Sakhardande, N., Karve, S., Anagal, V., Garud, A., Manewa, A. and Siriwardena, M., 2025. From policy presence to enforceability: Evaluating water circularity in the Indian construction frameworks. In: Waidyasekara, K.G.A.S., Jayasena, H.S., Wimalaratne, P.L.I. and Tennakoon, G.A. (eds). *Proceedings of the 13th World Construction Symposium*, 15-16 August 2025, Sri Lanka. pp. 758-772. DOI: https://doi.org/10.31705/WCS.2025.57. Available from: https://ciobwcs.com/papers/

# FROM POLICY PRESENCE TO ENFORCEABILITY: EVALUATING WATER CIRCULARITY IN THE INDIAN CONSTRUCTION FRAMEWORKS

**N. Sakhardande[1], S. Karve[2], V. Anagal[3], A. Garud[4], A. Manewa[5] and M. Siriwardena[6]**

## *ABSTRACT*

*With increasing water scarcity and accelerating urbanization in India, embedding circular water practices within the construction sector has become a critical imperative. This study undertakes a comprehensive evaluation of how Indian policies, standards, regulations, and green certifications address principles of water reuse and circularity across the building lifecycle. Using a structured assessment framework centred on eight key Construction Water Principles (CWPs) —such as water demand reduction, greywater reuse, rainwater harvesting, and lifecycle-based water planning—the research assesses each document based on three parameters: Presence (whether a principle is acknowledged), Strength (the technical clarity and detail), and Enforceability (the existence of legal and institutional mechanisms). These parameters are scored on a standardized scale to allow comparative analysis. The findings indicate that while several national frameworks exhibit strong recognition and moderate technical guidance, there is a consistent shortfall in legal enforceability and accountability. Critical gaps persist in areas such as dual plumbing mandates, construction-phase reuse, and integrated infrastructure planning. The study demonstrates that policies often remain symbolic in nature, with limited translation into implementable actions. To address these issues, the research proposes a replicable and scalable evaluation model that can help policymakers, regulatory bodies, and practitioners diagnose gaps and align regulatory instruments with circular water goals. Ultimately, the framework aims to shift focus from policy recognition to practical execution, advancing water sustainability in India's construction ecosystem.*

**Keywords:** *Building Construction; Policy Evaluation; Regulatory Gaps; Sustainable Construction; Water Circularity.*

## 1. INTRODUCTION

Water is a finite and indispensable resource, and less than 1% of the Earth's freshwater is accessible for human use (World Green Building Council, 2023). The intensifying

[1] Student, M.Arch (EA) II, Dr. B. N. College of Architecture for Women, India, nishigandha.sakhardande@bnca.ac.in
[2] Professor, Dr. B. N. College of Architecture for Women, India, sujata.karve@bnca.ac.in
[3] Associate Professor, Dr. B. N. College of Architecture for Women, India, vaishali.anagal@bnca.ac.in
[4] Assistant Professor, Dr. B. N. College of Architecture for Women, India, amruta.garud@bnca.ac.in
[5] Senior Lecturer, Liverpool John Moores University, Liverpool, UK, R.M.Manewa@ljmu.ac.uk
[6] Senior Lecturer, Liverpool John Moores University, Liverpool, UK, M.L.Siriwardena@ljmu.ac.uk

global water crisis has led to an urgent rethinking of water use strategies, especially in the construction sector where water demand is significant and recurrent across all project stages. As cities grow and climate change intensifies, the imperative to shift from linear water use models to circular approaches has become paramount (United Nations, 2018). Water circularity refers to the design and operation of water systems that minimize extraction, maximize reuse, and close the loop on wastewater streams. In the context of the built environment, this includes strategies such as greywater and blackwater reuse, rainwater harvesting, demand reduction, dual plumbing, and lifecycle-based water planning. Globally and in India, several policies, codes, standards, guidelines, and certification frameworks attempt to address these themes. However, there exists a notable lack of cohesion, consistency, and enforceability in how water circularity principles are integrated across these instruments.

The construction industry accounts for roughly 15% of global freshwater withdrawals (World Green Building Council, 2023), yet water circularity in the built environment remains largely overlooked in policy and practice, particularly in India. The Indian building and construction sector is governed by a fragmented mesh of documents ranging from national codes (e.g., IS standards, National Building Code), environmental regulations (e.g., EIA Notification), sectoral guidelines (e.g., CPCB/SPCB), and voluntary certifications (e.g., GRIHA, IGBC, LEED India). Internationally, frameworks such as LEED USA, BREEAM (UK), Green Star (Australia), CASBEE (Japan), and regulatory initiatives like Israel's Water Efficiency Law or Singapore's ABC Waters Programme have attempted to embed circularity. Yet, despite the presence of multiple instruments, the sector still lacks a systematic, comparative evaluation framework to assess how comprehensively and effectively water reuse and circularity principles are being addressed. Without a structured tool to diagnose and compare the strengths and gaps across these diverse frameworks, policymakers, practitioners, and researchers are left with fragmented insights and limited strategic direction.

To address this need, this study proposes a structured evaluation methodology based on a triadic framework of Presence, Strength, and Enforceability (P-S-E), applied to eight carefully chosen Construction Water Principles (CWPs). These CWPs reflect the most critical domains within the circular water paradigm applicable to the built environment: water demand reduction, greywater and blackwater reuse, rainwater harvesting and recharge, construction-phase water circularity, dual plumbing and infrastructure integration, reuse-ready storage systems, water quality for safe reuse, and lifecycle-based water planning. The triadic lens helps capture three key dimensions: whether a principle is recognized (Presence), how technically robust the articulation is (Strength), and whether it is supported by legal or institutional enforcement mechanisms (Enforceability). Each dimension is scored from 0 to 3, offering a quantifiable yet nuanced view of each document's performance.

## 2. LITERATURE REVIEW

The integration of water circularity into policy frameworks is a relatively recent yet expanding field of research. Traditionally, water governance studies have focused on supply-side management and centralized infrastructure planning (Gleick, 1998). However, the global shift towards sustainable urban development and the limitations of conventional water systems have prompted a growing body of literature emphasizing decentralization, resource recovery, and reuse (United Nations Environment Programme - UNEP, 2016). Circular water strategies in buildings offer multiple benefits: reducing dependence on freshwater sources, minimizing wastewater discharge, and enhancing resilience against climate-induced water stress (Dobbs et.al., 2011). Nonetheless, the success of these strategies depends largely on the supporting regulatory and policy environment, a theme echoed across environmental governance literature (Ostrom, 2009).

Policy effectiveness in environmental domains is often evaluated using multidimensional frameworks. Howlett and Cashore (2009) argue that "policy content" is the foundational layer in evaluating a policy's capacity and intent. Without formal recognition of a principle, it remains outside the sphere of policy attention. In this context, the Presence parameter in this study ensures that circular water principles are at least acknowledged in the regulatory narrative (TERI University, 2017). Similarly, the technical robustness or Strength of a provision determines whether it can be operationalized. Ostrom (2009) and Rogers et al. (2000) emphasize that clearly defined and measurable policy directives are essential for effective implementation and accountability. Vague or symbolic references fail to drive institutional change or influence design and construction practices.

Enforceability, the third pillar, is often the weakest link in policy frameworks, especially in the Global South. The United Nations Environment Programme – UNEP (2019) report on Environmental Rule of Law identifies poor enforcement as a major challenge, even where policies exist on paper. The Organisation for Economic Co-operation and Development (2020) adds that monitoring capacity and legal clarity are crucial to achieving environmental outcomes. Cashore et al. (2004) distinguish between voluntary and mandatory regimes, highlighting that enforceable standards are more likely to produce tangible results. In the domain of green building, global certifications like LEED, BREEAM, and Green Star incorporate enforcement indirectly—through third-party verification, performance tracking, and credit-based incentives. However, regulatory codes often lack such operational tools, especially in India where implementation mechanisms vary across states and municipalities.

Several studies have attempted to assess water-related policies, but most adopt qualitative or thematic analysis. For instance, studies evaluating the EIA Notification (2006) or National Building Code (2016) focus on policy gaps or sectoral limitations. Others explore the alignment of green certifications with sustainability goals. Yet, there is little consensus on a unified assessment method. This study's P-S-E framework builds on existing approaches used in policy content analysis (Scholz & Wang, 2006) and Regulatory Impact Assessment (RIA) tools by OECD and the European Union. These frameworks underscore the need to evaluate not just the existence of a regulation, but also its clarity and enforceability. The P-S-E methodology distils these insights into a concise, replicable tool specifically tailored for water circularity.

The choice of eight CWPs is based on a synthesis of contemporary literature and best practices in sustainable water management. In a CE, water is treated as a closed-loop resource, meaning it can be reused and recycled within the system (Bouziotas et al., 2023). Municipal sources are already strained, borewell extraction accelerates aquifer depletion, and tankers often rely on informal or illegal extraction, undermining local water equity (World Bank, 2016). Water flow in building construction can be made more sustainable by integrating systems that recycle greywater, harvest rainwater, and reuse treated wastewater for non-potable purposes (Gonzalez et al., 2021). By adopting innovative technologies and integrating water recycling, the construction sector can play a significant role in mitigating water scarcity and environmental degradation (Frijns et al., 2024). Water demand reduction is universally acknowledged as a first step in conservation (Gleick, 1998). Greywater and blackwater reuse are gaining momentum, especially in water-stressed regions, supported by case studies from Singapore, Israel, and California (World Bank, 2016). Rainwater harvesting and recharge have been mandated in several Indian states, yet implementation remains uneven. Construction-phase water use is often ignored, although it constitutes a significant share of project-stage consumption. Infrastructure provisions such as dual plumbing and reuse-ready storage are prerequisites for enabling future reuse, aligning with lifecycle-based planning perspectives advocated in Integrated Water Resource Management frameworks (Global Water Partnership Technical, 2000).

The integration of water quality standards is essential for safe reuse, yet in India, guidelines like IS 3025 and CPCB norms often remain non-binding. Lifecycle-based planning, a core tenet of circular economy thinking, is largely absent in conventional water codes. This fragmented landscape demands an evaluation tool that can holistically assess how policies, standards, and certifications address each of these principles. By combining thematic relevance (CWPs) with policy analysis parameters (P-S-E), the framework proposed in this study seeks to fill this methodological gap. It enables cross-comparative analysis between Indian and global instruments, identifying patterns, strengths, and lacunae.

In conclusion, there is a critical need for a structured, evidence-based evaluation method to know how well water reuse and circularity principles are embedded in the regulatory ecosystem of the construction sector (Ministry of Environment & Forests, Government of India, 2010). As water scarcity becomes a central challenge for cities and buildings alike, the ability to diagnose policy gaps and recommend strategic reforms is more important than ever. The P-S-E evaluation method, aligned with eight CWPs, offers a promising methodology to achieve this goal. It is grounded in established literature on policy analysis, environmental governance, and sustainability metrics. Moreover, it provides practical utility for researchers, policymakers, and green building professionals aiming to advance water circularity in both Indian and global contexts.

## 3. METHODOLOGY

This study employs a structured, criteria-based evaluation framework to assess the comprehensiveness and effectiveness of water-related policies, standards, codes, and certifications that influence the construction and operation phases of buildings. The methodology is grounded in eight CWPs derived from key dimensions of sustainable and circular water management. These principles were selected based on international best practices, Indian green building standards, and interdisciplinary literature on IWRM, environmental governance, and circular economy transitions (Rogers et al., 2000; United Nations Environment Programme - UNEP, 2019; Ellen MacArthur Foundation, 2017).

### 3.1 SELECTION OF CWPS

The eight CWPs used for evaluation reflect both conventional and advanced water circularity strategies applicable to the built environment, as illustrated in Figure 1. These principles were developed after an extensive review of international frameworks such as UNEP's Circularity in Water Management (United Nations Environment Programme - UNEP, 2016), the EU Circular Economy Action Plan, and sustainability rating systems like LEED v4.1, BREEAM, Green Star, and Singapore's ABC Waters Programme. Additional inputs were drawn from scholarly research on urban water circularity, lifecycle-based infrastructure planning, and decentralized reuse systems.

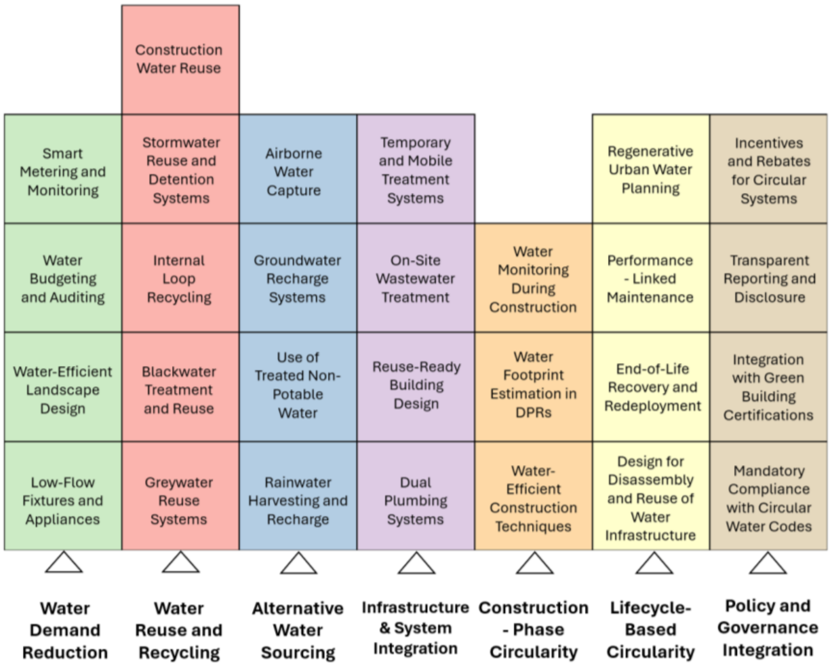


*Figure 1: Circular water principles in the built environment*
*Source: Author*

The formulation of these principles was guided by the need to evaluate not just water-use efficiency but also systemic infrastructure readiness, regulatory alignment, and construction-phase circularity—elements often overlooked in conventional water frameworks. The resulting eight CWPs include:

1. Water Demand Reduction – minimization of water consumption through design, fixtures, and behaviour change mechanisms.
2. Greywater & Blackwater Reuse – collection, treatment, and reuse of wastewater streams for non-potable or landscape applications.
3. Rainwater Harvesting & Recharge – on-site storage and infiltration systems to reduce runoff and augment groundwater.
4. Construction-Phase Water Circularity – strategies for water reuse, treatment, and management during the construction process.
5. Dual Plumbing & Infrastructure Integration – provision of parallel pipelines for potable and non-potable water flows to enable reuse.
6. Reuse-Ready Storage Systems – built infrastructure (e.g., tanks, reservoirs) that supports future water reuse scalability.
7. Water Quality for Safe Reuse – specification of quality parameters, treatment thresholds, and health safety for reused water.
8. Lifecycle-Based Water Planning – long-term, integrated planning of water systems across the building's lifecycle, including adaptive strategies for climate resilience.

These CWPs were curated to span both end-use efficiency and upstream planning and governance, thereby offering a comprehensive framework to evaluate Indian policies on water circularity. Full mapping of documents against these principles is detailed in subsequent sections, while justification tables are provided in the Annexure.

### 3.2 EVALUATION DIMENSIONS: PRESENCE, STRENGTH AND ENFORCEABILITY

Each document, be it a regulation, code, standard, or voluntary certification, was assessed across the eight CWPs using three evaluation dimensions:

1. Presence (P): Whether a particular principle is mentioned, recognized, or acknowledged in the document.
2. Strength (S): The technical clarity and depth of guidance provided, including any quantitative standards or engineering protocols.
3. Enforceability (E): The legal authority, mechanisms for compliance, and extent to which non-adherence is subject to monitoring or penalties.

These evaluation dimensions—Presence, Strength, and Enforceability (P–S–E)—were chosen based on well-established policy assessment models, such as the Regulatory Impact Assessment (Organisation for Economic Co-operation and Development, 2009), Scholz and Wang's (2006) policy content analysis frameworks, and environmental certification criteria used in LEED, BREEAM, and Green Star. Together, these dimensions offer a multidimensional lens for evaluating regulatory instruments, one that balances conceptual acknowledgment (Presence), technical specificity (Strength), and implementation potential (Enforceability). This approach is especially suited to the evaluation of environmental policy instruments, which must be assessed not just on their intent but on their depth and likelihood of real-world impact (Cashore et al., 2004; Howlett & Cashore, 2009).

### 3.3 SCORING FRAMEWORK

Each policy or standard was scored on a 0 to 3 scale for each of the three evaluation dimensions across all eight CWPs, with a total of 24 scores per document. The scoring scale is interpreted in Table 1 given below.

*Table 1: Score interpretation of the dimensions for CWP evaluation*

| No. | Dimension | Score | Score interpretation |
|---|---|---|---|
| 1. | Presence (P) | 0 | Not Addressed |
| | | 1 | Weakly or Implicitly Addressed |
| | | 2 | Moderately Addressed with Some Specific Guidelines |
| | | 3 | Clearly and Explicitly Addressed with Detailed Guidelines |
| 2. | Strength (S) | 0 | Weak or Not Specified |
| | | 1 | Weakly Mentioned or Suggestive |
| | | 2 | Moderately Strong with Some Technical Detail |
| | | 3 | Technically Strong and Detailed |
| 3. | Enforceability (E) | 0 | Not Enforceable (no legal backing or monitoring) |
| | | 1 | Weakly Enforceable (voluntary or advisory only) |
| | | 2 | Moderately Enforceable (some legal basis, limited enforcement) |
| | | 3 | Strongly Enforceable (legally mandated with monitoring, penalties) |

This quantitative rubric facilitates comparability across heterogeneous instruments—ranging from mandatory national codes like the National Building Code (NBC 2016) to voluntary certifications like GRIHA or LEED India, as well as operational guidelines from CPWD, CPCB, and various State-level DCRs and ULB policies.

Building on the evaluation dimensions discussed above, the study adopts a structured P–S–E scoring framework to enable systematic comparison across policy documents. This framework is grounded in established literature on policy evaluation and regulatory governance. It draws directly from the OECD's Regulatory Impact Assessment (RIA), which emphasizes the need to assess policy content for coverage, technical detail, and institutional enforceability (Organisation for Economic Co-operation and Development, 2009).

The tripartite structure is also aligned with Scholz and Wang's (2006) framework that distinguishes between the existence of a policy, its technical substance, and its administrative credibility. Furthermore, this scoring method reflects practice-oriented evaluation models embedded in green building certifications such as LEED, BREEAM, and Green Star, where criteria are scored based on presence, quality of guidance, and compliance assurance. Theoretical reinforcement comes from governance scholars like Cashore et al. (2004) and Howlett and Cashore (2009), who argue for integrated assessment of policy instruments based on content, capacity, and legitimacy.

Recent contributions in the urban water governance literature also support this approach, suggesting that the success of circular water frameworks depends not only on innovation in design but on enforceability, institutional alignment, and implementation tracking.

### 3.4 DATASET SELECTION

The documents selected for evaluation were categorized into Indian and global instruments. The Indian set includes five categories: (1) National Policies and Frameworks such as the National Water Policy (2012) and EIA Notification (2006); (2) BIS Standards and Codes like IS 456:2000, IS 1172:1993, and NBC 2016; (3) Regulatory Guidelines including those issued by the CPCB, SPCBs, and the CPWD Manual; (4) Local Government Instruments such as Urban Local Body (ULB) policies and Development Control Regulations (DCRs); and (5) Voluntary Green Building Certifications including GRIHA, IGBC, and LEED-India. These documents together represent the multi-tiered regulatory landscape shaping water-related decision-making in the Indian construction sector.

The global set includes instruments like LEED (USA), BREEAM (UK), Green Star (Australia), BEAM Plus (Hong Kong), CASBEE (Japan), ABC Waters (Singapore), and Israel's water reuse policy framework. These were selected based on their prominence in sustainability literature, adoption in urban water resilience case studies, or citation in global water governance reports (World Bank, 2016; United Nations-Habitat, 2020).

### 3.5 DATA COLLECTION AND CODING

Each policy and regulatory document was independently reviewed and scored by two researchers with expertise in sustainable construction, urban water systems, and Indian regulatory frameworks. They were selected for their familiarity with both technical standards and institutional contexts. In developing the coding framework, a broader panel of experts—including green building professionals, urban planners, and legal scholars—were consulted through interviews and informal feedback. While their insights helped refine the Circular Water Principles (CWPs) and scoring rubric, the two lead researchers conducted the primary scoring due to their overarching understanding and consistency.

Documents were evaluated across three dimensions—Presence, Strength, and Enforceability (P–S–E)—for each of the eight CWPs. Scores were based on explicit references, inclusion of technical details, and the use of compliance-oriented language (e.g., “shall,” “must”). A detailed coding guideline was developed, piloted on a sample of policies, and refined before full application to ensure consistency.

Discrepancies in scoring were infrequent but typically arose in the Strength and Enforceability dimensions. For instance, a performance target without technical depth could be interpreted differently depending on emphasis. Similarly, unclear implementation mechanisms (e.g., in state DCRs) led to varied enforcement scores. These differences were resolved through iterative discussions referencing the rubric and comparable examples until consensus was reached.

To enhance transparency, a justification matrix was created for each score assigned. These justifications are document-specific and based on direct textual evidence, technical annexures, and regulatory phrasing. For example, a Strength score of “2” was only given if a document showed moderate but incomplete technical detail related to a specific CWP.

While summary heatmaps are presented in the main text (Figures 2 and 3), the full justification tables are available in the Annexure. This enables readers to trace the reasoning behind each score and supports replicability of the method. The approach balances comparative synthesis with analytical depth, ensuring that the scoring process remains robust, transparent, and grounded in documented evidence.

### 3.6 ANALYSIS APPROACH

The scores were then aggregated and visualized using matrix heatmaps and comparative tables. Descriptive statistics (averages, standard deviations) were calculated for each CWP across all documents. Cross-sectional comparisons were conducted between Indian and global frameworks to highlight strengths, gaps, and opportunities for policy transfer or harmonization.

Special attention was paid to patterns of low Presence but high Strength or Enforceability (indicating niche technical interventions not widely mainstreamed), high Presence but low Enforceability (indicative of symbolic policy with limited follow-through), and consistently low scores across all dimensions for a principle (signalling critical lacunas).

This enabled both a horizontal evaluation (within a document across all CWPs) and a vertical evaluation (for a single CWP across all documents).

### 3.7 LIMITATIONS AND SCOPE

This evaluation is limited to textual policy analysis and does not assess on-ground implementation or stakeholder perceptions. Furthermore, the enforceability dimension is inferred from legal phrasing and mandates but does not include field verification or implementation of enforcement practices.

Nevertheless, this structured P-S-E scoring model allows for systematic benchmarking and policy diagnosis. It serves both as a comparative tool and as a basis for future work on policy enhancement, especially as circular water practices gain traction under climate resilience and urban sustainability agendas.

# 4. RESULTS AND FINDINGS

## 4.1 PATTERN ANALYSIS OF INDIAN POLICIES, REGULATIONS, STANDARDS AND CERTIFICATIONS FOR CWP IN CONSTRUCTION

In the real-world implementation of circular water practices in the Indian construction sector, it is essential to dissect the scope, strengths, and gaps in existing regulatory frameworks and institutional actors. The extended analysis below evaluates major national codes, standards, and policy instruments—against key Circular Water Principles (CWPs). The following Table 2 is essential as it maps the alignment of key Indian policies and regulations with each of the eight CWPs, offering a snapshot of the current policy landscape. It highlights both the areas of regulatory endorsement and the gaps in comprehensive adoption, helping to justify the need for a structured assessment framework that can evaluate presence, strength, and enforceability across these principles.

*Table 2: Alignment of key Indian policies and regulations with eight CWPs*

| No. | CWP Principle | Indian Policies and Regulations Endorsing It |
|---|---|---|
| 1 | Water Demand Reduction | NBC 2016, IS 456, EIA, GRIHA/IGBC, CPCB (guidance) |
| 2 | Greywater & Blackwater Reuse | NBC 2016, IS 456, EIA, GRIHA, CPCB, SPCBs |
| 3 | Rainwater Harvesting & Recharge | NBC, National Water Policy, GRIHA/IGBC, DCRs, ULBs, EIA, CPCB |
| 4 | Construction-Phase Water Circularity | IS 456 (partial), EIA (partial), CPCB (stronger), GRIHA (partial), SPCBs (compliance) |
| 5 | Dual Plumbing & Infra Integration | NBC 2016, GRIHA, DCRs, EIA |
| 6 | Reuse-Ready Storage Systems | IS 3370, NBC, CPCB (partial) |
| 7 | Water Quality for Reuse | IS 3025, IS 456, CPCB |
| 8 | Lifecycle-Based Water Planning | GRIHA, LEED, EIA, CPCB (early-stage C&D water reuse pilots) |

By comparing principles horizontally across policies, it becomes easier to pinpoint patterns of redundancy, fragmentation, and policy silence. For example, while rainwater harvesting is consistently addressed, construction-phase water reuse is frequently neglected across otherwise progressive codes. The mapping thus acts as both a compliance checklist and a policy integration matrix, offering a strategic view of the degree to which water circularity has been embedded—or omitted—within India's building and urban regulatory frameworks, as seen in Figure 2. This structured comparison lays the groundwork for identifying not just individual document gaps, but system-level misalignments in policy intent versus execution.

An analysis of Indian regulations reveals a mixed pattern in the integration of CWPs. On the positive side, green building rating systems such as GRIHA, IGBC, and LEED India, along with the EIA Notification (2006), consistently score high in both Presence and Strength. These frameworks provide detailed, technically sound provisions on aspects like water reuse, rainwater harvesting, and demand reduction. Similarly, guidelines issued by the Central Pollution Control Board (CPCB) and various State Pollution Control Boards (SPCBs) show stronger enforceability—particularly in areas related to wastewater reuse and quality standards—indicating a relatively robust regulatory mechanism for environmental water management.

| CW Principle | Water Demand Reduction | | | Greywater & Blackwater Reuse | | | Rainwater Harvesting & Recharge | | | Construction-Phase Water Circularity | | | Dual Plumbing & Infrastructure Integration | | | Reuse-Ready Storage Systems | | | Water Quality for Safe Reuse | | | Lifecycle-Based Water Planning | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E |
| National Water Policy (2012) | 2 | 2 | 0 | 2 | 1 | 0 | 3 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 0 |
| NBC 2016 | 3 | 3 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| IS 456:2000 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IS 3370:2009 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IS 2065:1983 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IS 1172:1993 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IS 3025 Series | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 0 | 0 | 0 |
| CPWD Manual | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| GRIHA/ IGBC/ LEED -India | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 |
| EIA Notification (2006) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| DCRs (State-wise) | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| ULB Policies | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| CPCB Guidelines | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 3 | 3 | 1 | 1 | 1 |
| SPCBs Guidelines | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 2 | 2 | 1 | 1 | 1 |

| Legend | Presence Score (P): | Strength Score (S): | Enforceability Score (E): |
|---|---|---|---|
| | 0 = Not Addressed | 0 = Weak or Not Specified | 0 = Not Enforceable (no legal backing or monitoring) |
| | 1 = Weakly or Implicitly Addressed | 1 = Weakly Mentioned or Suggestive | 1 = Weakly Enforceable (voluntary or advisory only) |
| | 2 = Moderately Addressed with Some Specific Guidelines | 2 = Moderately Strong with Some Technical Detail | 2 = Moderately Enforceable (some legal basis, limited enforcement) |
| | 3 = Clearly and Explicitly Addressed with Detailed Guidelines | 3 = Technically Strong and Detailed | 3 = Strongly Enforceable (legally mandated with monitoring, penalties) |

*Figure 2: Matrix mapping for Indian policies and regulations against eight CWPs based on Presence, Strength and Enforceability*
*Source: Author*

However, substantial gaps are evident. Many Bureau of Indian Standards (BIS) codes, such as IS 456, IS 3370, IS 2065, IS 1172, and IS 3025, suffer from low enforceability scores (mostly 0s and 1s), suggesting that these standards, while occasionally technically sound, lack binding mechanisms for implementation. Further, for more advanced water practices such as reuse-ready storage systems and dual plumbing infrastructure, both Presence and Strength are typically minimal or absent. These topics often score between 0 and 1, indicating a lack of recognition or technical guidance. Local-level policies, such as those formulated by Urban Local Bodies (ULBs) and embedded in Development Control Regulations (DCRs), show poor and inconsistent enforcement, with scores in the 0–1 range, pointing to significant decentralization and governance challenges in implementation.

## 4.2 PATTERN ANALYSIS OF GLOBAL BEST PRACTICES FOR CWP IN CONSTRUCTION

Globally, several leading policies and certification frameworks have mainstreamed CWPs as integral components of sustainable development in the built environment. These frameworks go beyond traditional water efficiency to incorporate closed-loop systems, lifecycle reuse, and infrastructure-level resilience. Green building certifications and national initiatives exemplify how CWPs are translated into enforceable design and operational strategies. These systems provide detailed technical guidance, mandatory performance metrics, and post-occupancy accountability, setting a high benchmark for water circularity in urban construction. The comparative Figure 3 outlines the key features of each framework that align with CWPs and illustrates the scope and ambition with which global best practices address water reuse, rainwater harvesting, stormwater management, and non-potable water infrastructure. This sets a reference point for evaluating the relative maturity and implementation potential of India's evolving regulatory ecosystem.

When compared to Indian counterparts, global policies and standards show much stronger integration of CWPs across the board. International certification systems such as LEED (USA), BREEAM (UK), Green Star (Australia), BEAM Plus (Hong Kong), and CASBEE (Japan) demonstrate consistently high scores in both Presence and Strength, typically ranging between 2 and 3. These systems incorporate comprehensive checklists, performance criteria, and technical detailing, ensuring that water-related design strategies are thoroughly embedded into the building lifecycle.

| CW Principle | Water Demand Reduction | | | Grey/ Blackwater Reuse | | | Rainwater Harvesting | | | Construction Phase Reuse | | | Dual Plumbing Readiness | | | Reuse-Ready Storage Systems | | | Water Quality for Safe Reuse | | | Lifecycle-Based Water Planning | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E | P | S | E |
| LEED v4.1 (USA) | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 1 | 1 | 0 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 1 | 3 | 3 | 1 |
| BREEAM (UK) | 3 | 3 | 1 | 2 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 0 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 1 | 3 | 3 | 1 |
| EU Circular Economy Plan | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 2 | 3 | 3 | 2 |
| ABC Waters (Singapore) | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Israel Water Policy | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sponge City Program (China) | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| BEAM Plus (Hong Kong) | 3 | 3 | 1 | 2 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 0 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 1 |
| Delta Programme (Netherlands) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 3 | 3 | 3 | 3 |
| CASBEE (Japan) | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 1 | 3 | 3 | 1 |
| Green Star (Australia) | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 1 | 3 | 3 | 1 |

| Legend | Presence Score (P): | Strength Score (S): | Enforceability Score (E): |
|---|---|---|---|
| | 0 = Not Addressed | 0 = Weak or Not Specified | 0 = Not Enforceable (no legal backing or monitoring) |
| | 1 = Weakly or Implicitly Addressed | 1 = Weakly Mentioned or Suggestive | 1 = Weakly Enforceable (voluntary or advisory only) |
| | 2 = Moderately Addressed with Some Specific Guidelines | 2 = Moderately Strong with Some Technical Detail | 2 = Moderately Enforceable (some legal basis, limited enforcement) |
| | 3 = Clearly and Explicitly Addressed with Detailed Guidelines | 3 = Technically Strong and Detailed | 3 = Strongly Enforceable (legally mandated with monitoring, penalties) |

*Figure 3: Matrix mapping for global best practices against eight CWPs based on Presence, Strength and Enforceability*
*Source: Author*

Beyond certification systems, leading national frameworks such as the Israel Water Policy, the Delta Programme (Netherlands), and China's Sponge City initiative stand out for their strong performance across all three metrics. These policies emphasize water reuse, flood resilience, and integrated planning, with enforceability mechanisms that are both structured and impactful. Singapore's ABC Waters Programme is particularly noteworthy for achieving high scores across the board, thanks to its emphasis on landscape integration, long-term planning, and stringent monitoring.

Nevertheless, even some global systems exhibit gaps, particularly in enforceability. For example, CASBEE and the EU Circular Economy Action Plan show weaker legal backing for advanced reuse strategies, scoring low in enforceability for niche principles such as construction-phase water circularity and reuse-ready infrastructure. This points to a global challenge in bridging innovative design concepts with legal mechanisms for compliance.

## 4.3 COMPARATIVE GAP ANALYSIS AND KEY LACUNAE

A comparative analysis between Indian and global regulatory frameworks reveals significant shortcomings in how Indian systems address Circular Water Principles

(CWPs). While global frameworks (e.g., Singapore, Israel, Netherlands) show uniform integration of circular strategies across building lifecycles, Indian policies remain fragmented. Except for GRIHA and IGBC, Indian regulations display weak coverage of CWPs, especially during the construction phase. The most evident disparity lies in enforceability—Indian instruments typically score between 0 and 1, whereas global policies range from 1 to 3, backed by institutional mandates and penalties. Technical strength is evident in NBC 2016 and the EIA Notification, but this is inconsistent across IS codes and silent on emerging areas like dual plumbing or reuse-ready infrastructure. Urban local governance in India further suffers from decentralization, resulting in fragmented DCRs and uneven policy enforcement at the municipal level.

Key lacunae include the lack of legal mandates and monitoring, leading to weak ground-level implementation even where water-related clauses exist (e.g., IS 456, NBC). Indian regulations are not integrated with urban planning or climate resilience frameworks, limiting systemic transitions to circularity. Moreover, infrastructure readiness is rarely mandated provisions for dual plumbing, greywater lines, or rainwater storage are absent in most codes. Construction-phase water circularity is also largely unaddressed, despite being a high-consumption phase. These limitations collectively hinder India's ability to mainstream circular water practices in its built environment.

# 5. CONCLUSION AND RECOMMENDATIONS

This study identifies critical gaps and misalignments in how Indian policies, codes, and standards address Circular Water Principles (CWPs) in the built environment. Through a structured evaluation across the dimensions of Presence, Strength, and Enforceability, the analysis reveals that while circularity is increasingly acknowledged in policy texts, significant inconsistencies exist in technical clarity and implementation mechanisms.

It is important to note a methodological limitation: the "Enforceability" dimension was inferred from the legal language, mandates, and institutional jurisdiction present in the documents, rather than verified through field-level assessment. As such, the enforceability scores represent theoretical enforceability—what *should* be enforced based on textual provisions—not what is *actually* enforced on the ground. This distinction is critical and underscores the need for future studies to incorporate empirical validation of policy enforcement and compliance practices, particularly at the level of urban local bodies (ULBs), state departments, and regulatory authorities.

To address the identified policy gaps and transition toward a more circular and resilient water paradigm, several strategic directions are proposed. First, legal enforceability must be strengthened across relevant instruments, especially those under the Bureau of Indian Standards (BIS), National Building Code (NBC), and EIA frameworks. Embedding mandatory provisions, backed by compliance audits and penalties, is essential. Second, comprehensive integration of CWPs into IS codes and building guidelines should be carried out through coordinated and harmonized revisions. Third, adoption of global best practices—such as Israel's compliance-driven mandates or Singapore's infrastructure-linked planning tools—can inform scalable solutions for India. Fourth, mandatory infrastructure readiness, such as dual plumbing systems, greywater lines, and rainwater recharge pits, should be incorporated into building approval processes across all jurisdictions. Fifth, dedicated circularity guidelines for construction-phase water use—currently a blind spot—must be developed to address temporary reuse systems, curing water recycling, and runoff management. Lastly, institutional coordination among ministries (e.g., Water Resources, Urban Development, Housing, Environment) and municipal authorities is essential to unify regulatory efforts under a circularity-oriented governance framework.

While these directions emerge from this analysis, they require further empirical testing through the study of actual projects, programs, and their outcomes. Future research should focus on ground-level enforcement, stakeholder capacity, and regulatory performance, to refine and validate policy strategies for water circularity in the Indian built environment.

## 6. ACKNOWLEDGEMENTS

This research is a part of the research project 'CAPABLE' funded by the Ministry of Education, India and the British Council under the research grants of the Scheme for Promotion of Academic and Research Collaboration (SPARC) and UK-India Education and Research Initiative (UKIERI) Schemes (Project Code: SPARC-UKIERI/2024-2025/P3900). We deeply appreciate the financial and literary resource support made available by Dr. Bhanuben Nanavati College of Architecture and Liverpool John Moores University for fostering a conducive environment for research and academic growth.

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## 8. ANNEXURE 1: Justification table for CWP scoring framework

| CWP | Water Demand Reduction | | | | | |
|---|---|---|---|---|---|---|
| **Level** | **P** | **Justification** | **S** | **Justification** | **E** | **Justification** |
| **National Water Policy (2012)** | 2 | Acknowledges water as an economic resource and promotes efficiency, but lacks detailed sector-specific guidelines for buildings. | 2 | Promotes water efficiency across sectors and recommends technologies for conservation, but lacks detailed implementation methods or technical benchmarks for construction. | 0 | High-level strategic framework with no legal binding or enforceable mandates on water efficiency. |
| **NBC 2016** | 3 | Strong emphasis on low-flow fixtures, water-efficient appliances, and water budgeting in building design. | 3 | Provides detailed technical guidance on low-flow fixtures, water budgeting, efficient landscaping, and water-saving plumbing designs. Appendices include fixture flow rates and design considerations. | 2 | Enforceability depends on whether state or city authorities adopt NBC provisions in local bye-laws; partial enforcement in Tier-1 cities. |
| **IS 456:2000** | 2 | Indirectly contributes through control of water-cement ratio and optimized curing, but does not address end-use demand. | 2 | Recommends reduced water use for concrete curing and mixing; indirectly supports water conservation in construction through water-cement ratio control and minimal usage practices. | 1 | Applied in structural engineering contexts; water-saving practices during construction are not independently enforced. |
| **IS 3370:2009** | 1 | Focused on structural storage; no provisions for demand reduction but indirectly supports water conservation through secure storage. | 1 | Offers technical specifications for storage tanks, indirectly enabling water conservation through containment, but does not address end-use reduction methods. | 0 | Focuses on storage tank design; no enforceable provisions regarding demand reduction or usage behavior. |
| **IS 2065:1983** | 2 | Provides water supply design standards and sizing, but based on outdated norms and without reduction focus. | 1 | Provides design sizing for pipelines, but the norms are outdated and not based on modern efficiency goals or reduced water consumption logic. | 0 | Outdated and not incorporated in regulatory approvals; no enforceable clauses on efficiency. |
| **IS 1172:1993** | 1 | Provides per capita consumption norms, but does not emphasize reduction or efficiency; norms are outdated. | 1 | Lists per capita water demand standards but does not guide efficiency improvements; norms are excessive compared to modern benchmarks and lack adaptive context. | 0 | Still used for plumbing design, but its norms are not binding in terms of water-saving compliance. |
| **IS 3025 Series** | 0 | Focuses entirely on water quality testing; no content related to demand reduction. | 0 | Entirely focused on water quality testing methods; does not contribute to demand reduction practices or plumbing efficiency. | 0 | Testing standards only; no direct linkage to regulatory implementation of water-saving measures. |
| **CPWD Manual** | 1 | Estimates construction water demand but does not promote reduced consumption or specify efficient methods. | 1 | Includes general estimates of construction-phase water requirements, but lacks technical suggestions for conservation techniques or alternate construction practices. | 1 | Binding only for government construction projects under CPWD; no enforcement mechanism outside of CPWD jurisdiction. |
| **GRIHA/ IGBC/ LEED -India** | 3 | Clearly encourages low-flow fixtures, metering, water budgeting, and efficient landscape design as rating criteria. | 3 | Highly detailed guidance for achieving water efficiency, including specific fixture types, irrigation strategies, and water budgeting approaches backed by performance metrics. | 1 | Voluntary rating systems; water efficiency measures are only enforced in participating certified projects. |
| **EIA Notification (2006)** | 3 | Mandates water balance charts, estimation of fresh and recycled water demand, and justification of source. | 3 | Strong in technical clarity—mandates submission of water balance charts, fresh and recycled water demand justification, and incorporates demand reduction via reuse systems. | 3 | Enforceable via Environmental Clearance for large projects; requires water budgeting, reuse targets, and periodic compliance submissions. |
| **DCRs (State-wise)** | 2 | Varies by state; many require water-efficient fixtures but lack uniformity or detail in mandates. | 2 | Varies significantly across states; where present, some include fixture efficiency and metering guidelines, but the depth of technical detail differs by region. | 2 | Many state-level DCRs now require water-efficient fixtures or plumbing standards during plan approvals; enforcement varies by municipality. |
| **ULB Policies** | 2 | Some urban local bodies promote audits, metering, and rebates for water-efficient fittings, though fragmented. | 2 | In cities with advanced building regulations (e.g., Pune, Delhi), ULBs issue guidelines for low-flow fixtures and water-efficient landscaping, though not always standardized. | 2 | Urban local bodies can enforce water-saving fixtures and metering through building permissions and plumbing inspections. |
| **CPCB Guidelines** | 2 | Encourages reduction in water use and reuse in construction-related environmental management practices. | 2 | Encourage efficient water use and reference good practices, but lack exhaustive design-level detailing. Often generalized and applicable at macro scale. | 2 | Integrated into EC processes via MoEF&CC and monitored indirectly through SPCBs; enforceability is medium-strength. |
| **SPCBs Guidelines** | 2 | Support efficiency during environmental clearances; however, demand reduction is not always explicitly mandated. | 2 | Offer moderate-level guidance on reducing water consumption in EC-compliant projects and suggest good practices for water efficiency, especially in large developments. | 2 | Enforceability stems from their role in monitoring EC compliance conditions, including water consumption and efficiency targets. |

* This table is only a sample table for Indian policies evaluated for one CWP for the purpose of understanding of the reader. Such tables were generated for all CWPs for all policies and guidelines studied (Indian and International) during the process of data analysis and research.