Design phase collaborative risk management factors: A case study of a green rating system in South Africa

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ABSTRACT

Purpose: We explore the design risk factors and associated managerial practices driving collaborative risk management for design efficacy in green building projects. By illuminating project design risk as an important project risk category in its own right, the study contributes to our understanding of optimising design efficacies for collaborative project risk management.

Design/methodology/approach: The study comprises exploratory interviews conducted with 27 industry project practitioners involved in the design and delivery/implementation of Green Star-certified building projects in South Africa.

Findings: The findings discursively highlight seven sources of design risk. We also identify seven specific collaborative risk management practices for design efficacy emerging from a consideration of how risk environments vary in the Green Star-certified projects, each with its own project design risk implications.

Originality/value: The study advances our understanding of how collaborations emerging from particular relational yet context-specific practices can be optimised to strengthen project risk management.

Keywords: *Collaboration; Risk management; Construction; Design*

1. Introduction

While the term '*Design'* has numerous connotations (Frost 1994; Marxt and Hacklin 2005; Ulrich 2011), it can be broadly defined to encompass the shaping "…*of ideas*" (Design Council 2023, p. 12) and "… *the physical form*" (Chan et al. 2021, p. 1007). It is during design that the majority of the innate attributes of green building projects are set out (Zhu et al. 2009); therefore, design is the cornerstone of the success of green building projects (Wood et al. 2016; Lambrechts et al. 2019; Kim and Kim 2022; de Paula et al. 2022). However, the efficacy of design can be significantly jeopardised by risks (Stolterman 2021; Abdelaal and Guo 2021; Ikudayisi et al. 2022; Li et al. 2022). Here, we draw on Marshall (Marshall and Ojiako 2013; Marshall et al. 2019a, 2019b) to define '*Risks'* as possible future states which will negatively impact exposed subjects.

In green building projects, '*design risks'* can be broad and diverse. We draw on the literature (see Ahn et al. 2013; Qin et al. 2016; de Paula et al. 2022; Li et al. 2022), to define 'design risks' as unintended, unplanned and exceptional situation[s] that can potentially negatively disrupt the efficacy of either design or the design phase of projects, or both. Design risks include behaviour risks, cost and financial risks, environmental risks, green certification risks, management (including competency) risks, operational risks, productivity risks, safety risks, and technical and quality risks (Ahn et al. 2013; Qin et al. 2016; Lambrechts et al. 2019; Li et al. 2022; de Paula et al. 2022). Thus, the importance of effective risk management during design cannot be overestimated (Qin et al. 2016; Li et al.

2022). We rely on previous studies (see Wright 2018; Marshall et al. 2019a), to define '*Risk management*' in the context of design as 'a structured approach focused on identifying, assessing, prioritising and analysing risks as well as their monitoring, management, control and communication throughout the design phase of buildings.

In buildings, design risks can potentially expose the actual design, the design process (i.e., the series of interconnected events which will commence with a recognition of a need, and will continue right through to the maintenance and servicing of the designed entity— see Frost 1994), and the design phase (i.e., phase of the project lifecycle where ideas, deliverables, processes, and resources are set out and planned) to very significant operational and performance failures (Li et al. 2022). This is particularly the case with green buildings (Ikudayisi et al. 2022; Li et al. 2022; Nguyen and Macchion 2023).

While these points are recognised in the literature, we are only aware of very few studies that have examined the sources of design risks in green building projects. These studies are also specific to Canada (Hydes and Creech 2000), China (Qin et al. 2016; Li et al. 2022), Brazil (de Paula et al. 2022), Malaysia (Lee et al. 2020), and the United States (Rajendran et al. 2009; Dewlaney et al. 2012; Ahn et al. 2013). Furthermore, although, for example, Viswanathan et al. (2020) and Kallow et al. (2023) both highlight how risk management practices influence project success, the managerial practices factors that drive collaborative risk management for design efficacy in green building projects remain unclear. Guiding this interest is our appreciation that the management of risk may be best undertaken through '*collaboration*' (Bryde et al. 2023; Marshall et al. 2024); in effect, "...*a process in which autonomous or semi-autonomous actors interact through formal and informal negotiation, jointly creating rules and structures governing their relationships and ways to act or decide on the issues that brought them together*" (Thomson et al. 2009, p. 25). The modicum of literature in this area, in addition to a recognition that the development of green buildings and its associated challenges has been varied in different countries (Zhang et al. 2019), implies that, potentially, design risk factors and associated managerial practices are country-specific (Hsee and Weber 1999; Clahsen et al. 2019; Salas et al. 2020; Nguyen and Macchion 2023). No prior study in this area has been undertaken within the context of South Africa, revealing a paucity of knowledge relating to (i) the design risk factors and (ii) the associated managerial practices driving collaborative risk management for design efficacy in green building projects in South Africa. With these points in mind, we ask the question:

> RQ: *What are the design risk factors and associated managerial practices driving collaborative risk management for design efficacy in green building projects in South Africa?*

To address the research question, we engaged with key project practitioners involved in the design of green (i.e., Green Star) certified building projects in South Africa. The Green Star certification is a rating tool developed by the Building Council of South Africa (GBCSA) to provide objective assessments/measurements of green buildings in South Africa (GBCSA 2020).

2. Study context

The importance of integrating green values into building design has been widely recognised in the literature (Kröhnert et al. 2022; Li et al. 2022; Pillay and Saha 2022; Kim and Kim 2023). However, such integration can bring significant complexity to building design (Tae et al. 2011; Ikudayisi et al. 2022; Hafez et al. 2023). These complexities include the uniqueness of green buildings, the disjointed/fragmented and iterative nature of its design processes (de Souza et al. 2023), the prevalence of significant approximations in detailing (Mohanta and Das 2023), and constant and last-minute configuration changes (Yap et al. 2018). When these are combined with complex issues of professional stove-piping (Ahuja 2023), they show that, when compared against the design of conventional buildings, green building design tends to present greater '*design risk*' (de Paula et al. 2022; Ikudayisi et al. 2022; Li et al. 2022).

Contextualising the study within South Africa is important for two reasons. First, South Africa is experiencing a major energy crisis exacerbated by a near-collapse in its energy-generating ability (Rathi 2022; Wiese and van der Westhuizen 2024). Recognising that the ongoing energy crisis represents one of the greatest threats to social and economic progress in the country (Government of South Africa 2012), the South African government has outlined a series of policies and initiatives on sustainability including some focused on green building construction (Department of Public Works 2018a, 2018b). Second, by situating our study within South Africa, we respond to calls by scholars such as Ikudayisi et al. (2022) and Li et al. (2022) for more sustainability-focused research domiciled in countries where building research and development is less mature and underdeveloped.

3. Literature

A key characteristic of design is that it tends to be construed as non-decomposable (Stacey 2006; Orth and Malkewitz 2008; Chan et al. 2021), leading to more emphasis on the 'whole' rather than its individual components or modules. Thus, efforts to develop holistic design solutions may encounter difficulties when attempting to partition its distinct elements. Of relevance is that viewing design as a non-decomposable construct often leads to design efforts being mistakenly construed as linear, relatively autonomous, and bounded (Maffin 1998). For green building design, this can limit design being framed within the broader context of wider sustainability concerns. Significant collaboration is, therefore, required to ensure that multiple individuals or teams are able to address multifaceted challenges likely to manifest in green building design.

Collaboration is best explained by the *Relational view theory* (Dyer and Singh 1998; Dyer et al. 2018). This is particularly the case noting how important relations are to collaboration risk management. The *Relational view theory* offers critical perspectives that best explain collaboration risk management. For example, it posits that, by investing in relational arrangements, organisations are likely to enhance their performance despite potential limitations that may be imposed by risks. It also posits that, by combining its resources with those of other organisations, resources can be optimised in a manner not available to an individual organisation that is not involved in a collaboration. Furthermore, the theory suggests that collaboration serves as a means by which the impact of interdependent risk can be mitigated.

By bringing together multiple individuals and teams, collaboration can expose those involved in design to a multitude of ideas and perspectives (Hargadon and Sutton 1997). By accelerating the sharing of experiences and the search for common solutions, collaboration also fosters the recombination and cross-fertilisation of ideas and learning (Wagner et al. 2019; Torgaloz et al. 2023). It also allows for skills assimilation and, where necessary, the exploitation of valuable knowledge (Hargadon and Sutton 1997; Chan et al. 2021). Of further note is that collaboration significantly drives the development of network resources needed to serve as a source of valuable knowledge and insight (Singh 2005). Specific to design, by reducing information asymmetry and opportunism, collaboration functions as a platform to enhance effective design change propagation (Ren et al. 2024) and design flexibility (Idi and Khaidzir 2018). This underpins the widely held view in the literature that collaboration drives design efficacy in building design (see Idi and Khaidzir 2018; Nguyen and Mougenot, 2022; Nthubu et al. 2022; George et al. 2024). Collaboration in design is, therefore, an important mechanism for ensuring that (i) sustainable functionalities in green buildings are optimised, (ii) assembly and production costs are minimised, and (iii) when green buildings are completed, they can be economically and easily maintained and serviced (see Idi and Khaidzir 2018).

Green building projects are primarily driven by efforts to integrate heterogeneous sustainability goals into building infrastructure and, in the process, reduce the carbon footprint of construction output (Wood et al. 2016). Owing to their uniqueness, however, the design of green buildings faces major risks. A number of studies have examined these risk factors. For example, Hydes and Creech (2000) examined risk factors associated with the reduction of mechanical equipment cost flowing from green design buildings. Based on two case studies, they found the prevalence of five risk factors: (i) '*Difficulties in sourcing equipment which meets all performance requirements*'; (ii) '*Lack of certainty that actual performance*'; (iii) '*Lack of manufacturer/supplier support*'; (iv) '*Lack of performance information';* and (v) '*No equipment warrantees'*. In Rajendran et al. (2009), the focus was on exploring how green building design impacted the health and safety of construction workers. Based on the comparison of the data gleaned from recordable data on lost time through injury and illness in green and non-green building projects, '*Construction worker safety and health'* was found to represent a significant risk in green building design. Dewlaney et al. (2012) sought to quantify the impact of various safety features earlier discussed in Rajendran et al. (2009), and found five features of green building design to be of significance. These are (i) '*Heat island effect',* (ii) *'Inclusion of on-site renewable energy',* (iii) *'Construction waste management',* (iv) *'Innovative wastewater technologies'*, and (v) *'Optimising energy performance'*.

Ahn et al. (2013) utilised data obtained from a survey of construction stakeholders who held membership in the United States Green Building Council (USGBC), and identified the most significant barriers (risk factors) to green building design as (i) '*Cost premiums*',

(ii) '*Long pay back periods*', (iii) '*Maintenance of current practices',* and (iv) '*Limited sub-contractor knowledge and skills*'. Qin et al. (2016) identified (and prioritised) level of risk across the life-cycle of green buildings in China. Their study identified nine key design risk factors classified against three risk categories: (i) 'Technical/quality risks' (i.e., '*Lack of design experience*', *Insufficient site investigation/design is not tailored to local conditions*', '*Risks of design innovation*', '*Poor constructability of design innovation*'); (ii) 'Financial risks' (i.e., '*Inaccurate cost estimation*'); and (iii) 'Management risks' (i.e., '*Lack of certification experience*', '*Unclear certification responsibility*', '*Poor communication ability of design team*', '*Lack of participation of project life cycle*'). Conversely, Lee et al. (2020) identified two main risk categories: (i) '*Technical/quality risk*' (i.e., '*Design experience risk*', '*Team performance risk*', '*Material innovation risk*') and (ii) '*Financial management risk*' ('*Cost estimation risk*', '*Quality risk*').

Li et al. (2022) employed systematic literature reviews and identified four major categories of design risks specific to the operating phase of green buildings in China as (i) '*Behaviour risks*', (ii) *'Green certification risks'*, (iii) *'Management risks',* and (iv) *'Technical risks'*. They also identified three major factors that moderate the impact of these risks on the operational performance of green construction buildings as (i) '*Exposure*', (ii) '*Resilience',* and (iii) '*Sensitivity'*. Li et al.'s (2022) study is particularly important as it reveals that all the four design risks will have a major negative impact on the operational performance of green construction buildings. Another study of interest is that of de Paula et al. (2022) which examined how social relationships between clients and designers impacted upon green building design in Brazil. Their study identified a number of risk factors impacting design, such as (i) '*Gaps between the product conception and the design stage*', (ii) '*Lack of freedom in the design activities*', (iii) '*Lack of definition and communication on stakeholder green sustainability strategies*', (iv) '*Lack of detailed design scope*', and (v) '*Design processes unable to support collaboration*'. In Table 1 (below), we provide a brief summary of this literature.

Table 1: Summary of the literature on design risk factors in green buildings

Author	**Country focus**	**Identified risk factors**
Hydes and Creech (2000)	Canada	*'Difficulties in sourcing equipment which meets all performance requirements'* *'Lack of certainty of actual performance'* *'Lack of manufacturer/supplier support'*

		'Lack of performance information' *'No equipment warrantees'*
Rajendran et al. (2009)	United States	*'Construction worker safety and health'*
Dewlaney et al. (2012)	United States	*'Construction waste management'* *'Heat island effect'* *'Inclusion of on-site renewable energy'* *'Innovative wastewater technologies'* *'Optimising energy performance'*
Ahn et al. (2013)	United States	*'Cost premiums'* *'Limited sub-contractor knowledge and skills'* *'Long pay-back periods'* *'Maintenance of current practices'*
Qin et al. (2016)	China	*'Inaccurate cost estimation'* *'Insufficient site investigation/design is not tailored to local conditions'* *'Lack of certification experience'* *'Lack of design experience'* *'Lack of participation of project life cycle'* *'Poor communication ability of design team'* *'Poor constructability of design innovation'* *'Risks of design innovation'* *'Unclear certification responsibility'*
Lee et al. (2020)	Malaysia	*'Design experience risk'* *'Team performance risk'* *'Material innovation risk'* *'Cost estimation risk'* *'Quality risk'*
Li et al. (2022)	China	*'Behaviour risks'* *'Green certification risks'* *'Management risks'* *'Technical risks'.*
de Paula et al. (2022)	Brazil	*'Gaps between the product conception and the design stage'* *'Lack of freedom in the design activities'* *'Lack of definition and communication on stakeholder green sustainability strategies'* *'Lack of detailed design scope'* *'Design processes unable to support collaboration'*

A number of studies have highlighted collaboration as key to managing risk in green building design. For example, Wood et al. (2016) explored how end-user demands could be systemically incorporated into green building design using quality function deployment (QFD), a popular technique in product design (see Yang et al. 2012). Their findings suggest that end users in green buildings primarily focused on technical design risks related to constructability (in this case, safety) and acoustics/lighting (in this case, ventilation and natural light). Thus, there was a need to incorporate fewer tangible considerations when seeking to assess the performance of green design in buildings. In Lamé et al. (2017), key findings suggest that the industry was failing to effectively incorporate sustainable factors at the crucial early stages of building design. A major risk factor driving this was identified as the lack of tools able to support multi-criteria design analysis of social, economic, and environmental drivers of sustainability. Lambrechts et al. (2019), on the other hand, sought to explore how sustainability competencies of individual practitioners could impact upon green building projects. Findings from the study suggest that competencies in the areas of action, an ability to embrace diversity, as well as interdisciplinary and interpersonal skills played significant roles in the success of key practitioners involved in green projects.

Scholars recognise that the design of green buildings is likely to encounter numerous significant risks and that one means of overcoming their impact may be through risk management practices which are collaborative in nature (Maseko and Root 2021; Nguyen and Macchion 2022). This form of risk management, which is referred to as '*Collaborative risk management*', has been defined by Salman (2014) as "*…the capacity of organisations, societies, and countries to coordinate and join efforts, prior to, during, and after major incidents, in an attempt to prevent or, at least mitigate adverse consequences through effective utilisation of technology, unique leadership, teamwork, and communications*" (p. 319).

Scholars further acknowledge that the uniqueness of green building design presents significant risks (with potentially unpredictable consequences) for buildings in terms of their operational viability and performance (Qin et al. 2016; Wu et al. 2019; Li et al. 2022). The potential interdependence of these risks may create further challenges, particularly relating to the identification and quantification of these risks resulting in further design complexity. The limitations associated with conventional design practices (i.e., specialisation focus) may further undermine risk management efforts. This is because such practices primarily rely on individual practitioners (e.g., contractors) and specialists (e.g., architects and engineers) to mitigate not only the risks but also their potential spill-over effect with only limited engagement of end-users and other stakeholders, despite their increasing role in determining the green attributes of buildings (El-Diraby et al. 2017). Under these circumstances, '*Collaborative risk management*' potentially serves as a more effective means of managing design risks, given its relational emphasis (Schillebeeckx et al. 2016). In particular, unlike conventional approaches to risk management which are narrow and specialisation focused (see Chapman 2001), drawing from the literature on collaborative risk management we will expect that, in green building design, emphasis will be on optimising the relationships of different parties involved in green building design.

This will be achieved by adopting practices that emphasise, for example, adaptive co-management (Dong et al. 2017), close coordination (Breuer et al. 2013), and integrated communication (Lehtiranta 2013).

We, therefore, justify collaborative risk management as an alternative to conventional design risk management. We highlight its potential to transform risk management strategies residing at an individual practitioner level into a more comprehensive cross-specialisation solution involving multiple parties working towards a common and mutual design objective. Although collaborative risk management practices have been discussed in a broader construction context (Rahman and Kumaraswamy 2002; Lehtiranta 2013; Philemon et al. 2018; Marinelli and Salopek 2020), we are not aware of any studies set within the specific context of design risks in green buildings. Thus, the purpose of this paper is to explore the design risk factors and associated managerial practices driving collaborative risk management for design efficacy in green building projects.

4. Method

In Figure 1 (below), we illustrate the study's approach.

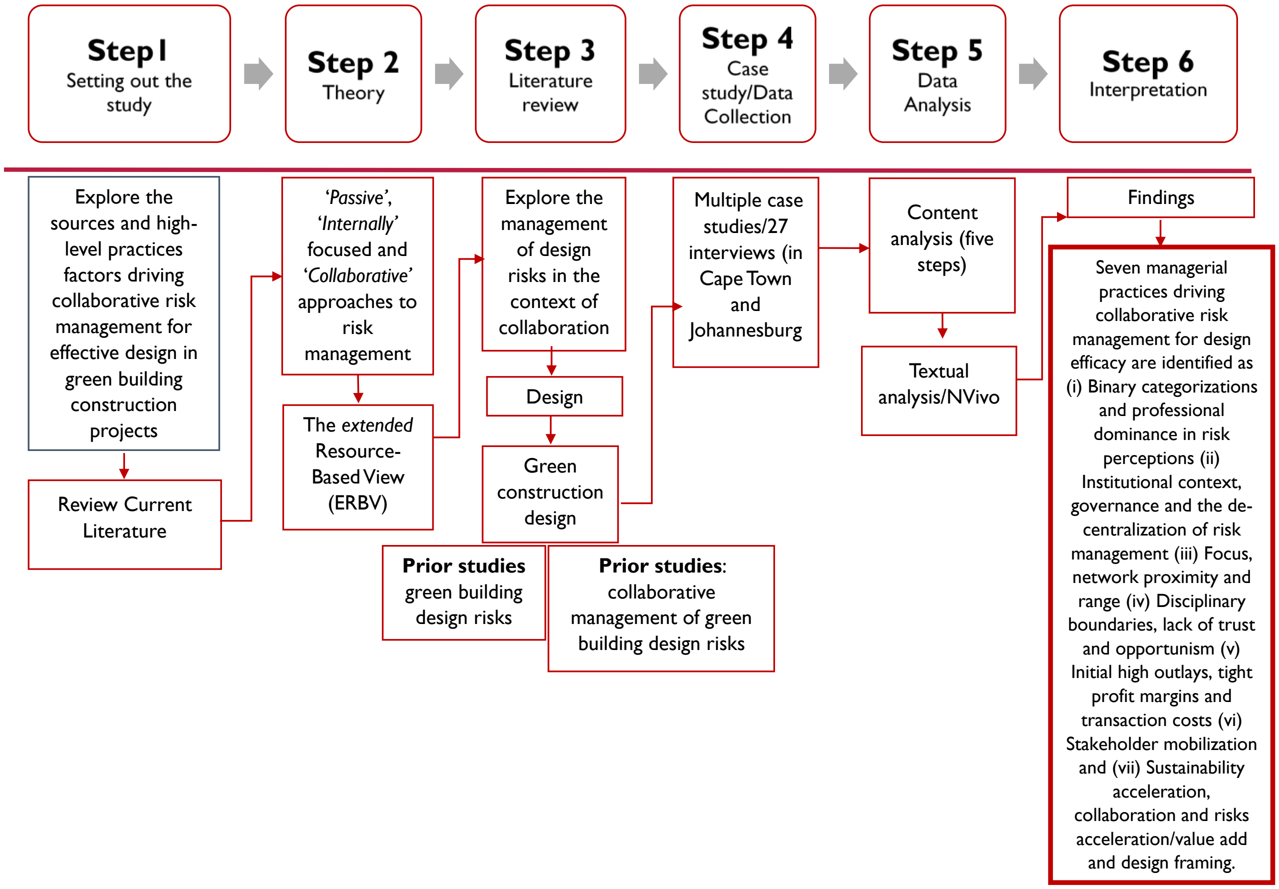

Figure 1: Research approach

4.1 Case study research

We employed a qualitative case study approach (Barratt et al. 2011; Ketokivi and Choi 2014). Over the last few years, although quantitative methods have dominated risk perception research, published qualitative research focused on stakeholder risk perception has increased significantly (Hawkes and Rowe 2008; Hawkes et al. 2009). While it is often the case that these qualitative studies serve as antecedents and, subsequently, inform quantitative studies (Hawkes and Rowe 2008), in some instances, the former have been conducted in the absence of an intention to underpin quantitative studies. Examples of such studies include Bannerman (2008), Veres (2009), Krane et al. (2012), and Ziaee Bigdeli et al. (2018).

We collaborated with four organisations involved in green building design projects in South Africa certified by the Green Building Council of South Africa (GBCSA). In line with Etikan et al. (2016), we selected our cases in a purposeful manner. We identified potential participants by conducting a search for (i) certified projects registered on the GBCSA's website (https://gbcsa.org.za/resources-listings/case-studies/) and (ii) the GBCSA's directory of accredited practitioners (https://gbcsa.org.za/resources-listings/accredited-professionals-directory/). Potential participants were asked whether they had specific (i) design management experience and (ii) associated green design risks. Potential interviewees were then asked to suggest participant organisations, thus providing contacts within the specific organisational context that would bring relevant insights to our study (Tongco 2007). Our unit of analysis was the daily collaborative risk managerial practices and how these impacted upon design efficacy.

Organisation 'A' was involved in the design and delivery/implementation of a 32,225m², three-storey secure academic forensic pathology facility located in Johannesburg (project at design phase). Awarded at a cost of R626 million (around USD37 million), the project was commissioned by the Department of Health in partnership with a provincial forensic pathology service and a major South African research-based university. The key emphasis of the design was functionality (health, safety, and security).

Organisation 'B' was involved the design and delivery/implementation of an 11-storey residential retirement block consisting of 58 terraced apartments in Cape Town (project at design phase). With an estimated cost of R105 million (approximately USD6.2 million), the project consisted of a nursing facility, two elevators, an ample basement, and underground parking garages. A key focus of the design was functionality (health, safety, and security), with additional design considerations in areas such as aesthetics (for example, open parking bays and extensive landscaped gardens) and practicality (wide corridors and door openings).

Organisation 'C' had been involved in the design/delivery/implementation of an urban, cosmopolitan living area in one of the more affluent waterfront precincts of Cape Town (completed project). The project involved the design and delivery/implementation of a collection of three cylindrical chambers into residential apartments characterised by projecting window boxes. Funding for the project was via a private–public consortium. The key emphasis of the design was utility, functionality (comfort), and aesthetic quality.

Organisation 'D' had been involved in the design and delivery of a 27,000m² commercial office space development in the Sandton business district of Johannesburg (completed project). The project was commissioned at a cost of R560 million (approximately USD33 million) and involved the building and development of two linked tower blocks constructed on a landscaped podium. Key green design elements of the project included sustainable features for rainwater harvesting, treatment, and reuse. Fully glazed facades were also incorporated into the design for maximum natural lighting (while also restricting glare and heat transmission). The design also entailed large floor plates which were punctuated by two atria.

4.2 Data collection

Data for the study were obtained over a period of 12 months (between January 2019 and June 2020). The second author was embedded for a period of time (approximately six weeks in each project) serving as a construction intern in each of the case organisations. The third and fourth authors served as academic advisers, providing direct research guidance.

Throughout the period of engagement with the four case organisations, the research team was given unfettered access to relevant internally generated design documentation, providing ample desired insights for the research team. Our engagement with the case organisations prioritised considerable engagement through conversations with recognised knowledge domain experts. We opine that such an engagement was necessary as we were keen to ensure that the practical relevance of our study was clear to the case organisations. There is acknowledgement in the literature that stakeholders deeply embedded in a phenomenon under examination potentially serve as sources of rich information and insight (Stapelbroek et al. 2022). Hence, their engagement with the research team was of critical importance.

In this respect, in collaboration with the relevant knowledge domain experts, the research team was then able to glean in-depth insights into the relevant risk management factors pertinent to the design phase of the various projects undertaken by the case organisations.

In total, 27 practitioners agreed to participate in our study (47% of the identified sample). Table 2 shows the breakdown of the study participants. The interview protocol consisted of nine core questions all drawn from or influenced by the literature (Table 3).

Table 2: Breakdown of study participants

Professions	**Description**	**Organisation**	

		A	B	C	D	Referral Participant
Structural Engineer	Structural, civil, and geotechnical services	√	√	√	√	-
Quantity Surveyor/Cost Manager	Cost management services and contractual advice	√	√	√	√	√
Architect	Leads design services and develops the client's brief	√	√	√	√	√ (x2)
Green Design Engineer	Green design and engineering solutions	√	-	-	√	-
Project Manager	Oversees the cost, programme, project administration	√	-	√	-	√
Risk Manager	Evaluates risk control measures and updates risk analysis	-	-	-	√	√
Client	Sets the project objectives	√	-	-	√	-
Development Manager	Supports technology infusion	-	√	-	-	-
Construction Manager	Monitors the overall project development and management	-	-	-	√	√
Sustainability Specialist	Sustainable building design and green building certification services	-	-	-	-	√
Landscape Designer	Landscape design and advisory services	-	-	-	√	-
Contractor	Constructs/delivers the building development	√	-	-	-	√
Number of Interviews		**5**	**4**	**4**	**6**	**8**

All the questions in the protocol (see Table 3) were underpinned by theory (in this instance, *Relational view theory*—Dyer and Singh 1998; Dyer et al. 2018) framed around three main themes in green building design: (i) experience, knowledge, and awareness of collaborative risk management; (ii) perceptions/views on current risk management implementation and impediments; and (iii) experience/involvement in collaboration.

The design of the interview protocol was driven by a need to encourage the respondents to elaborate on meaningful personal experiences of collaborative practices. In the process, the second part of the research question (focused on identifying managerial practices driving collaborative risk management for design efficacy) would be addressed.

The first question was influenced by a recognition in the literature that there are significant differences in how the meaning of 'risk' is constructed. In fact, Ewald (1991) opines that risk "*…all depends on how one analyses the danger, considers the event*" (p. 1999), while Horlick-Jones (1998) suggests: "*This multiplicity of meanings lies at the heart of why a given risk is sometimes perceived by different social groups as posing a very different degree of threat*" (p. 80). Hence, we expect heterogeneity in terms of the framing of '*Design risks'* among the different practitioner groups (and subgroups) involved in green building design. The focus of the second question was on potential stakeholder congruence relating to contractual arrangements and design-related dispute resolution. Earlier, Markovits (2004) had opined that, through social coordination and the promotion of efficiencies in resource allocation, contracts present distinctive opportunities for collaboration beyond the narrow confines of individual interests. On the basis of Cheung et al. (2002), we also expect the same when disputes arise among members of the design team.

The third and fourth questions were influenced by the literature (Rahman and Kumaraswamy 2002; Lehtiranta 2013; Philemon et al. 2018; Marinelli and Salopek 2020) which acknowledges the discussion of collaborative risk management practices in a broader construction context, but not specific to design risks. The fifth question explored three perspectives. One focused on awareness of the challenges associated with misconceptions about the non-decomposable nature of design (Stacey 2006; Orth and Malkewitz 2008; Chan et al. 2021). It also explored the need to focus on components and modularity (Idi and Khaidzir 2018; Piran et al. 2020; Chan et al. 2021) and the interdependence or mutual affect among design risks (Zhang 2016; Guan et al. 2020; Bashir et al. 2022). Thus, efforts to develop holistic design solutions may face difficulties when attempting to partition its distinct elements. Of relevance is that viewing design as non-decomposable often leads to design efforts being mistakenly construed as linear, relatively autonomous, and bounded (Maffin 1998). This also has implications for the management of design risks. Zhang (2016) had earlier highlighted that project risks were often incorrectly presumed (and analysed) on the basis that they were independent, despite the reality that they exhibit mutual effect.

Questions 6 to 9 explored the broader significance of the study participants acknowledging or recognising the potential significance of collaboration driving the ability of multiple individuals or teams to address the multifaceted challenges likely to be present in green building design.

Table 3: The interview protocol

S/N	Questions	Driver	Supporting references
1	What does the term 'risk' mean to you and how do you understand the term 'risk management specific to design/the design phase of green buildings?'	Recognition that the literature alludes to significant differences in the meaning of 'risk'.	Ewald (1991); Garland (2003); Holton (2004); Hansson (2010); Marshall and Ojiako (2013).
2	How does the current risk management practice affect the contractual arrangement and how do stakeholders	Recognition that contracts and the resolution of disputes present distinctive opportunities for	Markovits (2004); Cheung et al. (2002).

	handle design-related disputes? (If they occur)	collaboration among members of the design team.	
3	What risk approaches do stakeholders employ and how are they employed during the design phase of green building projects?	Gaining insight into risk management practices.	Rahman and Kumaraswamy (2002); Lehtiranta (2013); Philemon et al. (2018); Marinelli and Salopek (2020).
4	What are the implications for collaborative risk management during the design phase of green buildings?		
5	Can you personally pinpoint any experience dealing with risk interdependencies in the design phase of green building projects?	Design is often mistakenly construed as non-decomposable, leading to less emphasis on partitioning its distinct elements. Furthermore, there appears to be an incorrect assumption that project risks were independent.	Stacey (2006); Orth and Malkewitz (2008); Zhang (2016); Idi and Khaidzir (2018); Piran et al. (2020); Chan et al. (2021).
6	How are risks shared and allocated among stakeholders in the design phase?	In light of the literature discussing the benefits of collaborative risk management practices, the focus of these questions was to explore the broader significance collaboration as a mechanism for design risk management.	Rahman and Kumaraswamy (2002); Lehtiranta (2013); Philemon et al. (2018); Marinelli and Salopek (2020).
7	Specific to design, how is risk managed in green building design?		
8	What are the major obstacles to optimal management of design risks?		
9	What solutions are available to remedy the potential negative impact of current risk management practices in green building construction?		

4.3 The interviews

We conducted face-to-face semi-structured interviews with the participants. The primary consideration is that semi-structured interviews are well suited for the exploration of the perceptions and opinions regarding complex and sometimes sensitive issues. The use of semi-structured interviews also helped to clarify the answers. All interviews were recorded (McDougall 2000). To prevent confirmation bias (Leung 2015), during the interviews, the second author was accompanied by the third author who also made independent notes (Pagell and LePine 2002). In all instances, the average interview time was between 1 and 2½ hours. By the time that 19 interviews were completed, no additional significant insights had been generated from the study as might warrant extending our participant base beyond the initial 27 (see Holsti 1969; Lincoln and Guba 1985). Our data analysis was undertaken in a manner consistent with content analysis (Vaismoradi et al. 2013; Cohen et al. 2018). We adopted a five-step approach involving (i) '*Concept identification*', (ii) '*Definition of relationship types*', (iii) '*Textual coding with reference to concept identification and relationship definition*', (iv) '*Statement coding via NVivo*', and (v) '*Graphic display and* *analysis of the resulting'*) which was earlier reported in Ojiako et al. (2023—drawn from Mayring 2014). This approach is diagrammatically represented in Figure 2 (below).

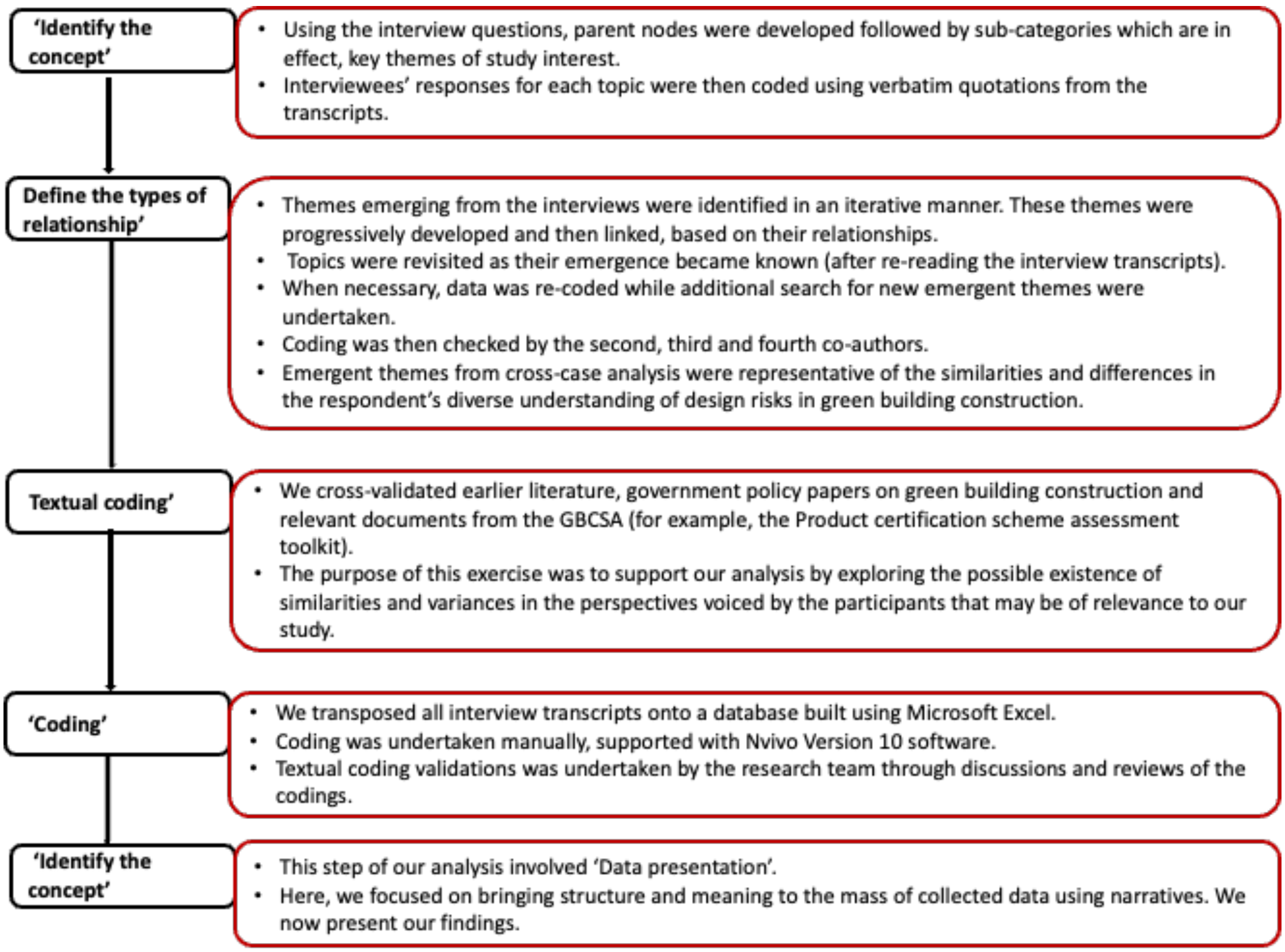

Figure 2: Data analysis approach

5. Findings

We had set out in this paper to address the research question (RQ): *What are the design risk factors and associated managerial practices driving collaborative risk management for design efficacy in green building projects in South Africa?* Following the semi-structured interviews (consisting of nine core questions) with the participants and an analysis of the data, various sources of design risk emerged under which we could describe collaborative risk management practices. In the following sub-sections, we elucidate, in greater detail, the various sources of design risk that emerged from the interviews.

5.1 Risk perceptions/categorisations

In the four organisations, the initial stages of the design appeared to be dominated by small professional teams led by two or three individuals with overall responsibility for design. These individuals functioned as the intellectual intermediaries of their respective projects and, by default, as the main drivers of risk framing. While we expected the participants to frame risks based on theoretical (abstract) and practical (concrete) knowledge (Marshall et al. 2019a), they predominantly highlighted a binary (i.e., negative–positive) perception of risk. Furthermore, such binary notions of risk were construed as: "…*cause of problems and danger*" (Contractor 2) and "…*a bad outcome*" (Contractor 1). The participants expressed limited or no views on an alternative view of risks (i.e., as an opportunity—see Qazi et al. 2020).

There was widespread acknowledgement of the importance of collaboration to ensure that design risk was not simply construed as "…*a bunch of different concepts*" (Architect 4). Other views demonstrated a recognition of the challenges associated with "…*project stakeholders hav[ing] differing risk views"* (Risk Manager 1). It was noted (for example in Organisation 'C') that participants with similar roles did not frame risk in the same manner (we would have expected strong disciplinary identities to be highly influential in risk framing—see Ahuja 2023). We reasoned that this might conceivably—at least in part—reflect differing underlying perceptions of how risk ownerships were distributed via project contracts, given that clients sometimes overestimate risk transfers to contractors.

There were concerns that such heterogeneity will *"…define how they [stakeholders] assess the probability of occurrence and impact of a given risk on a project*" (Risk Manager 1). In both Organisation 'A' and Organisation 'C' with projects commissioned by consortia, competing framings of risk did not feature in the interviews to the extent that we had anticipated. In sum, therefore, as relates to '*Risk perceptions*':

> Finding 1—The findings suggest a predominant framing of risk as an event/burden of dis-value (and, by implication, failure to recognise that risks could also represent opportunities); how risks were framed appeared to be dominated by specific professional groups who maintained strongly held professional/disciplinary views; this dominance and their associated strong views functioned as an impediment to the design teams' ability to exploit collaborative risk practices.

5.2 Risk management practices

A recognition that risk management "*…provided a very clear advantage*" (Project Manager 2) suggested acknowledgement of its critical importance to design efficacy. Risk management was construed as "*… a process whereby decisions are made to accept a known or assessed risk and the implementation of actions to reduce the consequences or probability of occurrence*" (Client 1). The interviews drew to the surface the potential for the "*…absence of an effective process of design planning*" (Client 1), giving particular attention to the need for institutions' (primarily, governance) architectures that are focused on achieving optimal balance between the design process and institutional mechanisms governing the design effort. It was suggested that an exciting prospect was that risk management might address the potential impasse that exists in design between governance and creativity. This was deemed important because "*…a constant focus on striving to overcome design blocks was likely to lead to unsuccessful repetitive efforts which unfortunately were only likely to make the development of new ideas much more difficult*" (Green Design Engineer 4). It was further stated that risks arose with "*…the absence of unified design codes and a standardised green application process*" (Green Design Engineer 1); "*…stakeholders not providing sufficient details of their requirements*" (Client 4); and "*…excessive and complicated governmental approvals*" (Sustainability Specialist). The participants acknowledged the importance of potentially decentralising the management of such risks. Specifically, the need to adopt risk management practices, which encouraged "*…breaking down barriers*" (Project Manager 2), was highlighted. Noting this concern, it was further highlighted that, key to such risk management efficacy, there was the need to "*…improve co-ordination between disciplines and exert managerial control over the design process*" (Architect 1). That being so, the suggestion was offered that the focus should be to avoid "*… a situation perpetuated by a lack of understanding in the co-ordination of cross-disciplinary information, the task dependencies and availability of fully integrated design techniques*" (Architect 3). To therefore sum up, as relates to '*Risk management practices*':

Finding 2—The findings suggest that, to develop a collaborative risk management practice that will support efficacy in design risks management, there was a need to frame appropriate governance architectures in a manner that supports the optimal balance between the design process and institutional mechanisms governing the design effort. Decentralisation of risk management decision making was also highlighted as important.

5.3 Knowledge

The findings included evidence of the need for detailed knowledge integration across the numerous disciplinary domains to ensure design efficacy. Contextualised within design risks, '*Knowledge*' could be regarded as being part of "…*an embedded practice, constructed through individuals' social interaction to support unlearning of old routines and behaviour"* (Architect 6). It was recognised that the "…*volume of knowledge within the projects could serve as serious obstacles for successful design*" (Green Engineer 4). The design processes employed by both Organisation 'A' and Organisation 'C' were particularly susceptible to complication due to the nature of vertical integration in these two projects and the number of design functionalities that required integration. This was amplified in particular by the clients maintaining their own separate domain experts. Furthermore, as highlighted above, in Organisation 'C', design was controlled by a single entity, meaning that knowledge distribution was "…*a bit patchy*" (Architect 3). Moreover, the thin dissemination of knowledge had "… *proven disadvantageous*" (Architect 2), especially in obstructing consensus-oriented decision_making. Maintaining separate domain experts encouraged the different design teams to form informal coalitions primarily with those sharing common knowledge (and, thus, professional affinity). This created the potential risk that members of the design team will only be able to draw on expertise (and knowledge) which is limited, such that they might search for design solutions "…*which were only known*" (Contractor 1) as opposed to innovative.

Acknowledging that we "…*need the dialogue*", Contractor 1 suggested that the knowledge base available during design potential could be limited due to the emergence of restrained knowledge networks. This was a key concern highlighted by Organisation 'C', where the design team was geographically dispersed (in the United Kingdom and South Africa). Preferably, it would have been more advantageous to geographically locate the design team/s; thus allowing for several advantages such as meeting informally to discuss the design as it progressed. Another advantage is that it would have provided much flexibility and the ability of the design team to respond very swiftly to emergent issues as they arose.

Ideally, there was a need for knowledge to be available at the early stages of design. Thus, it was stated that "…*the sooner we get the expertise in the project, the greater is a chance to avoid the problems in building*" (Client 4). Early involvement was also important because "*...there were current practices where risk management is not a major part of consultants' assignments*" (Contractor 3). In sum, therefore, as relates to '*Knowledge*':

Finding 3—The findings suggest that stakeholders maintain their own separate knowledge domain experts, coupled with differences in knowledge focus, limited team proximity, and a focus on knowledge sources, which were excessively internal as against external.

5.4 Contract practices

Contractor 1 suggested that the project contract functions as a critical component *of* "*...shaping the behaviour of the project stakeholders and has a significant impact on the successful completion of the project*". However, there was also a recognition that "*...an over-reliance on contractual provisions could, in fact, be detrimental to design*" (Green Design Engineer 1). Disciplinary boundaries between the design and delivery/implementation teams served to impede the development of shared understandings with respect to contract provisions. Reflective of reported fragmentation in South Africa's green/renewable energy sector (Mauger and Barnard 2018), various teams involved in design and delivery/implementation appear to have focused on contractual matters, primarily from within their own areas of professional interest, thereby creating the appearance (as was noted in Organisation 'C') of potential contractual inefficiencies. This phenomenon was also manifest in Organisation 'A', where the design team had been appointed through a tender process managed by another government department (not the lead client).

We opine that this, however, represents an unfortunate and well-known reality of the building construction sector. Traditionally, contracts are dominated by adversarial provisions which focus on the consequences of failure (Jagannathan and Delhi 2020); that is to say, they transfer accountabilities for dealing with such consequences—and often not in sufficiently clear terms. Despite this, there was recognition that contractual provisions were important as they "*...define what to expect*" (Contractor 1), thereby guarding against opportunist contractor behaviour. Regarding contract type, Contractor 2 claimed that "*...what we want is a clean contract; just allow for people who want to work collaboratively, to do that without the noise*". Such interest in countering opportunism was of relevance because "*...the awarding criteria are based on the best assumptions of the return on investment and not on realistic benchmarks*" (Development Manager).

The need to "*...carefully select[ing] the right contract type to improve the effective involvement of these stakeholder groups*" (Project Manager 2) was required to mitigate against opportunism. It also required cultivating trust. A particular mechanism employed by Organisation 'D' involved the client constituting a 'Design Forum' to function as a platform for open discussion on concerns about the speed/pace with which design specifications were being made available to the design team. The participants also reported concerns that, despite espousing the importance of collaboration, the contracts perhaps produced the opposite effects. For example, Construction Manager 1 suggested that, "*…once you signed the contract, you put it in the drawer. If things go wrong and you refer to the contract to solve the problems, you will lose the relationship. The contract is a document; risks are dynamic and not one-off definitions that need to be managed beyond the contract. You could never prescribe how to solve a problem and how to mitigate risks in a contract*". In sum, therefore, as relates to '*Contract practices'*:

Finding 4—An emphasis on professional/disciplinary boundaries, significant lack of trust, and contractual opportunism had resulted in contractual inefficiencies as contracts become ever more cumbersome. In their current form, contracts served to impede the development of much desired collaboration.

5.5 Costs

The relatively high-cost outlay of green building construction was recognised to represent a major design risk because: *"…Financial factors are normally the highest priority for owners when new standards or technologies are introduced into the construction industry"* (Sustainability Specialist). However, Project Manager 3 stated that cost concern "*…seems quite normal for clients*". Thus, the focus of clients was on the need to "*…set milestones and complete them within the given time*" (Risk Manager 1). The drafting of contracts *"…using imprecise contract language"* (Quantity Surveyor 2) was flagged as a driver for high costs. Two participants opined that the imprecise contract language was most likely deliberate with the intent to "*insulate*" specific parties against costs associated with design uncertainties (Quantity Surveyor/Cost Manager 4) while Green Design Engineer 2 stated that the "*…constant back and forth of information [which] results in rework or redesigns*" was often associated with significant cost implications.

To help reduce costs, an emphasis on formal structures was justified on the basis that control was better placed to reduce coordination costs. While it has been opined that formal controls function as "*…superior information-processing mechanisms*" (Gulati and Singh 1998, p. 784), it was also recognised that there, nonetheless, remains a possibility that such formality (i.e., centralisation) could stifle innovation in the management of design risk, leading to an "*…inability to illuminate the black box and improve the accuracy required for better costing"* (Quantity Surveyor 3).

There was a recognition that maintaining geographically dispersed teams despite perceived benefits (e.g., a justification for Organisation 'C' to maintain geographically dispersed design teams was that it offered enhanced opportunities to leverage externally driven knowledge) did impact coordination costs overall. In particular, it was recognised that substantial investments (incurring both direct and indirect costs) had to be made to facilitate the development of collaborative cultures. This was the case, for example, where disciplinary differences meant that some members of the design and delivery/implementation teams had thought that team building efforts were simply "…*a time-consuming exercise*" (Structural Engineer 3). In sum, therefore, as relates to '*Costs'*:

Finding 5—Initial high outlay costs, tight profit margins, and very high transaction costs, alongside poor industry practices of unfair risk allocation, potentially impeded design and delivery/implementation teams' efforts to derive benefits from collaborative risk management for design efficacy. Geographic dispersion of design teams was also perceived as impacting costs (in particular, by raising coordination costs).

5.6 Stakeholder interactions

The importance of design team interactions was, however, widely acknowledged. It was noted that stakeholder interactions were "*…a crucial daily job and, by doing it jointly, the project team will get the bigger picture to perform*" (Development Manager). Another participant highlighted that *"…common objectives bind different teams, and, through this, people are prepared to accept their responsibilities and confirm what they want to achieve in terms of the design. In the end, you will get the best out of everyone"* (Structural Engineer 1). However, Project Manager 3 raised concerns regarding the efficacies of ever-expanding design teams because "*…the tables are getting longer and longer. That is not good, and it is […] counterproductive"*.

In Organisation 'D', a 'Design Forum' was introduced to facilitate open discussions and allow for the design teams to *"…embrace differences in opinions for a constructive discussion and mutuality"* (Green Design Engineer 2). The key to success was perceived as being to *"…show reciprocity in the relationship"* (Architect 2). Recognising the benefits of social ties formed through informal interactions in Organisation 'C', a series of patterned events in the form of 'away-days' were planned and organised. Organisation 'A' also organised a relationship-building workshop which provided ample opportunities for informal cross-disciplinary engagement nested in dialogues/exchanges, in order to facilitate creative insights among the various teams.

Structural Engineer 3 highlighted that, *"If the different teams agree to collaborate…it helps in spreading risks"*. Related to this was the perception that not fully engaging the entire design team could lead to the emergence of major knowledge gaps, especially during the transition from design to implementation. Fostering the optimal level of interaction, however, faced several challenges. Among them were concerns that some of the design team members had no previous history of working together (as in Organisation 'C'). One approach adopted to develop trust (by Organisation 'A') was to include the contractors and other major material suppliers early on in the design phase. In sum, therefore, as relates to '*Stakeholder interactions*':

Finding 6—The findings suggest that (i) the lack of shared design objectives, (ii) potential power imbalances/differentials centred outside the design team, and (iii) low levels of trust potentially impeded deliberation to agree and pursue common goals. The *mobilisation* of stakeholders in a manner that released key collaborative capabilities was deemed essential for overcoming these problems. This attests to the idea that stakeholder communication is key to embedding social interactions in green building design. It appears that framing, reflection, and reasoning among designers searching for common goals can be further enhanced through team decentralisation.

5.7 Technology

There was recognition among the participants that technology advanced and embedded sustainability goals into building design. Architect 2 opined that the exploitation of modern technology ensured that "*…our buildings not only appealed to the user, but also that our brand survived far into the future"*. In Organisation 'A', "*…simulation tools were used to support robust decision making*" (Quantity Surveyor 3). In Organisation 'B', technology, in effect, allowed for *"…a huge amount of interdisciplinary functionality [to be] …brought into our design"* (Architect 4). Technology also provided functional support for collaboration; hence, according to a Sustainability Specialist, "*…modern web technologies, such as cloud computing, web services and the semantic web have the potential to shape future online collaborative environments in design"*.

It was also recognised that technology offered collaborative platforms. In Organisation 'D', for example, having access to shared platforms was deemed desirable because "*…success…hangs on well-managed, precision conveyance of information within* *the stakeholder network*" (Project Manager 3). Organisation 'C' employed a virtual data exchange platform to ensure secure seamless transmission and exchange of design data among the geographically dispersed design team.

Technology was, nonetheless, also recognised as presenting significant risks. We were informed, for example, of instances where "*…information was lost when captured in digital models*" (Architect 4). This was of particular concern, given that design success *"…hangs on well-managed, precision conveyance of information within the stakeholder network"*, according to Project Manager 1. There were also user-related challenges with available technology. For example, Structural Engineer 3 highlighted that they were "*…informal communication channels not captured by such technology*" (. Another participant pointed out that *"…the BIM environment had not made it easy for stakeholders who are not trained to use new communication technologies"* (Sustainability Specialist). It was further noted that, *"…although BIM is widely used in information management, BIM-based knowledge management is rarely known"* (Risk Manager 2). In sum, therefore, as relates to '*Technology*':

Finding 7—The findings point to technology functioning as a major accelerant of sustainability in both design and functionality. Technology also appears to function as a major enabling platform for collaboration, primarily when used to create a common data environment (CDE). Despite these advantages, technology also presents design with unique collaborative risks pertaining to (i) data loss and (ii) various user-related challenges such as where there are skills deficits for more highly specialised technologies.

6. Discussion

Our findings revealed several sources of *'Design risks'*. The interaction of these risks with associated collaborative practices appears complex and interrelated, thereby raising questions of how collaborative risk management for design efficacy in green building construction projects is best enhanced. We illustrate the key interactions between risk factors and managerial practices, albeit simplified, in Figure 3.

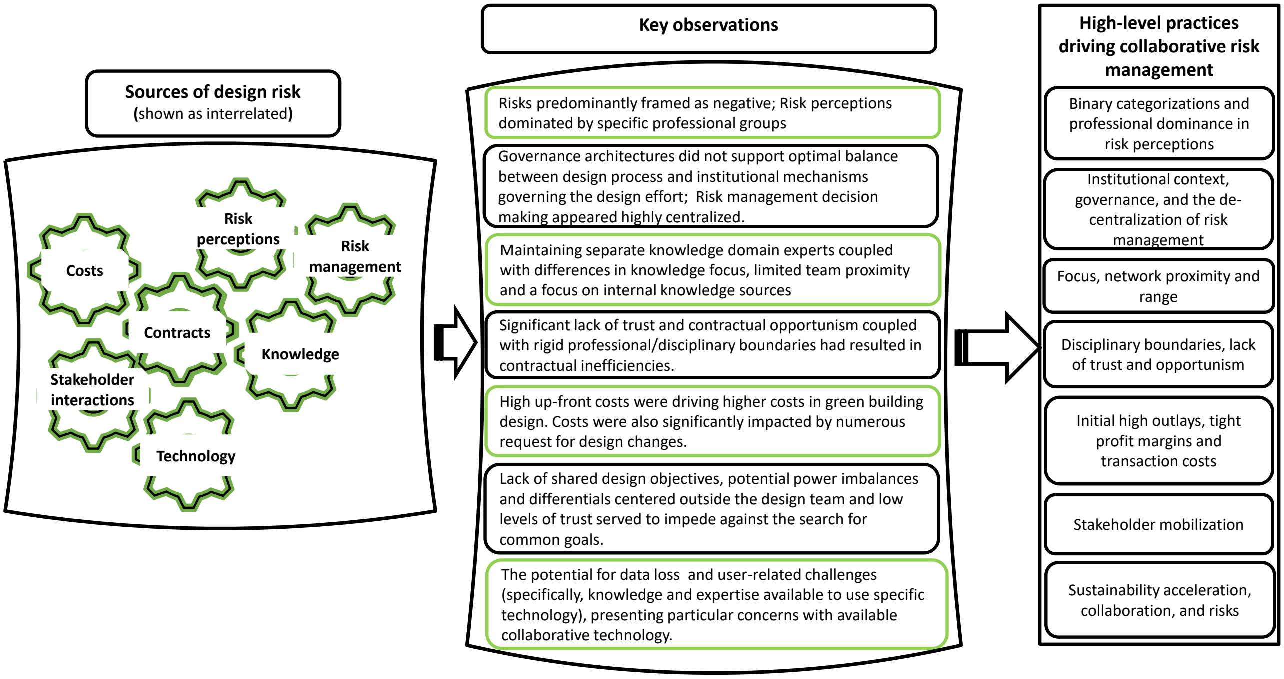

Figure 3: Sources and manifestations of interaction challenges

6.1 Binary categorisations (perceptions) and professional dominance in risk perceptions

Binary categorisations of risks are potentially simple useful tools for assessing risks (see Foroughi Pour et al. 2021). They involve the use of absolute/fixed category pairs (i.e., negative–positive) as basic principles of structure and complexity reduction for individual risk perception. They can be contrasted with risk perceptions based on expected value (Elliott 2003).

The use of binary categorisations can create several challenges to the efficacy of collaborative risk management for design. For example, they can raise the prospects of over-simplifying the nature of risks and of potentially dividing design teams between those who adopt negative or positive frames. Such rigid thinking can lead to conflict, especially where design decisions are centralised (see de Paula et al. 2022; Ahuja 2023). They can also accentuate stark inconsistencies in risk probability and quantification. Generally, such rigidities are driven by strong professional identities (see Sollami et al. 2018). Recognising this, we would expect that, while collaboration between teams maintaining similar risk perceptions will tend to increase, there may well be simultaneous decreases in collaboration between out-teams whose risk outlooks are more diverse.

One way to overcome the potential limiting impact of binary categorisations is to encourage a transition to a 'risk continuum' approach based on what we term '*gradations of intensity*'. This approach is more attuned to the infinite richness of risk, amplifying the (i) multidimensional and asymmetric '*constructedness*' of risk (e.g., whether to emphasise ex ante or ex post risk identification) and, also, (ii) contradictions in professional logics (Ahuja 2023) that particularly exist in project design due to fragmentation within the green construction sector (Raouf and Al-Ghamdi 2019). The resulting collaborative risk management for design efficacy may also be facilitated by the design team's willingness to attenuate their identities (by altering their understanding of the design context and practices) in order to expedite further risk collaboration (see Ahuja 2023).

6.2 Institutional context, governance, and the decentralisation of risk management

Within the context of decentralising the management of design, governance can be considered a 'method of ordered rule' emphasising the desirability of mixed and changing participative styles and fluid boundaries between participating entities (see Stoker 1998).

The relational functionality obtainable through appropriately framed governance mechanisms can be further theorised as itself incentivising design actor collaboration. On this logic, through the appropriate governance mechanisms, the various teams involved in design will be able to coordinate elements of their activities with the view of achieving synergic advantage. Essentially, they will find that this allows them to operate as a single virtual entity. (Walker et al. 2002) while allowing for the decomposition of design into individual components and modules. At the same time, this also ensures that the design's holistic features are not ignored. Ultimately, it ensures that individual practitioners, specialists, stakeholders and/or users involved in green building design are able to draw upon their different domains to develop an integrated understanding of what is important during the design process and to the design itself. The materialisation of these advantages requires decision architectures that are aligned with the leadership and culture mantra which accepts that the distributed management of risks will enhance collaboration (Qiu et al. 2008). These insights merge to suggest that orchestrating governance via decentralised structures may often prove optimal for alliance-based collaborative risk management. Such decentralisation may bring several specific advantages. For example, it may encourage flexible knowledge pooling. It may also mitigate against potential coordination challenges.

6.3 Focus, network proximity, and range

Teamwork is essential for multidisciplinary design collaboration (Idi and Khaidzir 2018; Chan et al. 2021). The literature highlights that proximity (whether geographical, technological, or social) does impact collaboration (Li et al. 2021). In particular, proximity may impede the design team's ability to effectively construct and share mental representation of design artefacts (Dong 2005). Although some studies suggest otherwise (see Vivona et al. 2023), we were swayed by the literature supporting the view that teams in close geographic proximity are likely be more productive than those that are more geographically dispersed (Moradlou et al. 2022). There are various reasons for this; for example, geographical proximity can reduce transactional costs. It can also enhance both the frequency and depth of team interaction and, therefore, knowledge exchange among the design teams (and, by implication, across broader collaborative networks). While such proximity is desired, we caution that it is likely to prove insufficient for optimising the frequency and depth of knowledge exchange. Moradlou et al. (2022), for example, highlight that the exchange of knowledge in collaborative settings is only likely to be amplified where 'safe environments' exist to support knowledge sharing. The literature (e.g., Prim et al. 2023) surfaces how the *diversity* (larger and more internally diverse networks are more likely to create larger and more diverse knowledge pools), the *depth* (deeper integration of actors within the knowledge networks will exert more influence on collaborative priorities), and the *stability* (durability of relationships between network actors) of actor network configurations can heighten collaboration.

An alternative perspective (i.e., teams more geographically dispersed are likely be more productive than those in close geographical proximity) will suggest that maintaining the geographic dispersion of the team can serve to leverage externally driven knowledge. Moreover, this can allow for *more* significant creativity because it entails drawing from a knowledge base comprised of design team members with significant social, cultural, and national differences. There is literature to support this alternative perspective (Vivona et al. 2023). Furthermore, maintaining geographically dispersed design teams creates opportunities for establishing broad knowledge spaces that may be harnessed to develop necessary design expertise (see Mannucci and Yong 2018). These knowledge spaces are directly associated with a diverse professional environment.

6.4 Disciplinary boundaries, lack of trust, and opportunism

Traditionally, contracts have been presented as a means of facilitating exchanges that may eliminate risk (Malhotra and Murnighan 2002; Markovits 2004) and create the platforms necessary for collaborative risk management. However, collaboration can also be achieved without contracts being in place.

Essentially, trust—which we construe as "…*a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another*" (Rousseau et al. 1998, p. 395)—points to a recognition of the mutuality of interest, shared aspirations, consensus, and cooperation (see Gino 2019). It may well be that, as trust increases, the need for formal written contracts decreases overall, with generally benign implications for fluid, spontaneous, and heterarchical patterns of collaboration. The alternative is to write more formal agreements into contracts. However, we very much doubt that a reliance on formal contractual provisions will mitigate against potential opportunism, noting Markovits's (2004) earlier assertion that, "…*in spite of the obviously communal character of […] contract, the most prominent accounts of its […] practices remain firmly individualistic*". Therefore, contracts may not be able to comprehensively deal with all potential contingencies that may arise in collaborative environments (see Bernheim and Whinston 1998). The reality is that cataloguing (as much as is possible) all potential opportunist behaviours and consequences will, more often than not, result in cumbersome contracts. For example, one obvious risk issue may simply be false confidence in opportunism reduction via contracts. This will be particularly poignant in green settings, where the workability of very detailed contracts is particularly questionable, noting that most contracts are drafted to allocate costs to activities which are rigidly sequenced (Lamé et al. 2017). One way forward will be to emphasise the use of 'non-binding contracts'. Essentially, these types of contracts do not make legal provisions for the enforcement of any terms or conditions. Instead, as observed by D'Agostino and Lisciandra (2018) and Marmor (2019), they rely on trust as their mechanism of enforcement. The use of non-binding contracts may enhance trust, leading to collaboration.

6.5 Initial high outlays, tight profit margins, and transaction costs

Green building projects are expensive (Chegut et al. 2019) and costs are one of the most reported risks to green building design reported in the literature (Ahn et al. 2013; Li et al. 2022; Simpeh et al. 2023). Contractors involved in green buildings have reported concerns about significant high outlay/transaction costs, and other cost-related concerns such as tight profit margins (Cross 2024). In fact, costs have even been cited as a major impediment to widescale adoption of the sustainability agenda within the building sector (Li et al. 2020). These realities applies to South Africa as well (Marsh et al. 2020; Simpeh et al. 2023).

Our finding that cost considerations were a major concern for clients and project sponsors is consistent with other studies (e.g., Ofek and Portnov 2020; Addy et al. 2021). Design has been identified as one of the core elements of green buildings contributing to its high costs (Chegut et al. 2019). Surprisingly, though, our findings did not surface concerns about high design fees, despite its prominence in the literature (see Ikudayisi et al. 2022). When compared against conventional non-green certified building design, the average total cost difference for green certified building construction projects can be as much as 32% (rising to between 40% and 150% for green certified excellent/outstanding buildings) even though it represents only about 3% of overall project lifecycle costs (Chegut et al. 2019). This suggests that, overall, clients are prepared to pay the extra premium for green expertise. Coordination costs are expected to increase with geographic distance among design teams. The literature acknowledges that both size and geographical dispersed are factors that may contribute to the costs of collaborative ventures, with collaboration between larger and more widely dispersed teams being costlier (Vivona et al. 2023).

6.6 Stakeholder mobilisation

Several practices relating to stakeholder mobilisation are highly detrimental to collaborative risk management for design efficacy unless used in a manner which will ensure that they are mobilised to engage in consensus-based collaborative action (see Rowley and Moldoveanu 2003). Factors of importance to such mobilisation may include prior experience working together and the existence of social ties (Meyer and Rowan 1977). These social ties may sometimes develop outside the specific setting of a particular project; in other instances, they may develop following interventions by the project sponsor (e.g., the above-highlighted Design Forums). However, perhaps overriding all this is that the willingness of stakeholders to mobilise for collaboration may reflect their recognition of the importance of the different expertise and insights that each brings to the design (see Rowley and Moldoveanu 2003). This argument resonates with the literature that emphasises the roles of shared beliefs, expressions of common interests, and consensus-based trust in mobilising disparate stakeholders (Ashforth and Kreiner 1999; Reypens et al. 2021).

It is important to highlight that some stakeholders may be motivated to engage in collaborative risk management for design efficacy *only* on the condition (or expectation) that they will receive credit from doing so. This idea resides on the notion that some stakeholders involved in design might regard collaboration as threatening. In other words, they perceive that collaborative working will potentially obscure the contributions that they are likely to make to the design efforts. This view may arise if there is a belief (perhaps from past experience) that the credit premium from such collaboration will not compensate for the perceived relinquishment of decision control. This is likely to occur where key design decisions are made outside the design team.

6.7 Technology, collaboration acceleration, and risks

In addition to being able to facilitate the automatic assessment of green functionalities throughout the entirety of the design process (Jalaei and Jrade 2015), the use of technology to support collaboration in design is well recognised in the literature (Idi and Khaidzir 2018; Brisco et al. 2020; Yu et al. 2022). Technology can play a major role in bringing about profound changes in the ways in which design practitioners collaborate. For example, technology in the form of visualisation/virtualisation and simulation will support more reliable exchange, the development and sharing of virtual models (Idi and Khaidzir 2018), and also the reconciliation and validation of design information. An example is the use of technology to enhance multi-threaded social information exchanges (Brisco et al. 2020). Many technologies which support design collaboration also have the potential to unlock new capabilities across the entire design value chain (Gasco-Hernandez et al. 2022). Prominent among technology practices impacting collaborative risk management for design efficacy were those focused on providing common data environments (Lahti et al. 2004).

Despite establishing new possibilities and opportunities for design, technology can expose design to unique collaborative risks. These risks can be functionality driven and arise where overlapping technology functionalities create confusion in terms of the progress and future direction of the design and/or create tensions between members of the design team

(Brisco et al. 2017). To minimise these effects, it is necessary to carefully select technologies that support the requirements of the design project and the individual team members. The use of collaborative channels residing outside institutional platforms may create new exposures to the loss of critical design knowledge/information (El-Diraby et al. 2017). The literature also suggests that integrating collaborative channels into institutional platforms may well make matters worse by creating significant further data security risks (e.g., Wang et al. 2022). Considering the above, the selection of collaborative technology that also addresses the wider project requirements is of paramount importance (Gibson and Cohen 2004).

7. Conclusions

Working in collaboration with four organisations involved in green building design projects in South Africa certified by the Green Building Council of South Africa (GBCSA), we conducted case studies to identify the design risk factors. We also explored the associated managerial practices driving collaborative risk management for design efficacy in green building projects in South Africa.

In our findings, in a discursive manner, we focused on seven sources of design risk: (i) *Risk perceptions/categorisations,* (ii) *Risk management practices,* (iii) *Knowledge,* (iv) *Contract practices,* (v) *Costs,* (vi) *Stakeholder interactions,* and (vii) *Technology*. Each of the highlighted design challenges was unique. Further, in surfacing the distinguishable implications of these sources of design risk in green building design, our findings shows the somewhat abstruse relationships between different sources of design risk and the associated collaborative risk management practices for design efficacy. At the heart of these practices are their complex mutual dependencies upon one another. Based on this, we opine that our study does contribute to the advancement of understanding how design risks can arise within the context of in green buildings and the implications of the associated collaborative risk management practices that organisations can pursue.

Our findings are summarised in Figure 4 (below). The implications of these findings now conclude our paper.

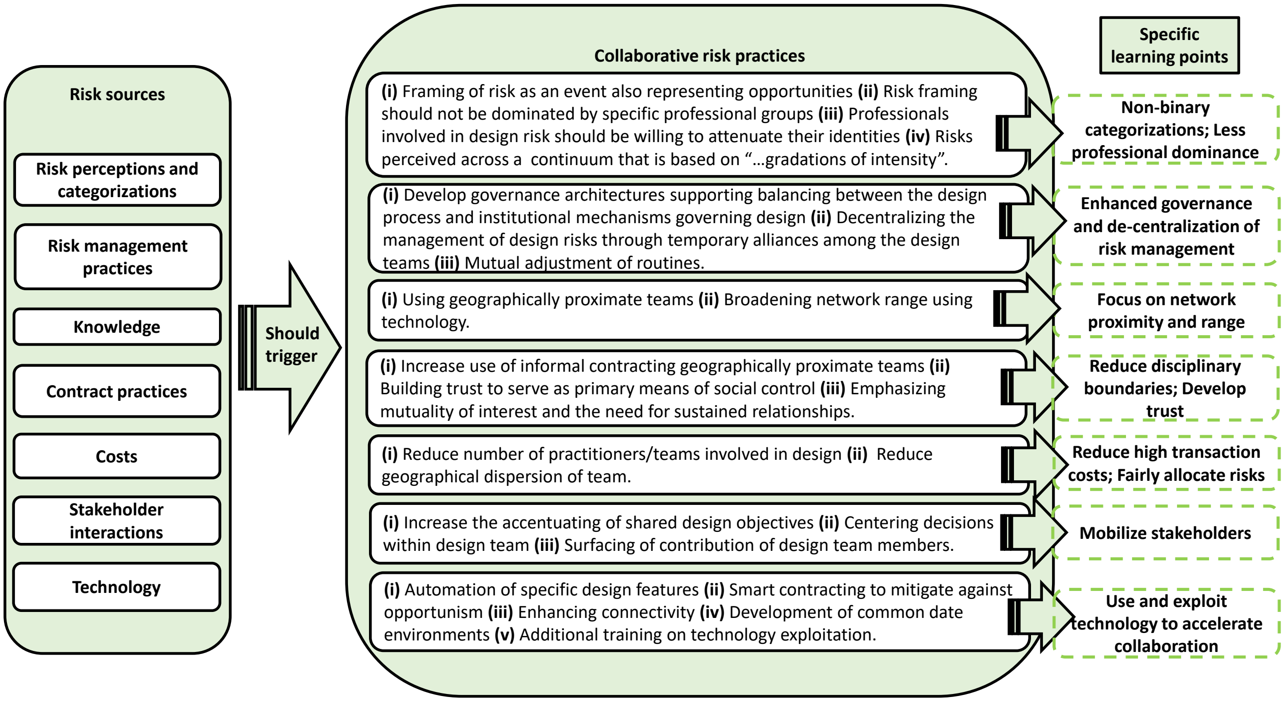

Figure 4: Summary findings

7.1 Theoretical implications

In terms of theoretical implications, despite highlighting the various channels through which collaboration can positively impact the efficacy of building design (and the nature of their interactions with the managerial practices), it is important to caution scholars (and, to an extent, practitioners) against face-value optimism about the potential positive impacts of collaboration. There are two reasons for this. The first is that we expect to find a potential gap in the theory and practice of collaborative risk management for design efficacy in terms of expectations and practical realities. As highlighted above, there is considerable attention in South Africa on green (i.e., sustainable) performance of buildings. Proponents of green buildings opine that key stakeholders (such as project sponsors) will benefit from the cost savings of green buildings. Thus, various interest groups (such as the GBCSA) and the Government of South Africa (through the Department of Public Works) are also exerting pressure on the construction industry to embrace green principles. Design, which is a core element of these initiatives is, however, challenged by several risks. Coupled with this, while green design (i.e., "*…the rational and structured process to create something new for solving green-related problems*"—see Baldassarre et al. 2020) may be supported by a substantial knowledge base on how sustainable challenges can be successfully addressed, scholars do point out that the implementation of ideas is particularly problematic. In the context of our study, the result potentially leads to a gap arising between abstract knowledge and concrete collaborative risk action (see Marshall et al. 2019a; Baldassarre et al. 2020). The second reason is that collaborative practice is only likely to be as good as context-specific design risk management practice. Accordingly, despite recognising collaboration as generally very likely to enhance design efficacy, we also highlight that this relationship may be nuanced by the extent to which these practices can be leveraged together rather than separately. This is particularly the case noting the complexities, differences from traditional buildings, and context peculiarities of green building design specific to South Africa. At present, the promotion of the green agenda in South Africa is fragmented (Mauger and Barnard 2018) and green building studies and research in South Africa are still in their infancy (Marsh et al. 2020; Agbajor and Mewomo 2024).

Thus, we further opine that the interdependent risk management practices which we have identified may also serve as a useful team-level template for scholars and practitioners for assessing and evaluating green building design readiness for collaborative risk management in South Africa before, during, and after the project design phases. It is of further interest to frame these various design practices as managerial mechanisms for collaboration when considered from the standpoint of how collaboration ensures that organisations gain access to relation-specific resources to support successful design outcomes within projects. This itself has further implications for how we might theorise design risks in terms of impediments to such access. This resource access view of risk rarely features as a focal point within risk management literature, and yet it can be regarded as at least implicit within this study's view of green building design risk.

We suggest that our study's pursuit of a collaborative solution to design risks becomes much more compelling when situated within the theoretical context seeking to balance managerial collaborative risk practices with the overriding ethical imperative of pushing forward and shaping the development of sustainable design. We look to collaboration in search of design risk solutions partly because ideas of collaborative practice align very strongly with two leading risk management paradigms with the potential to transform sustainability—(i) resilience and (ii) enterprise risk management (ERM). Both philosophical frameworks provide convincing rationales for broad stakeholder participation in building design. Enhancements to the management of design risk emerging via collaborative rationales co-arising from these two risk management paradigms, working in concert, seem to offer much potential to drive improvements to the 'views of risk' that are formalised by risk management. Thus aligned, they seem to provide powerful rationales for making greater use of a broader range of risk assessment tools and techniques which increasingly serve as the key design management arenas where collaborative interaction routinely takes place.

7.2 Practical implications

As South Africa grapples with the challenges of adopting and implementing green building projects, industry is also being challenged by increasing complexities and the need to ensure that building design is resource-efficient and environmentally responsible. This is particularly important noting that design can sometimes result in unintentional consequences. A key constituent element of any desired managing-for-sustainability ecosystem will be largely driven by close collaboration between the various members of the design team (including other stakeholders). In this respect, the study findings serve as guidelines for practitioners involved in risk management for design efficacy in green building projects. By illuminating project design risk as an important project risk category, our study contributes to how those involved in green building design may best understand their collaborative ecosystem and collaborative interactions. Practitioners involved in green building design may need to relentlessly structure, shape, and reshape their responsibilities, objectives, and practices to ensure alignment with green design needs. We also posit that, in as much that they describe designated managerial actions to be emphasized, the collaborative risk management practices for design efficacy practices that were identified, potentially also serve as a useful template by which design practitioners can evaluate and assess their readiness for design efficacy. It is likely that these collaborative practices continue to evolve through increasing ingenuity in aligning them with desired sustainability outcomes via more and better specifications of best practice. It should be a simple and highly practical matter for any project working toward such outcomes, and willing to experiment with best practice solutions, to work through our seven-item framework and consider its contents for possible relevance.

The identified sources of design risks in this study can be utilised to alter the practices driving collaborative risk management. This will require practitioners to adjust the way that the GBCSA green rating system is being used. He et al. (2018), for example, suggest that, instead of viewing green rating systems as measure-based 'technical checklists', they should be construed as best practice performance guides for green design risk strategy. Those involved in green design may be, arguably, best positioned operationally as the natural owners of these improvement pathways. Similarly, they are likely to be best placed to consider the risk reflexivities (as manifest in 'project design risk) which they themselves produce as they strive toward such solutions. Of course, this cultural intelligence around design (see Chipulu et al. 2016)—even though country-specific—is most likely to happen within cultures of collaborative practice. More fully, those involved in building design need to constantly frame and reframe their relationships to align with changes across the sustainability domain (including changes in green certification and standards).

Design professionals often ignore the inter-relatedness of risks which can potentially result in dysfunctional design decisions by practitioners accumulating over the design phase of green buildings, leading to persistent poor design decisions. Constant change in the configuration of design attributes also means that how the range of diverse stakeholders involved in design will have to collaborate will constantly evolve. Differences in design focus, however, entail that, in each project, there is a need to ascertain whether all or some combination of these collaborative risk practices should be utilised and to what extent doing so requires other design competencies/capabilities to be adjusted or strengthened. In this case, every project may, therefore, be considered an experiment of one, and yet it seems likely that our proposed best practice framework will continue to hold considerable relevance.

7.3 Limitations

The main limitations of this study are as follows. First, the range of literature sources employed in the study may have been associated with an element of bias in their selection, potentially impacting on the study conclusions. Despite the primary feature of narrative reviews in their description and appraisal of relevant literature, scholars routinely acknowledge this potential limitation in their use. As an alternative, systematic reviews which offer selection criteria that are clearly defined have been proposed and employed by various scholars (Tranfield et al. 2003; Thomé et al. 2016). Employing a systematic review in this study would have provided much needed focus and clarity in the literature search.

Second, we do acknowledge that, despite its ubiquity in construction/project management research, the appearance of our overdependence on interviews may suggest the lack of much needed pluralism in our study. It may also lead to two concerns; one relating to the extent that our study was able to capture, at an appropriate level, the nature of the practices discussed in this study and the other relating to the validation of the views expressed by the study participants (in other words, its validity and reliability). Furthermore, the method employed meant that the research findings were justified on the basis of observations.

Thus, future studies need to engage with additional multiple secondary data sources. As an example, in Liu et al. (2021), while their study was based primarily on interviews, it was augmented with data collected through archived documents and site visits which further enabled understanding of the daily practices and social situations in the projects studied. Future studies also need to further explore the validity of our conclusions by more explicitly drawing out questions investigated in different design settings.

Third, although we covered multiple relationships between the various risk sources, managerial practices, and associated learning points, we did not look systematically at the influences at play so as to rank these risk sources. Bashir et al. (2022) have developed an information exchange model which may be appropriate for such further analysis.

Fourth, while our findings identified professional dominance in risk perceptions, we did not fully explore the power relationships which do or can exist between those dominating risk perceptions and which can lead to contested and contradictory risk logics, thus negatively impacting upon collaborative efforts to manage design risks. However, despite these limitations, the study offered valuable opportunities to develop in-depth explanations of how design efficacies can be enhanced through collaborative risk management.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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