, yet distinct from, several established streams of literature relevant to sustainability and PM in MMC. Rather than replacing existing approaches, the framework is intended to complement them by addressing explanatory gaps at the project level.

Within the sustainability literature on MMC, prior research has predominantly adopted an outcome-oriented perspective, focusing on the measurement of sustainability performance, especially environmental impacts through life-cycle assessment and indicator-based evaluation (Jaillon and Poon, 2014; Kamali and Hewage, 2016). This research direction has been effective in demonstrating the potential sustainability advantages of MMC, but it has largely treated sustainability as an outcome to be assessed rather than as a form of project value to be realised through delivery. The proposed framework is positioned relative to this literature by shifting analytical attention from performance measurement to the project-level processes through which ESG-centred project value is achieved during MMC delivery.

The framework is also related to activity-based and process-oriented studies, including lean construction and workflow-focused research, which have examined how specific activities and practices influence project performance and workflow efficiency (Ballard and Howell, 1998; Koskela, 2000). While these studies highlight the importance of activities in shaping outcomes, they typically treat activities primarily as optimisation targets without explicitly situating them within a broader value logic. In contrast, the proposed framework positions ESG-centred project activities across the MMC project life cycle as the execution layer, thereby linking activity execution to the realisation of ESG-centred project value rather than to efficiency improvement alone.

In relation to the project capability literature, existing research has emphasised the role of collective capabilities in enabling coordination, adaptation and performance in temporary organisational settings (Davies *et al.*, 2016; Davies and Hobday, 2009; Söderlund and Tell, 2009). This literature provides important insights into how projects manage complexity and

uncertainty, but has rarely been explicitly connected to sustainability-oriented value realisation in MMC contexts. The proposed framework is positioned to extend this trend by situating capabilities within an ESG-oriented sustainability setting, where ESG-centred project team capabilities enable the consistent achievement of ESG-centred project value across life cycle activities.

Taken together, the ESG value realisation framework occupies a distinct position at the intersection of sustainability research on MMC, activity-based project studies and project capabilities literature. By integrating these perspectives, the framework provides a project-level explanatory structure for understanding how ESG-centred project value is realised in MMC projects, without duplicating the analytical focus of existing research directions, while providing a process-oriented explanation of ESG-centred value realisation in MMC projects.

5. Discussion

This section discusses the implications of the proposed framework for sustainability research on MMC, PM theory and practice.

5.1 Reframing sustainability on MMC through ESG-centred project value

This study reframes sustainability on MMC by shifting attention from the measurement of sustainability performance to the realisation of ESG-centred project value. Prior sustainability research on MMC has predominantly conceptualised sustainability in terms of performance outcomes especially environmental indicators obtained from life-cycle assessment and carbon accounting (Jaillon and Poon, 2014; Kamali and Hewage, 2016). While such approaches have been essential in demonstrating the sustainability potential of MMC, they implicitly position sustainability as a property of construction methods or technologies rather than as a value to be realised through project delivery (Martinsuo *et al.*, 2019; Silvius and Schipper, 2014), thereby obscuring the organisational, managerial and governance processes through which sustainability potential is translated into, or undermined by, project practice.

Under this reframing, ESG-centred project value emphasises that sustainability is inherently multidimensional, encompassing ESG that must be prioritised and balanced over time (Eccles *et al.*, 2014). From this perspective, sustainability is not reducible to a single performance dimension, nor can it be treated as an outcome that automatically follows from MMC adoption (Goodier and Gibb, 2007; Pan *et al.*, 2012). Instead, ESG becomes a value orientation that shapes project decision-making and delivery processes across the project life cycle, influencing how environmental efficiency, social responsibility and governance accountability are prioritised and enacted in practice.

This perspective is particularly important in MMC contexts, where ESG-centred project value depends not only on technological choices but also on how projects are organised, coordinated and governed. By treating ESG-centred project value as the focal outcome of interest, the framework foregrounds ESG as a PM concern that shapes decision-making, coordination and delivery processes, rather than as a set of technical or evaluative indicators. In doing so, it provides a conceptual bridge between ESG-centred project value and project delivery, enabling a more nuanced interpretation of how ESG outcomes emerge in MMC projects.

5.2 From performance measurement to implementation explanation

A central contribution of the proposed framework is that it makes implementation analytically visible and explainable at the project level. Existing sustainability studies on MMC are well equipped to quantify environmental impacts and identify performance

differences between construction approaches (Jaillon and Poon, 2014; Kamali and Hewage, 2016), but they offer limited insight into why sustainability outcomes vary across projects using similar MMC technologies and configurations (Martinsuo *et al.*, 2019; Silvius and Schipper, 2014). As a result, sustainability performance variability is often attributed implicitly to contextual factors or treated as residual noise rather than as an object of explanation.

The proposed conceptual framework addresses this limitation by locating sustainability outcomes within project delivery processes. Through this linkage, the framework explains sustainability outcomes as emergent results of how ESG-centred project value is achieved during project execution. Differences in sustainability outcomes are therefore interpreted as differences in the configuration, sequencing and conducting of activities under ESG-oriented value, shaped by variations in project team capabilities.

This perspective has important implications for how sustainability evidence on MMC is interpreted. Rather than viewing sustainability outcomes as direct reflections of construction methods, the framework highlights implementation as a critical source of outcome variability. Similar MMC configurations may yield divergent ESG outcomes not because the technologies differ, but because project teams differ in their ability to integrate ESG into delivery activities and to sustain such integration across life cycle stages. By making implementation analytically visible, the framework complements outcome-oriented evidence with a project-level explanation of sustainability performance variation.

5.3 Implications for PM research

The proposed framework has several implications for PM research. Firstly, it extends project value research by demonstrating how value can be structured around sustainability considerations through ESG. While project value literature has emphasised the emergent and processual nature of value (Laursen and Svejvig, 2016; Zwikael and Smyrk, 2015), sustainability has often remained an implicit or under-specified dimension. By introducing ESG-centred project value, the framework provides a structured way to articulate sustainability as a form of project value that can be analysed and managed at the project level.

Secondly, the framework contributes to activity-based and practice-oriented research by repositioning ESG-centred project activities across the MMC project life cycle as execution layer of value achievement. They constitute the primary units through which ESG-centred project value is enacted and realised in practice. This perspective shifts the focus of activity-based research from efficiency improvement to value realisation, offering a richer explanation of how sustainability-oriented intentions are translated into project outcomes.

Thirdly, the framework advances capability research by situating project team capability within an ESG-oriented sustainability context. Rather than treating capability as a generic success factor, the framework conceptualises project team ESG-centred capability as an enabling condition for managing ESG-related trade-offs and sustaining value-oriented decision-making across project lifecycle stages. This contextualisation highlights the importance of examining how capabilities operate under specific value regimes, such as sustainability, rather than assuming their effects are uniform across project contexts.

5.4 Implications for practice and decision-making

From a practical perspective, the framework suggests that achieving sustainability outcomes in MMC projects requires more than the adoption of advanced construction technologies or compliance with sustainability standards. Although MMC technologies may enable environmental improvements, sustainability outcomes ultimately depend on how project teams organise and execute project delivery activities. Conceptualising sustainability as

ESG-centred project value implies that project teams must explicitly recognise ESG and integrate them into project delivery decisions throughout the project life cycle.

This perspective shifts attention from technological adoption to the organisation of project delivery activities. In MMC projects, many critical decisions occur in activities such as design coordination, manufacturing planning, logistics organisation and on-site assembly (Goodier and Gibb, 2007; Söderlund, 2004). These activities represent key points where ESG-centred project value can be embedded into project delivery practice. Making ESG-centred project value considerations explicit within these activities helps project teams move beyond symbolic sustainability commitments towards more coherent decision-making about how project delivery work should be organised.

This framework also highlights project team capability in enabling ESG-centred project value delivery. Achieving ESG-centred project value requires project teams to coordinate activities across multiple lifecycle stages and across multiple organisations involved in MMC delivery. Capabilities related to coordination, logistics management, safety management and cross-organisational communication therefore become critical conditions for embedding ESG-centred project value into delivery execution. By emphasising capability alongside activities, the framework suggests that sustainability in MMC projects is not only a technological issue but also a capability challenge for project teams.

Building on these insights, the framework can also guide how project teams structure ESG-centred decision making across the MMC project life cycle. Rather than treating sustainability as a set of external performance indicators, the framework conceptualises ESG-centred project value realisation as a process embedded in project delivery decisions. In practice, this involves recognising the decision context in which delivery decisions arise, clarifying how ESG-centred project value considerations should influence those decisions, structuring delivery activities accordingly and ensuring that appropriate governance responsibilities and capabilities are aligned to support implementation.

Figure 4 illustrates this life cycle-oriented ESG-centred decision structuring process. The figure shows how decision contexts emerging across MMC lifecycle stages interact with the decision structuring process through which project teams interpret ESG-centred project value, organise delivery activities and mobilise project team capabilities. Through this iterative process, ESG-centred project value becomes embedded in project delivery execution rather than treated as a separate sustainability objective. In this sense, the framework provides a practical way for project teams to interpret ESG-centred project value and translate it into delivery decisions across MMC project life cycle stages.

6. Conclusion

This study addresses a persistent limitation in sustainability research on MMC: the tendency to conceptualise sustainability primarily through environmental performance outcomes, with limited explanation of how sustainability-oriented value is realised during project delivery (Jaillon and Poon, 2014; Kamali and Hewage, 2016; Martinsuo *et al.*, 2019; Silvius and Schipper, 2014). While environmental-outcome-oriented assessments have demonstrated the potential sustainability benefits of MMC (Jaillon and Poon, 2014; Kamali and Hewage, 2016), recent studies also highlight the growing importance of broader sustainability transitions in construction, including circular economy practices and digital transformation of project delivery (Das *et al.*, 2022; Senaratne *et al.*, 2025). As a result, sustainability outcomes are often treated as properties of construction technologies rather than as results of project delivery processes and organisational capabilities.

To address this limitation, this study develops the ESG value realisation framework, which conceptualises sustainability implementation in MMC projects as the realisation of ESG-

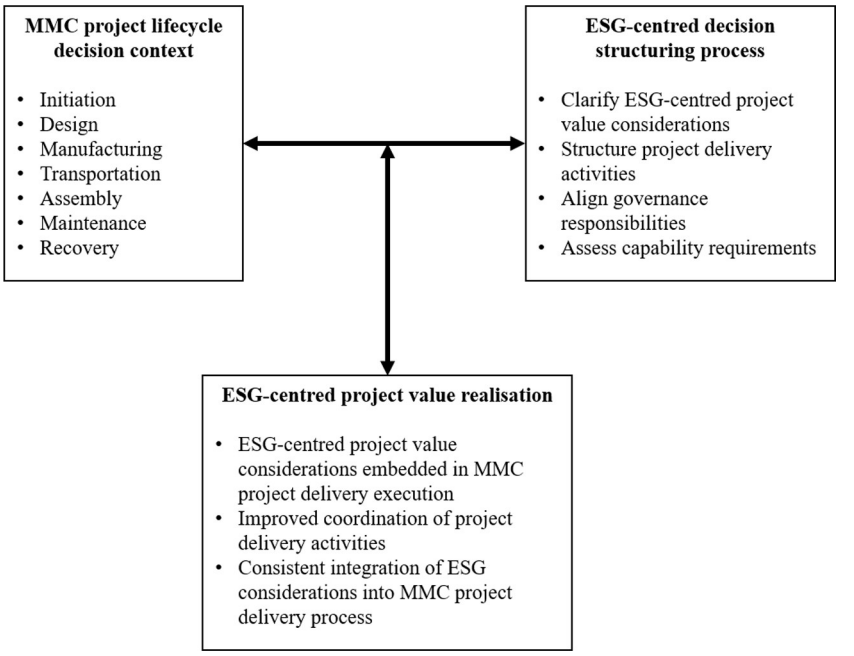

Figure 4. Life cycle-oriented ESG-centred decision structuring process
Source: Authors' own work

centred project value through project delivery processes. Rather than introducing ESG as an additional performance evaluation framework, the study adopts ESG as a value-structuring lens that clarifies the multidimensional content of sustainability at the project level. By integrating project value perspectives with activity-based and project capability research, the framework explains how ESG-centred project value emerges through the interaction between project delivery activities across the MMC life cycle and project team ESG-centred capability. In doing so, the framework shifts analytical attention from sustainability measurement to sustainability implementation and provides a project-level explanatory structure for understanding variation in sustainability outcomes across MMC projects.

The contribution of this study is conceptual. The proposed framework clarifies how sustainability can be understood as a form of project value realised through project delivery rather than as an outcome inferred from performance indicators alone. By linking ESG-centred value orientation with project delivery activities and project team capability, the framework provides a structured basis for analysing sustainability implementation in MMC projects. It therefore offers a foundation for future empirical research to examine how ESG-centred project value is realised under different project conditions and how variations in project delivery processes and capabilities influence sustainability outcomes. As a conceptually grounded framework, the ESG value realisation framework contributes to ongoing efforts to integrate sustainability considerations more explicitly into PM theory and practice. More broadly, this study contributes to emerging research examining how sustainability transitions in construction require not only technological innovation but also organisational and project delivery capabilities.

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Corresponding author

Zixin Lu can be contacted at: 22119144@student.westernsydney.edu.au