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# INTEGRATION OF WATER-EFFICIENT STRATEGIES IN GREEN CONSTRUCTION PROJECT MANAGEMENT IN PAKISTAN: A SYSTEMATIC LITERATURE REVIEW

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**Abstract**
*The evidence reviewed suggests that strategies that result in water efficiency can lead to potable water savings of approximately 30-50 per cent and construction-stage, water savings of up to about 30 per cent, when they are well implemented. Integration, on the other hand, happens at the planning and design phase and is diluted during implementation, monitoring and wrap-up. Water-efficiency outcomes were better when project teams reported structured planning, clearly assigned responsibility, and active monitoring, and when project management was weak or informal, adoption of any water-saving technology reported was poor, supporting the hypothesis that project management is a mediator between strategy and outcome. There is a persistent policy–practice gap, which dulls down these results–while the Green Building Code of Pakistan (GBCP-2023), the Energy Conservation Building Code (ECBC-2023), and the National Water Conservation Strategy provide clear requirements, poor implementation, inadequate managerial capacity and lack of measurable water targets in scope and procurement documents inhibit these at the project level. To the best of our knowledge, this is the first review of water efficiency in green construction, in the context of Pakistan, where the integration of water efficiency in construction projects is conceptualized as a problem for project management and not as a technical one. It provides a framework of conceptual variables (independent, mediating, dependent and moderating) and inter-variable relationships that is proposed and suggested for future empirical testing, and it identifies the management and policy context in which water-efficient strategies are most likely to be implemented.*

## 1. INTRODUCTION

Water scarcity is one of the most critical development issues of Pakistan today. The strain on urban water supply caused by population growth, unplanned urban development, and a decline in water levels, coupled with poor governance of the resource, has led to an imbalance between demand and supply that is now necessitating the over abstraction of groundwater in most major cities, according to the Pakistan Institute of Development Economics (2024). The deteriorating water quality also adds

to the issue and evidence across multiple cities suggest that the poor quality of urban water is related to over-extraction and poor management of the resource (Ishaque et al., 2024). The security of the urban water supply is not only a sectoral issue anymore, but a national one for a nation already vulnerable to climate change.

Building is at the heart of this issue. Much of the water consumed in the sector is used in the construction process, and these buildings require water for operation for decades to come, requiring more water than is currently recognized as necessary and can be reduced through better planning (Inácio et al., 2026). This is a very clear point of intervention, with national authorities placing emphasis on it as a priority area for increase in efficiency (Pakistan Council of Research in Water Resources [PCRWR] 2024).

In response, the framework of green construction has become the predominant approach, utilizing resources including water, sparingly throughout the building life cycle (Kibert, 2016). A range of existing initiatives, including rainwater harvesting, greywater reuse, water efficient fixtures and water management on site during the building construction phase, can significantly impact the amount of potable water a building consumes, and guidance from various international bodies outlines water-use reduction targets and best-management practices for indoor water use (World Green Building Council, 2024; US Green Building Council, 2024; International WELL Building Institute, 2024). What these studies also demonstrate repeatedly, is that the saving only happens when such measures are embedded in planning and implementation of the project rather than just charted on a drawing.

Pakistan's regulatory environment has recently shifted towards accommodating this change. The Green Building Code of Pakistan (GBCP-2023) and the Energy Conservation Building Code (ECBC-2023) have explicit provisions on water-use efficiency, monitoring and rainwater harvesting (International Code Council, 2024; National Energy Efficiency and Conservation Authority [NEECA], 2023); and national policy documents such as the National Water Conservation Strategy 2023-2027 identify construction as the priority area for efficiency gains (PCRWR, 2023). This direction has been further emphasized by the government's recent communication on the provisions for rainwater harvesting in new buildings (Press Information Department, 2025).

But actual adoption of the ground is also not uniform. The literature indicates that the requirements for sustainability are often not converted into the scope of projects, procurement, delivery and monitoring, meaning that "good intentions" do not always take to the delivery (Mehmood et al., 2025). The focus of the research conducted in Pakistan has been mainly on awareness, technical barriers and a high-level policy, rather than on the project-level mechanisms through which water-efficient strategies are — or are not — implemented. This gap, in other words, is managerial and not technical, and that gap is what the present review focuses on.

Taking that observation as its starting point, this paper treats water efficiency in green construction as a project-management integration problem and asks three questions:

- Which water-efficient strategies are most prominently reported in green-construction literature relevant to Pakistan?
- How do project management processes shape whether those strategies are integrated across the project life cycle?
- What regulatory and contextual factors influence integration outcomes in the documented evidence?

The remainder of the paper is organized as follows. Section 2 develops the theoretical framework and the conceptual research model that links the study's variables. Section 3 describes the review method. Section 4 reports the findings across five themes, Section 5 discusses their implications for policy and practice, and Section 6 concludes.

## 2. Literature Review

This review considers the literature surrounding water efficiency in green construction and identifies the question that inspires the present study: How water efficiency strategies are implemented in project management. This discussion focuses first on the magnitude of the

water issue for Pakistan, and the role of the construction industry in this issue and then looks at the strategies offered by the green construction movement and the managerial and institutional conditions that make or break them. It ends by tying up the strings that it has left loose and trying to plug up the hole of the study.

### 2.1 Water scarcity and the construction sector in Pakistan

The literature is unanimous that Pakistan has entered the state of 'Water Scarce'. A per capita availability lower than the 1000 $m^3$ per capita threshold widely considered as the threshold of scarcity is not only the case but the gap between the demand and supply for urban areas is widening owing to population growth, unplanned urbanization, and continuous depletion of groundwater, according to the Pakistan Institute of Development Economics (2024). The issue is not just about how much. Multi-city evidence indicates that the deterioration in water quality is driven by over abstraction and poor management of the resource, thus compounding water scarcity with the deterioration of water quality (Ishaque et al., 2024). The response from national levels has been to identify demand side management and conservation as priorities (Pakistan Council of Research in Water Resources [PCRWR] 2024).

Building is consistently cited as an area where those priorities strike back at the industry. Water is used in the construction and throughout the life of buildings, and recent modelling indicates significant amounts are used onsite during construction, which can be minimized by more careful planning (Inácio et al., 2026). The water demand of a building is largely determined at design and occupancy, thus water is considered a high leverage point for action in the sector (PCRWR, 2024). In brief, what this volume has laid bare is that the built environment is important in Pakistan's water future and what it has left unanswered is how the water performance of the built environment can be enhanced in practice. Water efficient strategies in green construction are discussed. Topics covered include discussion about water-efficient strategies in green construction.

### 2.2 Water-efficient strategies in green construction

It is offered as a 'lifecycle' approach that conserves resources, including water, throughout the design and construction process, and over the lifetime of the building (Kibert, 2016). In that context, literature is united on a familiar set of strategies. Rainwater harvesting is a prominent feature: Rooftop catchment can contribute to a significant portion of non-potable demand, as evidenced in Lahore, where a substantial proportion of rainwater catchment area features rooftops planned from the beginning of the design process (Haider et al., 2024); and studies of combined rainwater and greywater systems report greater and more consistent savings where rooftop catchment is planned alongside greywater (Habibullah et al., 2023).

The literature also highlights efficiency at the use point and throughout the operation phase, in addition to collection and re-use. Water-efficient fixtures and the reduction in water use that is now coded in in the rating systems (voluntary such as WELL and LEED), are more and more becoming part of the specification in commercial projects (International WELL Building Institute, 2024; US Green Building Council, 2024), and projects involving leak detection and metering reveal that these operational parameters play a crucial role in retaining efficiency over the service life of a building, as ongoing leaks will quietly reduce the efficiency of the water-efficient fixtures (Farah et al., 2024). The temporal point that is reiterated in this research is that the lifecycle water demand of a building is determined mainly during design and planning phase, where early decision making is an important factor and has significant impact (Bukhari et al., 2024). These strands are brought together into best practice policy and construction management guidance on a global scale (World Green Building Council, 2024). In aggregate, this literature has provided the basis for the conclusion that the technology of water-efficient strategies is not seriously challenged, but that the challenge remains one of delivery.

### 2.3 Project management as the mechanism for integration

A second strand of research moves the focus away from technology and focuses instead on delivery, suggesting that the key is the way in which measures are included and managed in a project's management. This attitude is most clearly reflected in the sustainable project-management literature. According to Silvius and Schipper (2014) sustainability is not an add-on to project management, but rather a fundamental transformational process. Zhang and Wang (2024) and Akadiri and Olomolaiye (2023) conduct systematic work finding that environmental goals are best met if these goals are part and parcel of the scope, procurement and quality control, rather than an optional add-on. The claim is reinforced by evidence from developing economies, which suggests that the maturity of green project-management (defined roles, gateways, monitoring routines) can better predict sustainability outcomes than the technologies selected (Raza et al., 2025), and critical success factors studies also indicate this (Alghuried et al., 2025; Usman et al., 2025). These findings align with the literature on digital delivery, which indicates that disciplined coordination using a model is linked to better integration of sustainability requirements (Sajjad et al., 2024), and studies on risk and quality management confirm that the process of green projects is highly beneficial to the discipline of process (Arshad & Khan, 2025).

The Pakistani picture confirms these international developments and adds some clarity. Poor coordination among stakeholders and a lack of responsibility have been cited as a frequent challenge for achieving translated green intentions (Khan & Ali, 2023; Hussain et al., 2024), while limited technical capacity among contractors and a lack of measurable water targets on site are cited as key barriers in contractor level research (Memon & Rahman, 2023). The idea that is apparent in this literature and present in this study is that project management serves as the vehicle for either the water efficiency requirement is transferred to the delivery or it is lost.

### 2.4 The regulatory and policy environment in Pakistan

The institutional context has significantly evolved in the last several years and literature reviews it as the place where project-level integration works or doesn't work. In addition, the Energy Conservation Building Code (ECBC-2023) provides minimum performance requirements for water-using systems (National Energy Efficiency and Conservation Authority, 2023), and the Green Building Code of Pakistan (GBCP-2023) explicitly calls for water-use efficiency, water-efficient fixtures, monitoring, and rainwater harvesting as a formal regulatory measure (International Code Council, 2024). The National Level National Water Conservation Strategy 2023-2027 identifies construction as a key sector for efficiency gains, and there are ongoing policy developments to encourage decentralized rainwater harvesting and awareness of stakeholders (PCRWR, 2023); recent federal communication indicates ongoing policy momentum including policy initiatives relating to rainwater-harvesting provisions in new buildings. These measures are located within the broader context of Pakistan's international engagements, as represented in reports at the country level (UN-Habitat, 2024). The distance between codes is the theme of most of the literature here, and its impact on site. A review of code implementation suggests that enforcement is weak and there is little management capacity to dampen the effect of the code at project level in practice (as code on paper does not necessarily drive decisions) (Mehmood et al., 2025). That is, the policy framework is becoming more adequate, the translation of that policy into delivered performance is not.

### 2.5 Barriers and enablers to adoption

A set of documents the factors that can facilitate or impede the adoption of water-efficient and green-construction practices. The literature suggests that on the barrier side, the main concerns are economic, specifically the perception of higher initial costs; institutional, in this instance related to enforcement issues; and socio-cultural, namely social and cultural inertia regarding new technologies, while limited

contractor capacity and immature local supply chains for some efficient products are also concerns (Hussain et al., 2024; Memon & Rahman, 2023; Mehmood et al., 2025). The enabling factors are the client demand (usually from the multinationals or institutional clients), structured project management practice, clarity of the regulatory signals combined with enforcement, and targeted incentives. What is striking is that these barriers and enablers are far from technical and are evident to a large degree in a managerial and institutional sense, in line with the framing of this review.

### 2.6 Synthesis and research gap

When read together there are three conclusions drawn from literature. In the first place, the technical solutions available to reduce water use in buildings are well known and are effective across a wide range of buildings. Second, they are dependent on project management - they are fulfilled when they are included throughout the project and lost when they are not included. Thirdly, the regulatory framework has moved forward in Pakistan but has failed to be effective in practice due to a longstanding mismatch between policy and practice. However, these three strands are typically studied individually. The green construction literature focuses on technology, the project management literature on process and the policy literature on codes and strategy, while few studies have attempted to explore how project management processes can combine water efficient strategies in Pakistan's construction industry. That gap, the project-level mechanism by which the water efficiency of a policy and design is translated into delivered performance is the space this study is filling, and it is where the review proposes a conceptual model of the relationship between water efficient strategies and the effective integration, moderated by the Pakistani context will exist.

### 2.7 Theoretical Framework

This review is presented with a conceptual underpinning that links two sets of literature. The first is green-construction and water-efficiency literature, which provides a listing of the technologies and design measures that can be used to reduce water demand in buildings, and the savings that can be realized (Kibert, 2016; World Green Building Council, 2024; Habibullah et al., 2023). The second is the sustainable project-management literature, which claims that environmental objectives can be achieved not only by technology, but by project management processes as well (Silvius & Schipper, 2014; Zhang & Wang, 2024). Combining the two literatures leads to one straightforward, but poorly explored, takeaway: Only water-efficient strategies are not enough. Affects only the water performance of a building when a delivery is managed to a project that has established a water requirement in a project management system that provides a link between a requirement and a delivered outcome, and the wider institutional context within which a project is delivered. This study poses that proposition as a conceptual research model consisting of four variables which are defined as follows.

***Independent variable — Water-efficient strategies.*** Proactive engineering and design strategies to minimize water consumption in green design practices such as rainwater harvesting, reusing greywater, water-efficient fixtures, leak detection and metering, and water use during the construction phase. These are the inputs that the review explores the impact of integration.

***Mediating variable — Project management processes.*** The water-efficiency requirement is specified, procured, delivered and verified in a structured project activity, including initiation, planning, execution, monitoring and control, and close-out. Project management is set as the mediation variable between water-efficient strategies and their effective incorporation, so it is the path that the independent variable takes to the dependent variable.

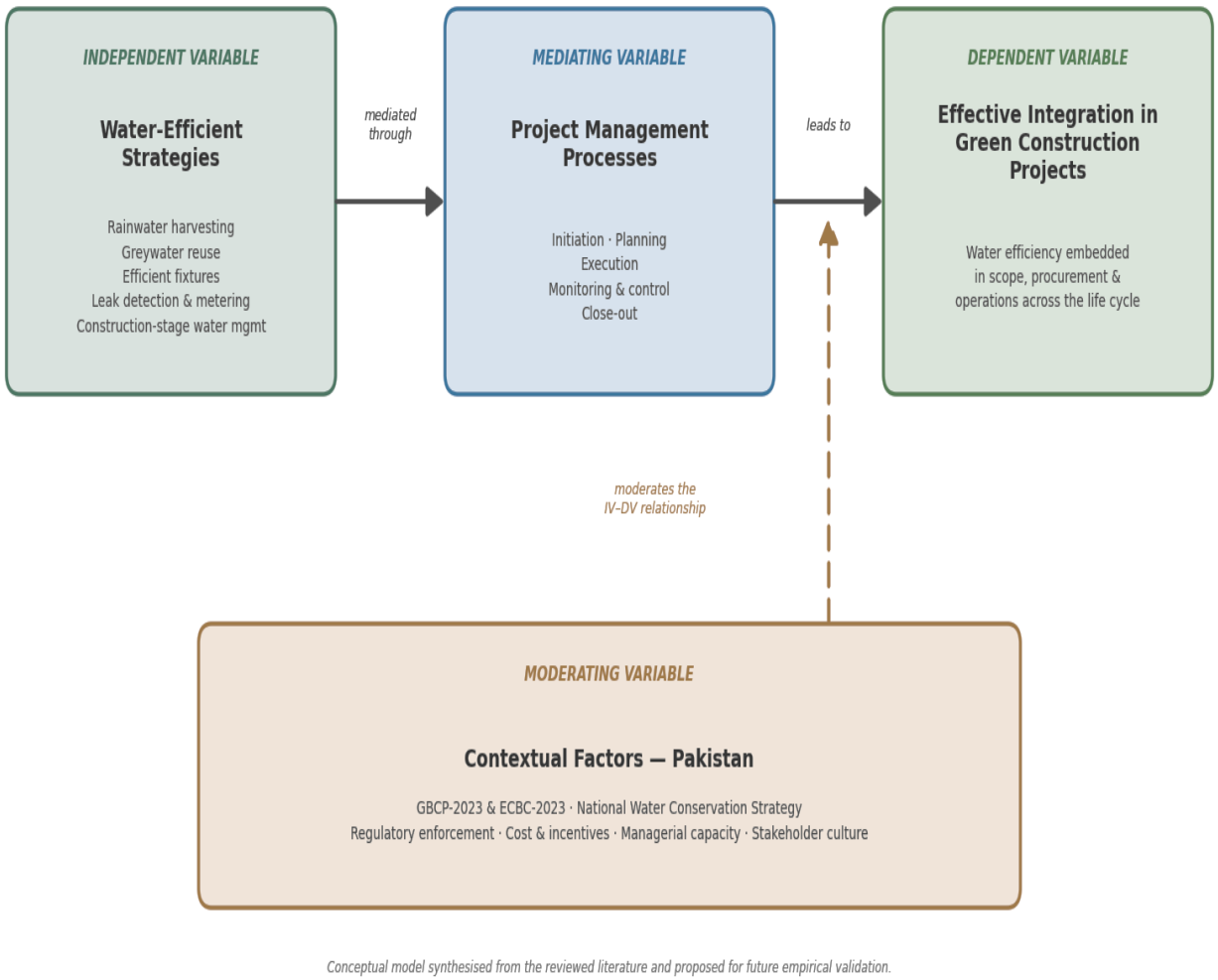
***Dependent variable — Effective integration of water-efficient strategies.*** The dependent variable is the ability to integrate water efficient strategies. The level of water efficiency consideration in scope, procurement, budget, quality control/quality assurance and operations (QCO) and as water performance at handover. This is what the review aims to clarify.

***Moderating variable — Pakistani contextual factors.*** The regulatory regime (GBCP-2023, ECBC-2023 and the National Water Conservation Strategy), enforcement, cost and incentive regime, managerial capacities and stakeholder culture. These conditions are not on the causal path, but they do amplify and/or weaken the connection between the water-efficient strategies and their effective incorporation.

The model is shown in figure 1. The independent variable and dependent variable are water-efficient strategies and the integration of these strategies in green construction projects, respectively, while the mediating variable is project management processes, and the moderating variable is the contextual factors of Pakistan. This model is presented as a conceptual formulation that summarizes the evidence reviewed here and as a framework for empirical investigation.

## Figure 1. Conceptual Research Model

Project management as the mediating variable between water-efficient strategies and effective integration




*Conceptual model synthesised from the reviewed literature and proposed for future empirical validation.*

**Figure 1.**

*Conceptual research model.* Water-efficient strategies (independent variable) influence the effective integration of water-efficient strategies in green construction projects (dependent variable) through project management processes (mediating variable). Pakistani contextual factors (moderating variable) strengthen or weaken the relationship. The model is synthesized from the reviewed literature and is proposed for future empirical validation.

The following thematic analysis is based on this model. It enables the review to distinguish between the technical effectiveness of a water efficient strategy, and the managerial conditions that are required to achieve that effective. It enables the review to identify the Pakistani evidence within each component of the relationship between the water efficient strategy and the managerial conditions required to make that strategy effective.

## 3. Methodology

### 3.1 Research design

This study is a qualitative systematic literature review (SLR), which follows the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) (Page et al., 2021). The SLR was selected due to research questions that focus on the current documented knowledge, rather than measuring new field data and building a conceptual model out of the evidence. The study does not gather primary data – the conceptual model presented in part 2 is recommended for empirical testing and any numerical values given below are taken from the reviewed literature.

### 3.2 Search strategy

The selected material (2015–2025) and key regulatory and policy documents from Pakistan issued during the same period were searched from four database, namely, Scopus, Web of Science, ScienceDirect and Google Scholar. The search strings included three sets of keywords such as water measures (water efficiency, rainwater harvesting, grey water use, water-efficient fixtures, water conservation), delivery context (green construction, green building, sustainable construction, project management) and geography (Pakistan, developing countries). Hand searching of reference lists was used to find references to the most relevant studies that had not been captured in the database searches.

### 3.3 Inclusion and exclusion criteria

The sources were included if they (a) were published in English in a peer-reviewed journal, or a government code, policy document or institutional report; (b) mentioned water efficiency, green construction or sustainable project management; and (c) were related to water-related issues in Pakistan or to similar developing country water contexts. Sources were also deleted where they only cover water resources that were not built, covered energy and/or carbon without water, or were opinion pieces and/or promotional materials without a clear evidential or documentary basis.

### 3.4 Screening and quality appraisal

287 records were found for this search. Duplicates were removed and 206 of the records were screened by title and abstract, from which 94 were progressed to full text assessment. There were 58 papers excluded at full text, due to not meeting all inclusion criteria, and 4 papers were excluded at quality appraisal due to the absence of establishing the basis for their claims. After this, 32 sources were left for thematic synthesis. The process is summarized in Table 1; the numbers in this table refer to this review.

Table 1. *PRISMA-aligned screening summary*

| Stage | Records |
|---|---|
| Records identified through database searches | 287 |
| Records after duplicate removal | 206 |
| Records screened (title–abstract) | 206 |
| Full-text articles assessed for eligibility | 94 |
| Studies excluded at full-text stage | 58 |
| Studies excluded at quality appraisal | 4 |
| Studies retained for thematic synthesis | 32 |

### 3.5 Data analysis

The retained corpus was analyzed thematically, following six steps as determined in the literature (Braun & Clarke, 2006) namely: (i) reading each source comprehensively and getting to know the content; (ii) coding extracts based on the research questions and the four variables of the conceptual model; (iii) grouping the codes into candidate themes; (iv) reviewing the themes with the coded extracts; (v) defining and naming the final themes; and (vi) writing the synthesis. All the elements of the water-efficient solution were captured (strategy), all the elements of the project management addressed (processes), all the elements of the regulations and contextual issues discussed (contextual factors), and all the elements of integration outcomes reported (integration outcomes). All sources were analyzed as sources, and a brief coding handout was provided to assure consistent coding of indicators. To enhance the trustworthiness of the data, a subsample of the sources was re-coded after a period and compared with the initial coding, the differences resolved against the manual.

## 4. Findings

The synthesis yielded five themes which mapped on to the conceptual model variables: water-efficient strategies most reported (independent variable); extent of integration early in project life cycle (dependent variable); barriers and enablers recurring across the evidence; and the moderating influence of regulation and context.

### 4.1 Reported water-efficient strategies and uneven adoption

The literature reviewed has shown that water efficient practices are playing a significant role in the development of sustainable green buildings, however their implementation in Pakistan is limited and sporadic. Rainwater harvesting and water efficient fixtures were the most mentioned strategies across the corpus, followed by greywater reuse, construction stage water management, and finally least mentioned was leak detection and metering, indicating a blinding point on operation. Tracking of case evidence from Lahore shows that rainwater catchment systems can contribute a significant portion of the non-potable demand when designed from the ground-up (Haider et al., 2024), while international research on the combined use of rainwater and grey water shows similar savings when both are planned from the beginning (Habibullah et al., 2023).

Operationally, the evidence is consistent that gains must be maintained in the long term. Leak detection and metering are essential to maintaining efficiency over the life of a building and keep water usage reductions hidden, undetected and unnoticed, while voluntary rating systems like WELL and LEED increasingly incorporate water-use reduction goals for indoor use that influence specification decisions for commercial buildings (International WELL Building Institute, 2024; US Green Building Council, 2024). What becomes clear is that the menu of strategies is well-known, that their technical effectiveness is not seriously challenged,

but that the challenges are downstream – in delivery.

**4.2 Integration concentrated early in the life cycle**

The evidence also captures the places where integration takes place...and does not take place. Water efficiency documents mentioned planning and design more frequently than execution, monitoring or close-out, indicating that the desire to be water efficient is more powerful in the planning and design phases and diminishes as a project goes to construction and hand-over. There is evidence to support this reading, as the lifecycle water use of a residential building is to a large degree determined at the design and planning phase and hence the decisions made in this phase are far more important than the drift away from them in the later part of the lifecycle (Bukhari et al., 2024). Effective integration is therefore not an event, much more it is a chain which needs to be maintained throughout the whole process; and the literature suggests that it tends to come undone at the design stage.

**4.3 Project-management capacity as the mediating mechanism**

The third most significant theme is the mediating effect of project management. Structured planning clearly assigned responsibility and active monitoring were reported to support stronger and better-sustained water-efficiency outcomes – whereas weak and informal management were reported to support poor on-site adoption, regardless of technology. This aligns with the general sustainable project-management literature, which has shown that sustainability goals are more effectively delivered when they are embedded in scope, procurement, quality-control activities, as opposed to being add-ons (Silvius & Schipper, 2014; Zhang & Wang, 2024; Akadiri & Olomolaiye, 2023), and with evidence from developing economies that the maturity of project-management practices (defined roles, gateways and monitoring routines) is a better predictor of sustainable project-management outcomes than are the technologies specified (Raza et al., 2025).

The point is further supported by the studies in Pakistan. Amongst the reported challenges in implementing green intentions into delivered performance are weak stakeholder coordination and fragmented responsibilities (Khan & Ali, 2023; Hussain et al., 2024), while inadequate technical capacity of contractors, and the lack of measurable water targets on site, are reported as significant challenges at the contractor level (Memon & Rahman, 2023). Structured delivery and digital tools are found to be related to the sustainability integration outcomes, with positive evidence supporting the use of more mature project management practices, such as BIM-based coordination (Sajjad et al., 2024; Usman et al., 2025; Alghuried et al., 2025). The evidence supports the main tenet of this model: project management is a mediating variable between water-efficient strategies and their successful integration; the strategies are the independent variable, and the managerial chain is the dependent variable.

**4.4 Regulation and context as the moderate influence**

The fourth theme has to do with the moderating variable. The literature has always identified limited enforcement, low managerial capacity and lack of measurable water targets in scope and procurement documents at project level as factors that hinder water efficiency (Mehmood et al., 2025; International Code Council, 2024; NEECA, 2023; PCRWR, 2023). In essence, the codes are there; institutional machinery is lacking in transferring them onto sites. Institutional commitments, as for example spelt out in national strategy and international engagement (UN-Habitat, 2024), are intended to give direction, but the evidence suggests that the distance from policy to practice has a positive or negative impact on the relationship between the strategy and integration whether or not there are evidence of enforcement, incentives, and capacity in a specific project context.

**4.5 Recurring barriers and enablers**

A last theme brings together conditions that literature repeatedly identifies to be supporting

and/or un-supporting integration. Barrier side, the evidence suggests that economic concerns, like that of higher upfront cost, as well as institutional weaknesses in enforcement, limited capacity of contractors, immaturity of local supply chains for some efficient products, and socio-cultural inertia linked to new technologies, all contribute to the barriers to implementing these technologies (Hussain et al., 2024; Memon & Rahman, 2023; Mehmood et al., 2025). On the enabling side, the recurring factors are the recurring factors of clients' demand, structured practice of project-management, clarity in signals given by the regulatory framework, accompanied by enforcement, and targeted incentives. These barriers and enablers work through the mediator of the Pakistani context – i.e. they are the reality of the Pakistani context that makes well-specified strategies happen or not.

## 5. Discussion

### 5.1 An integrated model for water-efficient project management

The five themes support the model for integration presented in Section 2. The idea of water efficient technologies (the independent variable) achieving their predicted savings depends on the demand being embedded in the scope and brief at project initiation, being clearly defined and recorded in procurement and being enforced during project execution, being monitored and recorded during commissioning, and being checked and verified upon handover (the mediating variable), and being supported by, and not undermined by, the Pakistani contextual conditions (the moderating variable). The model, which is reflected in the Pakistani literature, can help explain why using water-efficient technology and, in fact, saving water are not the same. If the managerial chain is there, and the context is optimistic, both go together, and when the chain is broken — usually during execution and monitoring — technically sound strategies fail to deliver their performance.

### 5.2 Policy implications for Pakistan

Several implications follow. First, the water-efficiency requirements of the GBCP-2023 and ECBC-2023 would be more influential if they were to be approved and checked in conjunction with, and not in parallel to, these codes. Second, embed the water-efficiency requirements within public procurement, and provide a measurable target, not a general statement of intent. Third, incentives that specifically reward water efficient projects (e.g., rebates) may help to offset the suggested barrier of higher upfront cost. All these interventions target the moderating factor: none are technological and all target and strengthen the context in which project management works.

### 5.3 Lessons for project management practice

There are lessons for both the professions as well. Water performance requires an owner: In the project team, they are the person who is accountable for water-efficiency outcomes throughout the full life cycle of the project and ensures accountability doesn't end after design. It should also be measurable, by means of a meter, leak detection and commissioning tests, which verify on site what was written in the specification. And it must have capacity, because the evidence consistently points to a lack of technical knowledge among both contractors and supervisors as a constraint – and training on water-efficient design and construction is low cost.

### 5.4 Limitations

This review is subject to limitations. The conclusions drawn in this report are limited to the quality and breadth of available records and, in particular, the conditions of water use in the construction sector in Pakistan are not well established—some of the quantitative estimates are based on international evidence and should be interpreted as illustrative rather than as evidence of the use of water in this country. Only English language literature was searched and not necessarily all Urdu or regional literature. The conceptual model is suggested but not empirically estimated and the screening counts given in Section 3 are merely for this screening. Lastly, with the regular changes in water and building code policy in Pakistan, there is a possibility for some changes from submission to publication, and the review was not pre-registered — which is a known shortcoming of SLRs.

## 6. Conclusion & Recommendations

While the use of green construction techniques is certainly a viable way to help solve Pakistan's water problems, as noted in this discussion, this is not just about technology, but it is about management also. The evidence reviewed suggests that potable water savings of approximately 30–50 per cent can be achieved through the use of water-efficient strategies in buildings, where they are effectively implemented and, where necessary, monitored and handed over, but such savings are often lost when the water-efficient strategies are limited to the design stage. The mediating variable is project management: with planning organized, responsibilities clear and performance monitored, water efficiency is achieved and maintained – without it, even finely-stripped plans fail to perform as well. The regulatory and institutional environment of Pakistan (moderating variable) affects the strength of that relationship.

The policy–practice gap, therefore, will require new technology and more managerial and institutional change; measurable water targets in scope and procurement; clear accountability; increased monitoring and commissioning; connection to the building codes; and capacity building in project teams. The next most useful step to be taken with regard to water-smart building as a phenomenon is empirical; a survey of project managers from across Pakistan's climate zones, and a series of primary case studies, would enable the conceptual model proposed here to be tested, and would allow the possibility of localizing the estimates of water use to the local context, making water-usage a national water policy issue instead of a niche one.

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