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Circularity in the Building Sector

PAKISTAN

Acknowledgments

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Content

Executive Summary

Pakistan's construction sector is one of the most economically significant and fastest-growing in South Asia, contributing 2.37 per cent of GDP and 13.01 per cent of total industrial value-added in FY2024, while directly employing around 7.64 million workers across more than 42 interconnected sub-sectors. Sustained urbanization – with the urban population share rising from 22.29 per cent in 1960 to 39.17 per cent in 2024 – is generating structural and growing demand for housing and built infrastructure. Yet the model underpinning this growth is overwhelmingly linear. The sector operates on a take-make-dispose model that consumes vast quantities of cement, steel, sand, and timber, while generating significant construction and demolition (C&D) waste with virtually no formal recovery or recycling systems in place. Burnt clay brick kilns are a major source of particulate matter and black carbon; unregulated riverbed sand mining degrades river systems and amplifies flood risk; and steel – the single largest material cost component – is rarely recovered from demolished structures. The sector contributes substantially to Pakistan's greenhouse gas emissions at a time when the country faces acute and growing climate vulnerability. This report examines where Pakistan's circular economy (CE) transition stands today and what it will take to accelerate it.

The evidence shows that circular economy awareness is genuinely rising. Contractors, designers, and suppliers are increasingly familiar with sustainability concepts, and early pilot projects are demonstrating that circular approaches are technically and economically feasible in Pakistan's urban context. Over the course of this project, stakeholders moved from general familiarity with "green" ideas to more concrete application of the 10R framework, particularly around Reduce, Reuse, Recycle, and Recover. Urban centers such as Karachi already host informal reuse and recycling ecosystems for construction materials, demonstrating that resource efficiency is not merely aspirational but is already happening in parts of the value chain.

At the same time, the report finds that circular adoption remains shallow and structurally constrained. Outside a small number of high-profile or internationally funded projects, CE principles have little practical implementation. For the vast majority of construction activity in Pakistan, the 10R framework is understood in name only. The integration of lifecycle planning, Design for Deconstruction (DfD), and systematic material tracking is largely absent, and the sector continues to be characterized by a pervasive linear mindset that cannot be reversed by isolated project-level interventions. Critically, the barrier to wider uptake is not solely financial. Interviews with over 50 industry professionals reveal that designers lack training in circular design methods, site teams do not systematically segregate or recover materials, and facility managers rarely use data to extend asset life. Without a cultural shift across the value chain, circular adoption risks remaining a compliance exercise driven by donor requirements rather than market conviction. The informal secondary materials market reinforces this fragility: though the market exists, it lacks quality standards, warranties, and traceability, leaving contractors and developers exposed to reputational and liability risks that suppress demand for secondary materials.

These challenges are compounded by a weak enabling environment. Pakistan has no dedicated circular economy strategy; building codes do not mandate material reuse or lifecycle assessment; and financial incentives for circular construction remain limited in reach and ambition. The absence of mandatory embodied carbon reporting, C&D waste data, and material passport systems leaves both the public and private sectors without the information base needed to optimize procurement, design, or end-of-life recovery.

To shift circular construction from localized practice to mainstream delivery, the report identifies five priority actions. Building codes and public procurement frameworks should be updated to embed binding CE criteria, including mandatory recycled content thresholds, C&D waste recovery targets, and lifecycle assessment requirements for projects above a defined scale. Green Public Procurement (GPP) in particular can generate the predictable demand signal that the market needs to organize around. Financial policy must also be reoriented: tax incentives, subsidies, and preferential financing should reward the use of recycled and locally sourced materials and investment in refurbishment over demolition, while Extended Producer Responsibility (EPR) mechanisms for cement, steel, and glass should be explored to internalize end-of-life recovery costs and make linear models less financially attractive.

Stronger market governance is needed in parallel. Government and industry should co-develop quality standards and warranty frameworks for secondary construction materials, supported by digital traceability systems linked to Building Information Modelling (BIM) and material passports. Bankable pilot projects, paired with green finance instruments, should be brought to market and their performance data published openly to reduce perceived risk for investors and contractors alike. Across the building lifecycle, adoption of BIM, lifecycle assessment (LCA) tools, and material passports should be actively promoted and, for publicly funded projects, required. Measurement and disclosure of embodied carbon, operational emissions, waste intensity, and recovery rates should be introduced progressively to drive accountability and investor confidence. Finally, workforce development must be scaled through coordinated continuing professional development for designers, project managers, site teams, and facility managers, while CE principles are integrated into university engineering and architecture curricula and vocational training programs. Demand-side awareness campaigns targeting building owners and developers are equally important, since the industry ultimately responds to what clients require.

These measures – supported by sustained international partnership through programs such as SWITCH-Asia – can accelerate Pakistan's transition to a construction sector that keeps materials in use, minimizes waste, and builds long-term resilience into the built environment.

1. Introduction

1.1. Purpose of the Report

This report aims to accelerate the integration of sustainable consumption and production (SCP) with circular economy (CE), climate, and urban agendas in Pakistan's construction sector by translating national commitments and international aspirations into actionable guidance. It builds a shared, evidence-based understanding of the SCP–CE nexus across the building value chain, raises awareness and ambition among public and private decision-makers, and enables stakeholders, developers, architects, contractors, suppliers, and city authorities to embed sustainability into planning, design, procurement, construction, operations, and end-of-life practices. In doing so, the report identifies priority opportunities and concepts for pilot projects that demonstrate CE in practice, outlines pathways for partnerships and financing, and provides practical recommendations to guide policies, standards, and investments that can drive a just, competitive, and resilient circular transition in Pakistan's construction industry.

The report is part of a broader SWITCH-Asia Technical Advisory (TA) project aimed at strengthening SCP and circularity in the building and construction sector across multiple countries. It outlines key policies that shape the performance of the value chain and practices within the building and construction sector in Pakistan. The cases presented in the report highlight diverse solutions and challenges across various construction stages, offering practical insights to enhance energy efficiency, environmental performance, and potential to promote sustainable consumption and production in particular. Therefore, the report contributes to the global effort to scale up SCP policies and practices, as well as international commitments, including the Sustainable Development Goals (SDGs) and the Paris Agreement.

1.2. Scope

Pakistan's construction sector is a significant pillar of the economy, amounting to PKR 1,409 billion in FY2021 and approximately PKR 1,848 billion in FY2022, contributing around 3% of GDP on average. In FY2024, the sector recorded 5.86% growth and was a notable contributor to overall industrial growth (1.21%), accounting for 13.01% of total industry and 2.37% of GDP as reported in the Pakistan Economic Survey 2023–24 (Government of Pakistan, 2024). Deeply interconnected with more than 42 subsectors including aluminum, bricks, cables, cement, fixtures, glass, kitchen and bathroom fittings, marble, paint, steel, tiles, transportation, warehousing, and wood, the industry also plays a vital employment role. According to the Labor Force Survey 2020–21, Pakistan's total labor force is 77.2 million, with construction directly absorbing about 9.9% (roughly 7.64 million workers). Sustained expansion in construction activity has continued to drive demand for projects as well as a steady supply of labor.

Within this report, the primary geographic focus is on urban centers, engaging key stakeholder groups such as construction companies, builders and developers, and architects and design firms. The analysis spans the full building lifecycle: urban planning and zoning; planning and design; material extraction and manufacturing; construction and associated logistics; maintenance and facility management during operations; and, ultimately, deconstruction and demolition. This end-to-end scope enables identification of CE opportunities, efficiency gains, and policy levers at each stage where materials, energy, and value can be conserved or regenerated.

1.3. Methodology

This study employed a mixed-methods approach combining several data collection streams:

Structured interviews: 10 structured interviews were conducted online and in person with purposively sampled sector leads and industry experts, including Business Development Consultants, Environment Specialists, Contractors, Senior Project Managers, Project Managers and Contract Administrators, Builders and Developers, and UN consultants in Pakistan.

Two surveys: An online capacity assessment survey of 50+ industry professionals and a material market survey across ten construction markets in Karachi, the latter supplemented by field observations at building and construction expos. Further detail on both surveys is provided in Section 2.3.

Desk research: A targeted desk review was conducted to establish the policy, regulatory, and market context for circularity in the sector. This included the review of national policy documents, legislation, sector studies, market reports, academic literature, and grey literature relevant to construction materials, building practices, waste management, energy efficiency, and circular economy approaches in Pakistan. Desk research also supported the identification of data gaps, particularly with regard to construction and demolition (C&D) waste, and recycling rates.

Case studies: Case studies were selected through desk research, stakeholder referrals, and interview findings. Projects were shortlisted where there was evidence of at least one circular economy principle being applied at the stages of conceptualization, design, construction, operation, or maintenance. Each case was reviewed using available project documentation, interview insights, and, where possible, site imagery or project communications. Cases were then assessed in terms of their relevance, innovation, replicability, and potential contribution to circularity and sustainable consumption and production in Pakistan's building sector.

Data quality was strengthened through crosschecks across sources, and limitations such as urban focus on Karachi markets, selfreporting biases, and modest sample sizes were acknowledged and mitigated through triangulation and careful interpretation.

1.4. Introduction to key concepts for bringing circularity to the built environment's lifecycle

The global construction industry constitutes a major sector of resource utilization and environmental repercussions, accounting for approximately 50% of all extracted raw materials, 40% of total energy usage, and over one-third of worldwide waste production, predominantly from construction and demolition activities. This significant environmental impact results directly from its persistent commitment to a linear economic model defined by a 'take-make-dispose' value cycle.

This paradigm accelerates the exhaustion of limited virgin resources, exacerbates landfill pressure, and leads to considerable economic and material value loss at a building's end-of-life, while the high embodied carbon from manufacturing new materials significantly contributes to global greenhouse gas emissions. In addressing these systemic difficulties, the CE offers a transformational framework designed to unlock economic activity from resource consumption. It aims to reinvent value generation by closing material loops, prolonging the functional lifespan of buildings and structures, and eliminating waste from the initial design phase onwards.

At the same time, the built environment consumes a large amount of energy for heating, cooling, lighting and other services. Thereby, the construction and building sector play a significant role in driving global carbon emissions, accounting for nearly 40% of total energy-related CO2 emissions when considering both direct operational emissions and embodied carbon from construction. Decarbonizing the building sector, which targets the planning, construction materials, construction, occupation/use, and demolition phases, is therefore a critical component of global efforts to combat the climate crisis and moving toward more sustainable, circular consumption patterns. By integrating material- and energy-efficient circularity-oriented building designs and renewable energy systems, buildings can drastically cut down on greenhouse gas emissions and other pollutants and decrease their material footprint. Optimizing both the materials production and the use of materials not only minimizes this material footprint but also extends the lifespan of buildings, reducing the frequency of resource-intensive construction cycles.

The 10 R model of activities implementing circular economy principles

A key operational framework for implementing CE principles within the built environment is the 10R model, which provides a hierarchical ladder of circularity strategies, prioritizing higher-value retention actions to guide decision-making from project inception to deconstruction and material recovery. The 10R model provides a framework for a more resource-efficient system, starting with the preferred options:

The implementation of the 10R model in construction also operationalizes Sustainable Consumption and Production (SCP) patterns within the built environment. The highest-order strategies—Refuse, Rethink, and Reduce—directly target the consumption nexus by enhancing resource efficiency during the design phase. This entails the application of advanced methodologies such as Design for Deconstruction (DfD) and Design for Adaptability (DfA), which integrate future value recovery into the initial building design, alongside the implementation of lean construction principles to reduce material offcuts and waste.

The five activities ranging from Reuse, Repair, Refurbish, Remanufacture to Repurpose are fundamental to a sustainable production system. Their emphasis is on maintaining the embodied energy, carbon, and economic value of existing buildings and components, which extends their functional service life and reduces the need for primary resource extraction and virgin material production. This systemic transition is dependent on various enabling factors. Digitalization can become an essential tool, as Building Information Modelling (BIM) progresses into detailed "digital twins" and "material passports" that offer specific data on component specifications, maintenance history, and deconstruction protocols, thereby enabling future reuse and remanufacturing. This could also mean a shift in business models, for example from linear take-make-waste models to Product-as-a-Service (PaaS) systems, wherein manufacturers maintain ownership of assets such as facades or HVAC systems and lease their functionality, thereby promoting durability and facilitating end-of-life take-back.

The integration of circular principles, supported by policies like Green Public Procurement (GPP) and Extended Producer Responsibility (EPR), reduces the ecological footprint of the sector while also generating economic opportunities. This approach leads to new markets for secondary materials, creates skilled jobs in remanufacturing and deconstruction, and lowers the lifecycle costs of buildings and structures, while minimizing their economic externalities, like pollution and waste, which are unaccounted for in the current linear paradigm.

The 10 Rs in a building's lifecycle: the six "stages" of construction

Integrating CE considerations into the construction sector necessitates a systemic transition from the current linear model. Utilizing the 10R framework, the principles of circularity can be mapped directly onto the specific phases, or "stages", of a construction project's lifecycle. The circularity requirement is simultaneously incorporated into every stage of the process, ranging from initial macro-level planning decisions to the detailed micro-level aspects of material recovery, and demolition as the final step for closing of the circularity loop. Each stage presents distinct opportunities and challenges, yet they are closely interconnected; decisions made in the initial phases significantly influence the circular potential achievable at the conclusion of a building's life. Construction sector actors must cohesively apply these principles across all six stages of the lifecycle to fully embrace circularity.

In each stage, there are fundamental considerations for applying circular principles:

1. Urban and Rural Planning and Zoning (Why, What, and Where)

Planners can prioritize the adaptive reuse of existing structures, instead of defaulting to new builds. This stage offers a high potential for circular impact by applying the principles of Refuse and Rethink.

2. Planning and Design of Engineered Structures

This is where circularity is embedded into the physical asset through Rethink and Reduce practices. Architects and engineers have a critical role in designing for longevity, adaptability, and eventual disassembly allowing for Reuse, Repurpose, Remanufacture, and Recycle.

3. Material Use, Manufacturing, and R&D

This stage focuses on closing material loops in the supply chain through Recycle, Remanufacture, and Reduce. It can also set the basis for Repurposing and Reuse.

4. Construction Works incl. Logistics

Construction is based on decisions made during all prior phases. On-site execution is crucial for minimizing immediate waste; value preservation of materials is achieved through Reduce and Reuse strategies.

5. Maintenance and Facility Management

The use-phase is where value is preserved and a product's life span is extended through Repair, Refurbish, and Reuse.

6. Deconstruction and Demolition

This final stage in a circular model focuses on Reuse, Repurpose, Remanufacture, and Recycle.

The transition to a circular system is a complex and incremental process, requiring the cooperation of a multitude of actors over different time horizons. For example, the potential for value recovery during deconstruction is fundamentally determined by design decisions made in the planning phase. The initial and essential action is to commence the process by identifying committed decision-makers and implementers. Implementing a singular circular practice, such as enhanced on-site waste segregation or the design of a project for disassembly, fosters essential knowledge, illustrates economic feasibility, and generates the momentum required for wider systemic adoption. It also demonstrates the need to shift policy frameworks towards circularity, creating the right incentives at different governance levels. A comprehensive shift would also include sanctions for non-circular practices, and monitoring to inform where incentives and sanctioning mechanisms need adjustment, as well as making linear models less profitable and feasible at national level, for example through taxation and import requirements. This can spur innovation and a shift in market actors' priorities.

2. Screening the Building Sector's Value Chain

2.1. Background

Pakistan is one of the most rapidly urbanizing countries in South Asia. According to the World Bank's World Development Indicators, the share of Pakistan's population living in urban areas stood at 39.17 per cent in 2024, up from 22.29 per cent recorded in 1960, with an annual urban population growth rate of approximately 2.4 per cent in 2024 (World Bank, 2024). This sustained urban growth, combined with a total population exceeding 230 million, generates persistent and structurally growing demand for housing and built infrastructure.

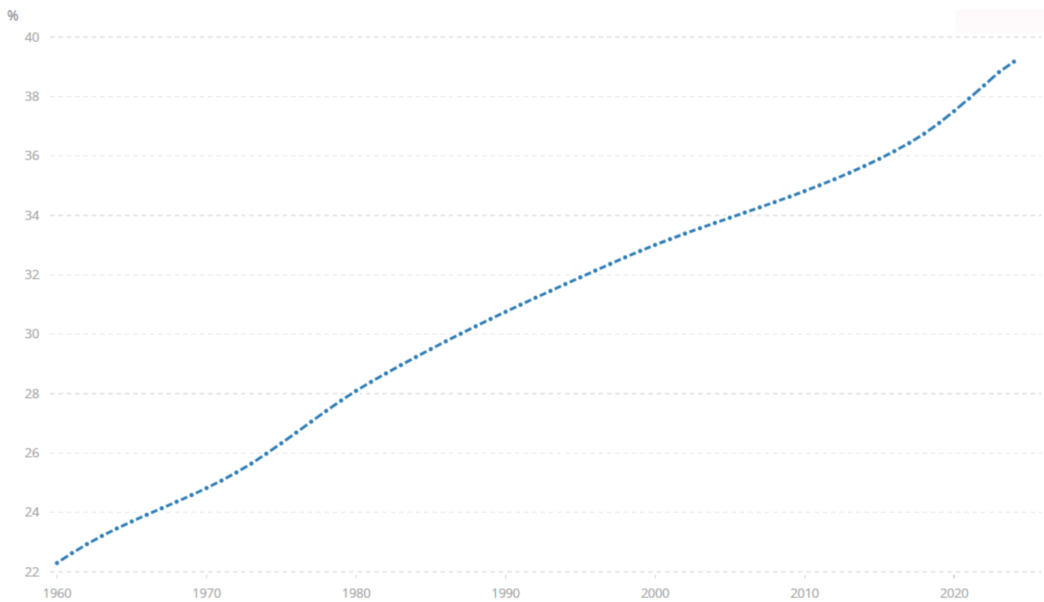

Figure 1 – Urbanization rate of Pakistan from 1960 to 2024

Construction is a structurally significant sector within Pakistan's economy, with extensive upstream and downstream linkages across the industrial base. Historically, the sector has contributed an average of approximately 2.8 per cent of GDP over the period FY2019–FY2024 (PACRA, 2025). Its output grew from PKR 1,409 billion in FY2021 to approximately PKR 1,848 billion in FY2022. By FY2024, the sector's contribution stood at 2.37 per cent of GDP and 13.01 per cent of total industrial value-added, with the sector recording growth of 5.86 per cent and emerging as one of the principal drivers of broader industrial expansion that year (Pakistan Economic Survey 2023–24). These figures reflect not only the direct output of construction activity, but also its extensive linkages across the economy: the sector interfaces with more than 42 related industries, ranging from cement, steel, glass, and timber to tiles, marble, paint, aluminium, cables, and transport and warehousing services. This interconnectedness amplifies both its economic footprint and the complexity of efforts to shift it towards more circular and sustainable practices.

On the employment side, construction absorbs approximately 9.9 per cent of Pakistan's total employed population – equivalent to roughly 7.64 million workers out of a total employed population of 77.2 million (Labour Force Survey 2024–25, Pakistan Bureau of Statistics, 2025, 19th ICLS). Pakistan's construction labor force includes a substantial informal component, with many workers engaged outside standard employment contracts and occupational safety frameworks. This informality has significant implications for skills development, productivity, and the adoption of more resource-efficient construction practices.

Pakistan faces a housing deficit of between 10 and 12 million units, with an annual demand for approximately 400,000 new homes (The Markhor Times, 2025). This shortfall has driven up property prices and pushed a significant share of urban residents into informal settlements, with an estimated 57 per cent of urban dwellers living in slums or informal housing (ADB, 2024). Despite cyclical contractions, the structural demand for construction remains acute. The sector is projected to expand at an average annual growth rate (AAGR) of

4.6 per cent during 2026–2029, following an estimated expansion of 5.1 per cent in 2025 (GlobalData, 2025).

The building and construction sector's scale and growth trajectory have direct consequences for resource consumption and environmental performance. The sector interfaces with a wide range of primary materials — cement, steel, aggregates, brick, timber, glass, and bitumen among them — and its expansion is generating growing volumes of construction and demolition waste at a pace that existing waste management infrastructure is ill-equipped to absorb. These dynamics are examined in detail in the sections that follow.

Box : Construction Profiles and Circularity Context in Pakistan's Three Largest Cities

Karachi: Karachi is Pakistan's largest city and its primary commercial and industrial hub, with a metropolitan population of approximately 18 million in 2023 — up from 14.9 million recorded in the 2017 census — and growing rapidly through continued in-migration (ADB, 2024). It is the centre of gravity for Pakistan's private construction market, hosting the country's densest concentration of commercial real estate, logistics infrastructure, and high-rise residential development. The city's construction profile is shaped by its port economy, a large and diverse industrial base, and a chronic housing shortage: an estimated 64 per cent of Karachi's residents live in informal settlements (katchi abadis), generating persistent demand for both formal and informal construction activity across all income segments (UN-Habitat, 2022).

From a circularity perspective, Karachi presents both the greatest challenge and the greatest opportunity. The sheer volume and informality of construction activity means that C&D waste generation is high, largely untracked, and almost entirely unmanaged through formal channels (ADB, 2021). At the same time, the city's market depth and density of industry mean it is the most likely location for pioneering circular business models in materials recovery and secondary markets — as evidenced by the case studies profiled in this report. The survey of ten construction markets conducted for this report was concentrated in Karachi, and its findings therefore reflect primarily the urban dynamics of this city.

Lahore: Lahore, Pakistan's second-largest city and the capital of Punjab province, had a population of approximately 13 million in 2023, up from 11.1 million in 2017 (ADB, 2024). It is the cultural and economic capital of Punjab and the centre of Pakistan's largest and most productive agricultural hinterland. Lahore's construction sector is characterized by a mix of large-scale residential development (including horizontally sprawling gated housing societies and a growing wave of vertical development) and commercial and logistics projects driven by its role as a trade hub for the wider Punjab economy. As of 2023, approximately 53.6 per cent of Lahore's land area was urbanized, with projections suggesting this could reach 75.8 per cent by 2048 (ScienceDirect, 2024).

From a waste management perspective, Lahore faces growing pressure as continued urban expansion and construction activity are likely increasing volumes of construction and demolition waste. As in other rapidly urbanizing parts of Pakistan, this may strain existing systems for waste collection, transport and disposal, although the scale and management of these waste streams remain insufficiently documented.

Islamabad: Islamabad, Pakistan's planned federal capital, serves as the country's administrative and diplomatic centre. Its construction sector is shaped by planned, often state directed development, including large institutional, administrative and public use buildings, expanding residential areas overseen by the Capital Development Authority (CDA), and a growing private market for high end residential and mixed use projects (Tariq & Waheed, 2023).

Islamabad has also emerged as a site for major commercial property developments, including gated smart city projects along key motorway corridors, and several of the more design oriented circular economy case studies in this report are located there. The CDA's role in planning and formal building control contributes to a relatively structured institutional setting for construction oversight. At the same time, the broader construction model remains material intensive and largely linear, with limited formal infrastructure for construction and demolition waste management (ADB, 2021).

2.2. Key Challenges

2.2.1. Resource Consumption

Pakistan's building and construction sector relies on a wide range of primary materials, each sourced from distinct domestic locations or supplemented through imports. Cement and steel dominate both consumption volumes and embodied carbon across the value chain, but the sector also draws significantly on natural aggregates, masonry materials, timber, glass, aluminium, bitumen, and ceramics — together constituting a highly resource-intensive production system that remains almost entirely linear in its current configuration.

Cement is the foundational construction material in Pakistan. Types widely used include Ordinary Portland Cement (OPC), Sulphate Resistant Cement (SRC), and White Cement, with the primary raw material — limestone — extracted from deposits in Punjab and Khyber Pakhtunkhwa. Major manufacturers including Lucky Cement, DG Khan Cement, and Fauji Cement operate large-scale quarrying and kiln operations supplying both domestic demand and export markets. Pakistan's installed cement production capacity reached 84.58 million tonnes per annum (Mta) in FY2024–25, nearly double the 45.62 Mta recorded in FY2015–16, making it one of the largest cement industries in Asia, though actual production remains significantly below installed capacity, pointing to structural overcapacity in the sector (CemNet, 2025). The critical sustainability challenge lies in the sector's energy profile: Pakistan's cement kilns rely almost entirely on coal as their primary kiln fuel, with approximately 53 million tonnes of coal consumed by the cement sector in 2022 alone, alongside approximately 1 million cubic feet per day of gas (Shafiq et al., 2023, citing Pakistan Bureau of Statistics, 2022). Research applying the Kaya identity and LMDI decomposition models to Pakistan's cement sector has identified production growth and energy intensity as the dominant drivers of rising carbon emissions in the industry over the period 2005–2020 (Rasheed et al., 2022). Globally, cement production is responsible for approximately 7 per cent of total CO_2 emissions, and Pakistan's population, projected to reach 276.5 million by 2030, is expected to drive cement demand to approximately 77.5 Mta, with a commensurate intensification of associated emissions (Ahmad et al., 2025). This heavy fossil fuel dependence renders cement production one of the most carbon-intensive activities in Pakistan's industrial base and a priority area for decarbonization.

Steel is the second major structural input, used primarily in the form of Grade 40 and Grade 60 deformed reinforcement bars. Domestic producers including Amreli Steels, Ittehad Steel, and Mughal Steel, supply a significant share of local demand, while imported steel serves specialized structural and high-rise applications. A recent study of construction material use in Pakistan found that steel accounts for approximately 27.3 per cent of overall construction project cost, the single largest material cost component, underlining the sector's significant dependence on this input (Hussain et al., 2025). The overall steel supply chain remains largely linear: formal systems for recovering or recycling steel from demolished structures are virtually absent, resulting in the loss of substantial embedded energy and economic value at each demolition cycle. The iron and steel sector directly accounts for approximately seven per cent of total energy system CO_2 emissions globally (IEA, 2020), and Pakistan's construction-driven steel demand amplifies this challenge at the national level.

Sand and aggregates represent the highest-volume material inputs by weight. Sand is sourced from the riverbeds of the Indus, Ravi, and Chenab rivers, with different varieties — including fine Ravi Sand, coarser Chenab Sand, and higher-quality Lawrencepur Sand, used selectively in concrete and masonry works. Crushed stone (aggregate) is quarried primarily from the Margalla Hills, Sargodha, and Taxila, and is essential for concrete production and road construction. Both extraction activities continue at significant scale with limited regulatory oversight, carrying direct consequences for river morphology, sediment transport, floodplain stability, and aquatic biodiversity. Unregulated riverbed sand mining is increasingly recognized as a factor that exacerbates flood risk by altering channel dynamics (Koehnken et al., 2020; Sreebha & Padmalal, 2022; Husain et al., 2017).

Masonry materials vary by region and reflect local climate and resource conditions. Burnt clay bricks remain the dominant masonry unit, produced in kilns across Punjab and Sindh using the traditional Bull's Trench Kiln (BTK) method — a process that is a significant source of particulate matter and black carbon, contributing to the severe winter smog events that afflict Lahore and other major Pakistani cities. In Karachi, cement blocks have increasingly displaced traditional bricks due to their durability, cost-effectiveness, and resistance to the humidity and salinity characteristic of the coastal climate; these blocks are manufactured from a mixture of cement, sand, and aggregate, and offer improved thermal insulation properties relative to fired clay brick. Research on Pakistan's built environment material stocks confirms that the building stock is dominated by bricks and concrete, with clay and biomass used in minor amounts and minimal steel in lower-income and rural contexts, highlighting the socio-economic stratification of material use across the country (Springer Nature, 2026).

Timber is used primarily for doors, windows, formwork, and interior finishes. Locally harvested varieties, including Deodar, Chir Pine, and Sheesham, sourced from forests in Swat, Chitral, and Gilgit-Baltistan, face growing pressure from construction demand, against the backdrop of Pakistan's already high rates of deforestation. High-quality timber is also imported from Malaysia and Canada to meet demand for premium finishes in the commercial and high-end residential sectors.

Glass is used for windows, facades, and interior applications. Local manufacturers such as Ghani Glass supply standard glass products, while high-end tempered and laminated glass is imported from China and the UAE. **Aluminium and UPVC** are used for modern window and door systems: while local manufacturers produce these materials, a substantial proportion of demand is met through imports. **Bitumen and asphalt**, essential for road construction and waterproofing, are sourced from Attock Refinery and supplemented through imports from Iran and the Middle East. **Tiles and ceramics**, including porcelain, ceramic, granite, and marble, are produced domestically by companies such as Master Tiles and Sonex Tiles, with luxury and speciality products imported from Spain, China, and Italy.

Taken together, this material profile reveals a sector that is heavily dependent on domestically extracted primary resources, with limited circularity at any stage of the supply chain. Construction and demolition (C&D) waste represents a particularly acute and poorly documented resource challenge: globally, C&D waste accounts for 25–30 per cent of total waste generated (Aftab et al., 2025), and Pakistan's rapidly expanding construction activity — driven by urbanization, infrastructure investment, and a chronic housing deficit — is generating growing volumes of such waste. The recycling rate for C&D waste in Pakistan is extremely low, though no official national figure exists. Available evidence consistently points to rates below five per cent. The market for recycled construction materials, such as recycled aggregate or reclaimed brick, remains negligible, constrained by the continued availability of cheap virgin materials and the absence of quality certification standards for secondary products (U.S. International Trade Administration, 2026; ADB, 2021). Much of what is informally recovered is retrieved piecemeal by scavengers before waste reaches any disposal site, and a large proportion of C&D waste never reaches a formal waste management facility at all (U.S. International Trade Administration, 2026).

2.2.2. Environmental Impact

The building and construction sector in Pakistan is a significant and growing source of greenhouse gas (GHG) emissions. Buildings are estimated to account for approximately 30% of Pakistan's total emissions, with the residential building sector growing at 4.7% per year and the commercial sector at 2.5% annually, driven by rapid urbanization (Sheikh et al., 2024).

The main emissions sources within the sector are building materials production and building operation. Pakistan's cement manufacturing sector, the dominant structural material, releases an estimated 16 Mt CO_2 per year according to the Global Carbon Atlas (2023), with some analyses suggesting the actual figure may be closer to 25 Mt CO_2/year when full process emissions are accounted for (Harder, 2025). Buildings constructed with cement and concrete, along with other construction materials, are significant embedded sources of CO_2 emissions (Siddique et al., 2024).

The brick manufacturing sector represents a further major environmental pressure point. Pakistan has approximately 20,000 brick kilns, employs around 1.3 million workers, and contributes an estimated 1.5% to GDP (ICIMOD, 2025). Traditional kiln technologies (predominantly fixed chimney bull's trench kilns (FCBTKs)) are highly inefficient and emit substantial quantities of CO_2, black carbon (BC), and fine particulate matter (PM2.5), contributing significantly to Pakistan's air pollution crisis. Progress is being made: Punjab province has mandated conversion to zigzag kiln technology since 2020, with over 11,000 kilns converted to date. Zigzag technology reduces PM2.5 emissions by approximately 35% and CO_2 emissions by around 30% compared to traditional kilns (ICIMOD, 2025).

Critically, Pakistan currently lacks a systematic, nationally representative dataset on carbon emissions from the construction process itself — a significant gap that limits evidence-based policymaking for the sector (Sheikh et al., 2024). This data deficit is symptomatic of broader structural weaknesses that cut across the sector's environmental governance, and it is far from the only challenge the sector faces. Beyond the measurement gap, the building and construction sector in Pakistan confronts a series of interrelated barriers spanning technology, waste management, energy performance, and institutional capacity.

On mitigation technology, discussions on Carbon Capture and Storage (CCS) remain largely theoretical in the Pakistani context, constrained by significant technological barriers, prohibitive upfront costs, and the absence of a regulatory framework or fiscal incentive structure that could catalyze private investment (Zia el al., 2024). The sector has not yet developed a credible decarbonization roadmap that moves beyond incremental energy efficiency measures towards deeper structural interventions.

Waste management represents a further critical failure point. The absence of robust construction and demolition (C&D) waste management systems continues to hinder the effective collection, sorting, and repurposing of materials at end-of-life, driving excessive reliance on unregulated landfill disposal and open dumping. This not only occupies scarce land resources but contributes to soil contamination and the pollution of water bodies in peri-urban areas. The lack of formal material recovery infrastructure means that potentially valuable secondary materials, including steel, aggregates, and timber, are routinely lost from the supply chain, undermining progress towards circular material flows and increasing pressure on virgin resource extraction.

Energy efficiency in buildings represents perhaps the most extensively documented underperforming area, with barriers operating simultaneously at the levels of regulation, financing, capacity, and governance (Sheikh et al., 2024). Pakistan's building stock is predominantly constructed without thermal insulation, and compliance with the National Energy Efficiency and Conservation Act (NEECA) 2016 and its associated building energy codes remains weak in practice — particularly in the informal and low-income residential segments that constitute the majority of new construction. This enforcement gap is rooted in a regulatory framework that sets minimal mandatory standards and lacks effective compliance mechanisms, giving building owners and developers little incentive to invest in energy-saving technologies or retrofit existing structures (Sheikh et al., 2024). Compounding this, many building professionals, including contractors, developers, and architects, lack the technical knowledge and skills necessary to design and deliver energy-efficient buildings, a gap attributable in part to the absence of comprehensive training programmes and certification processes within the sector (Sheikh et al., 2024). Access to finance further constrains uptake: energy-efficient technologies and construction materials typically carry higher upfront costs than conventional alternatives, and without accessible financing instruments — such as green mortgages, concessional loans, or performance-based incentives — the transition remains sluggish (Sheikh et al., 2024). Inadequate monitoring and evaluation systems compound these barriers: the absence of comprehensive data on the energy performance of Pakistan's building stock makes it difficult to track progress, assess the impact of policy interventions, or build the evidence base needed to justify further investment (Sheikh et al., 2024). Finally, institutional fragmentation — with responsibility for building regulation, energy compliance, and urban planning dispersed across federal, provincial, and municipal levels — leads to competing objectives, duplication of effort, and inconsistent enforcement, undermining the efficacy of what building energy regulations do exist (Sheikh et al., 2024).

Beyond energy, the sector faces significant challenges in water management and material sourcing. Greywater reuse systems and rainwater harvesting remain rare features even in newly constructed buildings, despite acute and worsening urban water stress in cities such as Karachi, Lahore, and Faisalabad. The widespread use of topsoil-fired bricks, which degrades agricultural land, and the continued extraction of river sand without adequate environmental controls further compound the sector's ecological footprint. The uptake of eco-friendly and low-carbon construction materials remains limited, constrained by higher upfront costs, limited domestic manufacturing capacity, and the absence of green public procurement standards that could stimulate demand at scale.

2.2.3. Regulatory Barriers

A persistent challenge in Pakistan – as in many developing economies – is the gap between policy ambition and implementation. Public awareness of CE principles remains limited, infrastructure for sustainable practices is inadequate, and the principles of reduction, reuse, and recycling remain insufficiently embedded in national strategies (SDPI, 2021). The Sustainable Development Policy Institute (SDPI) has highlighted the urgent need for high-level policy dialogue on the CE, calling for greater awareness among policymakers and private sector actors, the identification of effective circular business models across construction, packaging, and textiles, and the promotion of knowledge-sharing platforms and public-private partnerships to accelerate the transition (SDPI, 2021). These objectives broadly align with global policy directions established by the European Commission's (2020) Circular Economy Action Plan and the UNEP Global Resources Outlook (UNEP, 2023), both of which frame resource efficiency as a prerequisite for climate-compatible development.

Pakistan does not yet have a dedicated national CE policy for the building and construction sector. Several broader instruments indirectly support CE principles in the built environment, but a review of these instruments reveals a consistent pattern: reasonably ambitious federal policy on paper, sitting atop near-absent provincial and local enforcement infrastructure.

Energy efficiency: the ECBC implementation gap. The National Climate Change Policy (NCCP; Government of Pakistan, 2021a), designed as a "living document" guiding Pakistan towards a climate-resilient, low-carbon development pathway, explicitly calls for legislating opportunities for industry to transition to circular economy models and for boosting market demand for recycled products. Pakistan's updated Nationally Determined Contributions (Government of Pakistan, 2021b) similarly emphasise the systemic integration of resource efficiency, GHG emission reduction, and CE principles. However, analysts have noted that the NDCs lack binding sector-specific targets for construction and do not establish measurable milestones for CE adoption (Climate Action Tracker, 2022).

The most significant regulatory instrument for operational energy performance is the Energy Conservation Building Code (ECBC-2023), developed by the National Energy Efficiency and Conservation Authority (NEECA) with technical support from GIZ, and notified by the Ministry of Energy (NEECA, 2023; GIZ, 2024). On paper, it represents a substantive step: new buildings must adhere to the code from 2024, and existing buildings are required to undergo mandatory energy audits with five-year energy-saving plans by 2025 (NEECA, 2023). The ECBC also carries some indirect CE links (e.g. encouraging recycled insulation materials such as cellulose derived from recycled paper, promoting wastewater reuse for non-potable purposes, and supporting greywater recycling). However, several structural barriers undermine its effectiveness in practice. Enforcement authority sits with provincial and municipal development authorities, while NEECA's role is limited to facilitating amendments in provincial building bylaws — a process that requires individual buy-in from each provincial government (NEECA, 2023; CTCN, 2023). This creates a fundamental disconnect: the code-setting entity has no enforcement power, and the enforcement entities have limited technical capacity or political incentive to implement energy standards. Compounding this, the ECBC-2023 lacks a robust compliance framework — there is no standardised building permit process integrating energy performance verification, no mandatory third-party energy auditing at design or commissioning stage, and no penalties regime for non-compliance. The code is effectively advisory in practice.

The ECBC-2023 has also been criticised for insufficient climate-specific calibration across Pakistan's diverse climatic conditions (spanning hot-arid lowlands in the south to cold highlands in the north) making uniform application impractical and potentially raising costs for builders in zones where prescriptive requirements are poorly matched to local conditions (Mehmood et al., 2025). A further limitation is the code's overwhelmingly new-build focus. Electricity constitutes approximately 50 per cent of residential energy consumption in Pakistan (Mehmood et al., 2025), yet the regulatory framework provides no defined financing mechanism or institutional pathway for retrofitting the existing building stock. From a CE perspective, the ECBC's primary limitation is its narrow focus on operational performance, with limited attention to embodied carbon (the GHG emissions associated with material extraction, manufacturing and construction); integrating whole-life carbon assessment into the ECBC would significantly strengthen its alignment with CE objectives.

Circularity: a near-complete regulatory vacuum. On circular economy principles, the regulatory situation is more fundamental. Pakistan has no dedicated national legislation governing construction and demolition (C&D) waste. Existing solid waste management frameworks at provincial level focus on municipal solid waste; C&D waste falls outside any formal regulatory perimeter, with no mandatory waste segregation, recycling, or recovery targets for construction projects (ADB, 2021; Rashid et al., 2025). Building codes and bylaws contain no provisions for design-for-disassembly, material passports, or end-of-life planning, and building permit processes do not assess material circularity, recyclability, or embodied carbon. There are no regulations mandating or incentivising the use of recycled aggregates, reclaimed steel, or other secondary materials; existing quality standards for construction materials may in fact implicitly penalise recycled inputs by specifying virgin material properties without equivalence pathways for secondary materials.

Pakistan does sustain an active informal sector for material recovery — steel, bricks, and timber — but this operates entirely outside regulatory oversight, with no quality assurance, occupational health protections, or environmental controls (Iqbal et al., 2023). The absence of formalisation means that this de facto circular practice cannot be scaled, standardised, or integrated into procurement frameworks.

Cross-cutting structural barriers. Underlying both the energy efficiency and circularity gaps is a set of shared institutional weaknesses. NEECA, provincial Environmental Protection Agencies (EPAs), development authorities, and housing ministries have overlapping but uncoordinated mandates. Municipal building inspectors lack training in energy performance or material circularity assessment. There is no national building energy database, no quantification of C&D waste flows, and no material flow accounts for the construction sector. Critically, there are no financial incentives — no tax relief, accelerated depreciation, or concessional finance — linked to energy-efficient or circular building practices.

At the same time, the most substantive instruments reviewed demonstrate that the policy architecture is becoming more sophisticated. The Green Building Code of Pakistan (GBCP; Ministry of Climate Change, 2023) contains several directly CE-aligned provisions, including mandatory waste management plans for construction sites; a requirement that a minimum of 25 per cent of non-hazardous construction, demolition or deconstruction waste be diverted from landfills through reuse, recycling or composting; and a stipulation that recycled content and salvaged materials constitute at least 10 per cent of total building materials by cost. It further requires at least 10 per cent of materials to be regionally sourced within 400 km of the project site; wood components to contain at least 50 per cent certified content tracked through a chain-of-custody process; and an LCA in accordance with ASTM E2921 and ISO Standard 14044 to be performed for a minimum of two design alternatives. On-site greywater recycling and reclaimed water treatment systems are also required. While the GBCP-2023 represents a meaningful step forward, its enforcement mechanisms remain underdeveloped, and Pakistan's building sector is characterised by a large informal construction market that largely falls outside the reach of code compliance frameworks.

Complementing the GBCP, the Model Green Building Code Provisions for the Five Million Housing Programme, developed in collaboration with EU SWITCH-Asia, UN-Habitat, NED University and the Ministry of Climate Change, and drawing on the 2021 International Green Construction Code (IgCC; ICC, 2021), set out a waste treatment hierarchy that prioritises preparation for reuse, followed by construction material recovery and then energy recovery. The provisions require comprehensive pre-construction waste management plans, selective demolition techniques to maximise material recovery, a minimum 50 per cent landfill diversion rate for non-hazardous construction and demolition waste, and on-site rainwater and stormwater recycling. The National Action Plan on Sustainable Consumption and Production (NAP-SCP; Government of Pakistan, 2020) similarly outlines conceptual objectives for implementing SDG 12 at the grassroots level, calling for a paradigm shift towards high-value product systems, the incorporation of environmental costs into pricing mechanisms, and enhanced resource use efficiency across the full value chain, with sector-specific action plans covering buildings, water, energy, food and transport.

Taken together, these instruments demonstrate that the foundations for a CE-aligned regulatory framework exist in Pakistan. However, CE-relevant provisions remain fragmented across multiple codes and action plans with no overarching coordination mechanism or cross-cutting implementation body (OECD, 2022). Compliance is largely voluntary or unenforced in the informal sector. None of the instruments systematically addresses embodied carbon or material circularity across the full supply chain (IEA, 2023). There is no green bond framework, circular procurement mandate, or extended producer responsibility scheme specific to construction materials (OECD, 2022). The absence of a national construction materials database or waste tracking system also makes it difficult to measure CE progress or set evidence-based targets (UNEP, 2023). The critical bottleneck, therefore, is not the absence of codes but the absence of implementation architecture: compliance verification processes, trained inspectors, penalty regimes, financial incentives and data systems. Without these, even well-designed codes remain aspirational. Addressing these gaps will require not only stronger regulatory instruments but also institutional capacity, industry engagement and alignment with international financing standards.

2.3. Opportunities

2.3.1. Innovation Potential

At its core, the implementation of sustainable construction practices involves three key stakeholders: government, designers and architects, and construction firms. Whilst construction firms sit at the operational end of the spectrum, it is the government that holds the primary regulatory role, setting the framework within which the industry operates. Designers and architects, in turn, serve as the critical catalysts in this process. Contractors are, fundamentally, executors — by the time a project reaches them, it has already been fully planned; they are tasked with delivering precisely what the specifications and designs prescribe.

It is therefore essential that designs are developed with sufficient material flexibility, enabling the selection of components that can be readily disassembled, recycled, and reused. From a contractor's perspective, this presents a tangible limitation: conventional designs rarely permit the substitution or introduction of new elements, which significantly constrains their ability to promote CE practices. Beyond the design and regulatory dimensions, the preferences of investors and end users — whether buyers or renters — play an equally important role in shaping market demand and driving the uptake of sustainable technologies.

The Green Building approach, particularly through certified construction, holds significant potential for driving circularity in the construction sector. Participants of the Constructors Association of Pakistan (CAP) stakeholder dialogue acknowledged that a number of projects are already pursuing green building certification — most notably Leadership in Energy and Environmental Design (LEED) certification or equivalent standards. However, a critical bottleneck remains at the level of contractors' capacity: very few firms within the building construction sector possess the human resources or technical expertise required to conduct green building assessments in-house. This capacity gap represents a considerable obstacle to the genuine implementation of green building concepts and, by extension, CE principles — which participants broadly viewed as aligned with green building requirements. Compounding this challenge, platforms such as CAP have thus far done relatively little to address these gaps or to actively promote CE practices among their membership.

In structured interviews, experts highlighted that contractors in Pakistan are gradually developing competencies in sustainable construction, driven by growing environmental awareness, regulatory requirements, and market demand. Many have adopted eco-friendly building materials, energy-efficient designs, and waste reduction strategies to minimize their carbon footprint. They are also integrating advanced technologies such as BIM (Building Information Modeling) to optimize resource usage and improve project sustainability. Additionally, national contractors are investing in training programs to equip their workforce with green building skills, ensuring they stay competitive in an evolving industry. However, challenges remain, including the high initial costs of sustainable materials and the need for stronger policy support to encourage widespread adoption.

Structured interviews further underscored the importance of digital tools in enabling CE practices, with participants pointing to technologies such as Building Information Modelling (BIM), material passports, material tracking systems, and lifecycle assessment (LCA) tools as key enablers for planning reuse and recycling effectively. As per experience and research of the author, during the design phase, the adoption of an Integrated Design Process (IDP) offers considerable potential for embedding CE principles from the outset. IDP supports a range of applications — including green and energy-efficient building design, modular construction, and design for deconstruction and disassembly — and can be significantly enhanced through immersive visualization technologies such as Virtual Reality (VR), Mixed Reality (MR), and Augmented Reality (AR). These tools enable design teams to identify circularity opportunities early, before decisions become locked in.

Complementing this, Geographical Information Systems (GIS) can play a valuable role in promoting local resource utilization and material efficiency, whilst also helping to reduce the carbon footprint associated with material extraction and transportation. Finally, Life Cycle Assessment (LCA) tools provide a robust means of evaluating the circularity and sustainability of both resource consumption and construction processes, enabling practitioners to estimate environmental impacts in advance and adopt more informed, sustainability-oriented approaches accordingly.

Box: Methodology details on interviews and surveys

Structured interviews: 10 structured interviews were conducted online and in person with purposively sampled sector leads and industry experts. A common interview guide explored awareness and adoption of CE "10R" principles across five lifecycle stages – planning and design, material sourcing and manufacturing, construction and logistics, operations and maintenance, and deconstruction and demolition – as well as barriers, enablers, and policy and market levers. Informed consent was obtained; discussions were documented and thematically coded. Sector leader profiles were selected based on professional diversity, years of experience, engagement in industry-level initiatives and professional bodies, and convening power, with profiles vetted via LinkedIn and the authors' networks.

Two surveys: The online survey disseminated via contractors' and builders' association lists captured respondents' roles, experience, exposure to CE, current practices, constraints, and support needs using multiplechoice and Likertscale items; over 50 professionals responded, of whom 76% were engineers affiliated with designers and contractors, split roughly evenly between design engineers in consulting firms and site engineers with contractors. To map circular activity in material flows, the team conducted walkthroughs and vendor interviews in 10 Karachi markets, focusing on suppliers of reused, refurbished, and recycled materials (availability, quality, sourcing channels, indicative price ranges, and demand trends), supplemented by observations from sector expos.

2.3.2. Market Trends

Structured interview findings suggest that the CE in the construction sector remains in its early stages globally, with considerable variation in the pace of progress across regions. Developed countries are more actively integrating recycled materials, modular designs, and waste reduction strategies into mainstream practice. Many developing nations, including Pakistan, continue to face structural challenges — including limited awareness, insufficient incentives, and weak regulatory frameworks — that hinder meaningful uptake.

That said, there is growing recognition of CE principles globally, with progressive developers increasingly incorporating energy-efficient systems, recycled materials, adaptive reuse, and design for disassembly. The rise of sustainable certifications, evolving government policies, and technological advancements are gradually steering the industry towards more sustainable practices. In Pakistan specifically, CE principles are gaining traction — particularly in fast-track projects where efficient resource utilization is a priority. Nevertheless, the sector remains in a transitional phase: interest is growing, but systemic change and widespread adoption have yet to follow.

The stakeholder dialogue conducted with the representative group of the Constructors Association of Pakistan (CAP), led by its nominated sector lead, shed light on a number of existing practices that are already aligned with CE principles. Participants noted that lightweight blocks are currently in widespread use, and that debris and reinforcement materials are now commonly recycled and reused across projects. Modular construction also featured in the discussion, with participants citing the use of precast concrete elements as a notable example of CE-aligned practice. Such approaches reduce material wastage during construction, and the structural elements themselves can subsequently be reused or recycled at the end of a building's life.

A particularly compelling dimension of circularity in Pakistan's construction sector is the informal material recovery culture that has long been embedded in demolition practices. It is common for contractors undertaking demolition work to salvage and resell materials — including reinforcement steel, window and door frames, tiles, and grilles — through established old-materials markets, where they find a second life most notably in low-cost housing. This reflects a deeply rooted culture of material recovery that predates formal CE discourse.

This mindset was illustrated through a case study shared by one of the participating contractor representatives. During the construction or rehabilitation of a fire escape, the designer specified a cantilever on the uppermost floor to be suspended using steel ropes. However, the specified rope type was unavailable anywhere in Pakistan, and importing it was deemed cost-prohibitive. The contractor proposed sourcing a used steel rope from Shershah Market — a well-known old-materials bazaar in Karachi. Samples were tested, the results proved satisfactory, and the consultant approved the substitution. To this day, that floor remains suspended by the repurposed rope — a testament to the practical ingenuity and resource efficiency that characterizes much of Pakistan's construction sector.

LEED certification requirements, where stipulated by clients, have also proven to be an effective market driver, as the certification framework awards significant credits for the use of sustainable materials — creating a tangible incentive for contractors to adopt more sustainable sourcing practices. Similarly, the World Bank IFC's EDGE programme (Excellence in Design for Greater Efficiencies) is gaining increasing traction among stakeholders as a globally recognized green building certification, standard, and free software tool. Using a data-driven approach, EDGE supports improvements in energy, water, and material efficiency, and facilitates collaboration among designers, developers, financiers, and policymakers. It offers location-specific insights, estimates green building costs, and aligns with international green finance standards including GRESB, ICMA, CBI, and CDP — adding both global credibility and marketing value to certified projects.

For CE practices to gain meaningful traction in Pakistan's construction sector, a coordinated, multi-stakeholder response is required. Awareness must be strengthened, beginning at the level of structured education, with organizations such as CAP playing an active role as industry catalysts. Academia, policymaking organizations, and programmes such as SWITCH-Asia should collaborate to design targeted interventions that strengthen Sustainable Consumption and Production (SCP) and circularity in the buildings and construction sector.

Research and innovation also warrant greater investment. Significant work is already underway globally — including large-scale testing in China of materials recovered from demolished structures. Given that recycling is a highly localized practice, dedicated funding and support for research and awareness initiatives tailored to Pakistan's context are essential. Ultimately, stronger collaboration between stakeholders, more robust financial incentives, and stricter regulatory frameworks are needed to make CE practices the norm rather than the exception.

2.3.3 Policy Support

The stakeholder dialogue with the Constructors Association of Pakistan (CAP) revealed a notable absence of strong policy support and tangible regulatory frameworks for promoting CE concepts, green buildings, and net-zero construction.

From a policy perspective, participants highlighted the need for taxation rebate schemes to incentivize the adoption of CE principles, as well as mechanisms to formally document and recognize CE practices within the building and construction sector. Faster regulatory approvals were cited as another potential incentive — a practical and relatively low-cost lever through which government could encourage businesses to embrace CE approaches.

On the regulatory front, a significant step forward has been the development of the Green Building Code of Pakistan 2023, produced by the Pakistan Engineering Council (PEC) in collaboration with a broad coalition of stakeholders including the Ministry of Climate Change (MoCC), the Pakistan Council for Architects and Town Planners (PCATP), the Ministry of Science and Technology, UN-HABITAT, ASHRAE, NED University of Engineering and Technology, the International Green Construction Code (IgCC), and the International Code Council. The Code embeds a range of CE-relevant requirements within green building design as a regulatory standard. Complementing this, the State Bank of Pakistan's (SBP) draft National Green Taxonomy has identified IFC EDGE as an applicable certification system for green buildings in Pakistan — an important step towards enabling sustainable finance in the sector, where the lack of reliable data on building energy performance has historically necessitated reliance on international standards and certifications to determine green eligibility.

Notwithstanding these developments, significant policy gaps remain. Participants put forward the following key recommendations for strengthening the policy environment:

- Substantial policy making is required for the promotion of CE concepts, including certifications related to green buildings, net-zero buildings, and related standards.

- The government needs to actively create the enabling environment for implementing CE principles in the building and construction sector. For example, the reuse of old or extracted materials by 1%, 2%, or 5% in new projects could be mandated — ensuring that CE principles are embedded in project planning from the outset. Such a requirement could initially be implemented in public sector projects as a first step towards broader adoption.

3. Capacities and Capabilities Assessment

This chapter assesses the extent to which key market actors in Pakistan's building and construction sector are currently equipped to adopt and scale circular economy practices. While policy ambition and pilot projects are important, the transition towards circularity ultimately depends on the operational readiness of those who design, procure, build, supply, and maintain buildings. The assessment therefore focuses on two actor groups that are particularly influential within the sector: national contractors and material suppliers.

3.1. National Contractors

Strengths: Pakistan's national contractors are gradually developing competencies in sustainable construction, driven primarily by external pressures – regulatory requirements, client demands, and the pursuit of international green building certifications – rather than an intrinsic, sector-wide commitment to sustainability. During the industry professionals survey, 88 per cent of 50 respondent stakeholders acknowledged their awareness of sustainability in general and sustainable construction in particular. In a separate query regarding familiarity with circular economy (CE) principles, approximately 80 per cent indicated they were either very familiar or moderately familiar with CE. Most respondents also expressed interest in participating in additional discussions or training sessions on CE practices in construction.

Qualitative evidence from structured interviews with potential sector leads corroborates this picture. Interviewees noted that contractors have demonstrated a growing expertise in waste minimization, material reuse, and energy-efficient construction, and that several firms are familiar with green building standards such as LEED. Contractors can follow and replicate innovative design or execution methodologies where contractual or regulatory obligations require them to do so, and such external factors act as meaningful incentives to adopt sustainable construction practices. Most contractors typically work in an energy-efficient manner, using low-cost and long-lasting building materials as well as prefabricated structures. Larger, more organized contractors are increasingly integrating advanced technologies such as Building Information Modelling (BIM) to optimize resource usage and improve project planning. Some firms are also investing in workforce training programmes to build green building skills.

Several projects cited by interviewees illustrate these emerging capabilities in practice. Bahria Town Karachi was highlighted for its use of recycled materials and energy-efficient infrastructure. LEED-certified projects in the industrial sector were noted as important reference points, alongside rehabilitation road projects incorporating asphalt waste, and specific buildings such as the Centre of Advanced Studies in Energy at NUST/USAID and the Pioneer Cement Head Office. All case studies discussed in Section 4 of this report further highlight contractor capabilities in implementing CE principles and reducing environmental impact (see Table 2). Whilst encouraging, these examples remain relatively isolated, largely concentrated in high-profile or internationally funded projects, and are not yet representative of standard industry practice.

Weaknesses: Despite this growing awareness, implementation falls significantly short. When asked whether they had implemented specific CE initiatives or practices within their construction projects, only 11 per cent of survey respondents confirmed they had done so — a stark gap between familiarity and action. Pakistan's construction industry continues to follow a linear take-make-dispose approach, and project design and planning stages have yet to be systematically refined to allow thorough assessment of possible CE applications.

Structured interviews reinforced this diagnosis. Interviewees highlighted that contractors maintain low-to-moderate sustainability competencies, and that progress remains largely reactive rather than proactive. Many firms continue to rely heavily on external consultants for sustainability strategies, pointing to a significant gap in in-house expertise. The slow adoption of advanced practices — including net-zero design, passive design, and CE methods — combined with pervasive cost sensitivity, further limits the sector's ability to embrace CE principles at scale. The following specific weaknesses were identified through both survey and interview evidence:

- **Limited in-house expertise:** Reliance on external consultants for sustainability strategies.
- **Slow adoption of advanced practices:** Net-zero, passive design, and CE methods remain uncommon.
- **Cost sensitivity:** Sustainability is frequently treated as an add-on cost rather than a standard practice.
- **Limited skilled workforce:** Training for workers in advanced green construction techniques remains insufficient.

Survey respondents identified the main challenges to CE implementation as follows. The most frequently cited challenge was lack of awareness, identified by 50.9 per cent of respondents — a finding that resonates strongly with insights from the Constructors Association of Pakistan (CAP) stakeholder dialogue. Many clients and end users remain unfamiliar with CE practices and are often hesitant to accept reused materials, preferring new products due to quality concerns and cultural preferences. Awareness is comparatively higher on the manufacturing side than on the execution side. Whilst the private sector demonstrates at least some familiarity with CE principles, meaningful implementation remains limited. The most significant gap lies in the government sector, which drives the majority of construction activity and funding in Pakistan yet exhibits the least engagement with CE principles and the fewest incentives to apply them.

Resistance to change from traditional practices was cited by 45.5 per cent of respondents — the second most prevalent barrier. This reflects broader cultural and institutional inertia within the sector, where entrenched ways of working, stakeholder risk aversion, and limited exposure to CE alternatives collectively slow the pace of transition.

Cost concerns were identified by 36.4 per cent of respondents. Whilst participants broadly acknowledged the long-term value of CE practices, many expressed the view that upfront investment carries substantial costs — a perception that remains a significant bottleneck to mass adoption, particularly among smaller contractors.

Limited availability of materials was flagged by 30.9 per cent of respondents, pointing to persistent supply chain gaps and an underdeveloped market for recycled and refurbished products. Insufficient infrastructure for material recovery and recycling further constrains progress, leaving the sector caught between growing awareness of CE principles and the practical conditions needed to act on them.

Regulatory challenges were cited by 18.2 per cent of respondents. Though the least frequently mentioned barrier, these are typically systemic and multidimensional in nature: a lack of compliance is often symptomatic of deeper issues, including weak regulatory frameworks, insufficient clarity among stakeholders, and inefficiencies in implementation and enforcement.

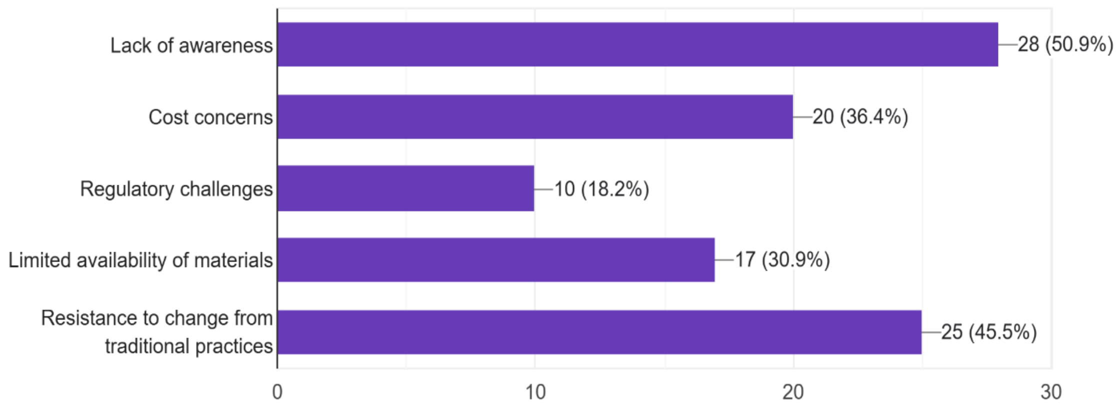

Figure 2 - Key challenges in circular economy principles in the construction industry

Structured interviews also shed light on the awareness and application of the 10R framework — Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover. The most frequently cited principles among interviewees were Reduce and Recycle, consistent with the existing sectoral focus on waste minimization and resource efficiency. One respondent emphasized Rethink; another highlighted Refurbish, Reduce, and Reuse as particularly impactful. The more advanced principles — such as Remanufacture, Refurbish, and Design for Disassembly — remain largely theoretical concepts within the

Pakistani construction context, their widespread application hampered by high initial costs, limited supportive infrastructure, and the absence of enforceable regulation.

Implications for circular economy uptake: A recurring theme across the structured interviews was the critical importance of integrating sustainability considerations as early as possible in the project lifecycle — specifically during the design and planning stages. Interviewees noted that early decisions on material sourcing and design for deconstruction directly shape outcomes at the execution and end-of-life stages, making front-loaded planning essential to achieving genuine circularity. Chief among the areas requiring improvement is the persistent dominance of a linear approach that prioritizes short-term cost efficiency over long-term resource stewardship. Interviewees specifically highlighted the need to shift towards:

- **Building lifecycle planning**, considering the full lifespan of structures from design through to deconstruction and material recovery.
- **Design for Deconstruction (DfD)**, enabling buildings to be dismantled efficiently at the end of their useful life with maximum material recovery.
- **Systematic material tracking and reuse strategies** across the full value chain.

The most frequently cited synergy was early collaboration between design teams, material suppliers, and contractors. This multi-stakeholder approach enabled the selection of eco-friendly, durable, and locally available materials, which led to measurable reductions in waste and improved cost efficiency over the project lifecycle. This finding underscores the value of shifting from siloed, sequential project delivery models towards integrated, collaborative approaches that embed circularity from the outset.

Survey respondents and interviewees broadly converged on the following priority areas for improving CE adoption:

- **Material Sourcing and Waste Management:** Increase use of recycled materials and improve C&D waste recycling systems.
- **Design for Durability and Disassembly:** Promote modular construction and design for reuse/recycling.
- **Reuse of Building Components:** Develop markets for reused materials and incentivize refurbishment over demolition.
- **Energy and Resource Efficiency:** Integrate energy-efficient systems and water recycling.
- **Policy and Regulation:** Implement mandates for recycled materials and provide incentives for circular practices.
- **Awareness and Collaboration:** Educate stakeholders and foster collaboration for closed-loop systems.
- **Digital Tools:** Use BIM and material passports to track and optimize resource use.
- **End-of-Life Management:** Shift from demolition to deconstruction for material recovery.
- **Communication:** Enhancing communication effectiveness amongst stakeholders and transferring focus from short term cost or time gains to long term benefits can support and promote such sustainable practices.
- **Promote Innovative Materials and Modular Construction:** Sustainable Building Materials, Energy efficient, Prefabrication & Modular Construction shall be promoted in the industry.

In the industry professional survey, respondents were asked about how contractors can enhance their skills in circular practices. Most respondents, i.e. 72% (see figure 3 below) think workshops/training sessions will enhance understanding or ability to implement CE practices.

Contractors think that presenting and involving stakeholders, clients (financing agencies, implementing & regulatory authorities), construction industry and government agencies in awareness activities related to CE in construction can improve the overall awareness.

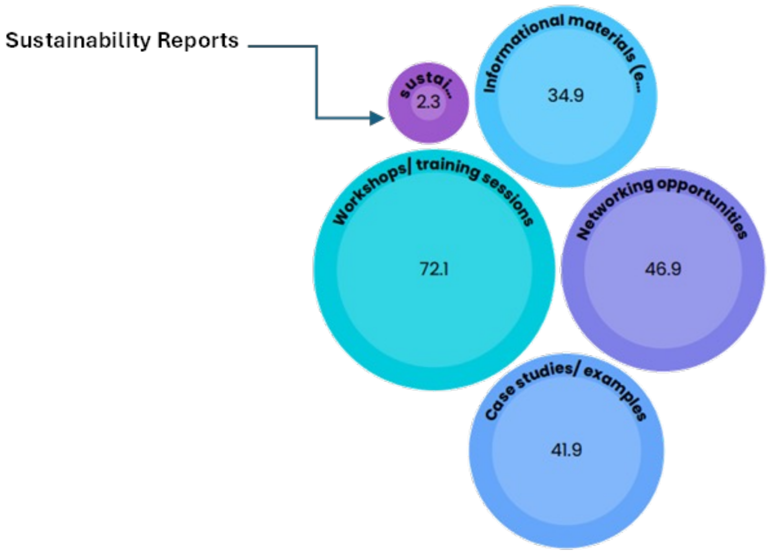

Figure 3 - Preferred methods for enhancing contractors' skills in CE practices

As per sector leads interview, respondents highlighted that contractors, material suppliers, and designers can enhance their skills in circular practices by:

- **Training and Education:** Attending workshops, courses, and certifications on CE principles.
- **Collaboration and Pilot Projects:** Working with industry experts and stakeholders to share knowledge and best practices. Collaborating with academia for pilot projects and open knowledge sharing amongst industry stakeholders, engaging in policy development at government level.
- **Adoption of Digital Tools:** Using BIM, material passports, and lifecycle assessment tools to plan for reuse and recycling.
- **Innovation of Materials:** Experimentation with recycled, bio-based, and low-carbon materials.
- **Designing for Disassembly:** Learning and application of modular and adaptable design techniques.
- **Staying Updated:** Follow industry trends, guidelines, and policies promoting circularity.
- **Socializing:** Connecting at conferences, industry forums and research initiatives related to the subject.
- **Creating a Forum for Capacity Building:** Creating a forum for capacity building and lesson learning, development of standards and regulations, and publication of best practices at industry level and case studies.

3.2. Material Suppliers

Strengths: Materials market survey (10) shows that recycled steel emerged as the most widely available material, with four vendors supplying it — significantly more than any other material category. Notably, the survey revealed that virtually every reusable material type is represented in the market in some form, suggesting that a baseline supply ecosystem for circular materials already exists, albeit at varying scales (see figure 4).

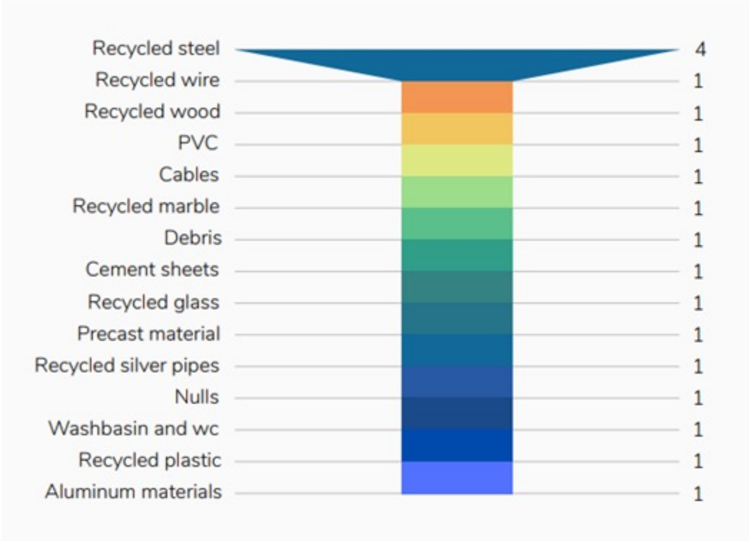

Figure 4 - Circular materials available in the market — number of vendors by material type

The radar analysis based on the material market survey (see figure 5) shows that steel bars are mostly considered reusable, i.e. a big portion of reclaimed/wastage from construction sites are supplied back to either material market for peripheral uses or supplied back to the steel mills for remanufacturing of steel.

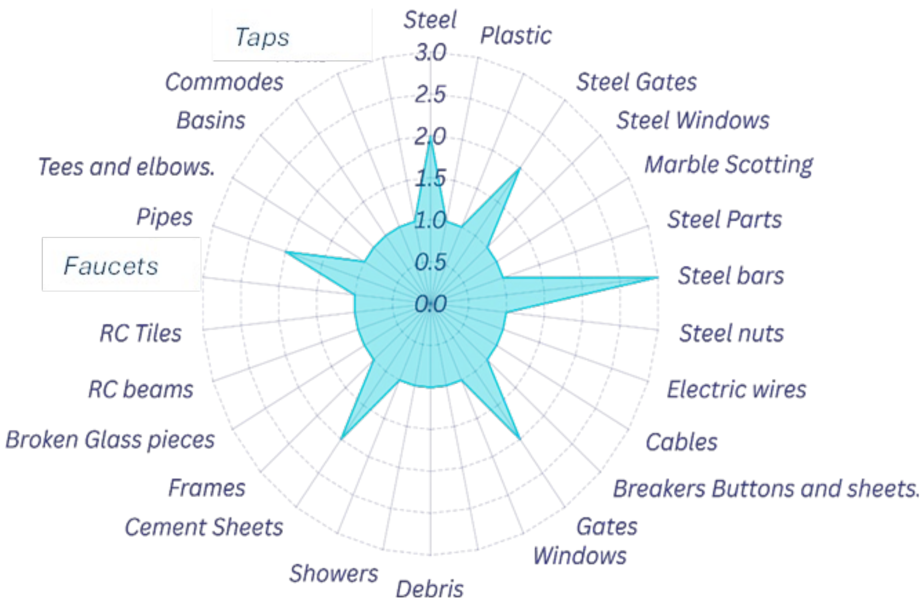

Figure 5 - Reusability of construction materials

Based on the industry professional survey, in relation to 10R principles of CE, the respondents highlighted (see figure 6) that the most reused (R3) materials are concrete and steel, the most repaired (R4) materials are asphalt concrete and steel, the most refurbished (R5) materials are wood and steel, the most remanufactured (R6) material are concrete and steel, and most recycled (R8) materials are plastic and steel. Therefore, it can be concluded that material suppliers are somewhat able to provide reused, repaired, refurbished, remanufactured, and recycled material to the construction industry.

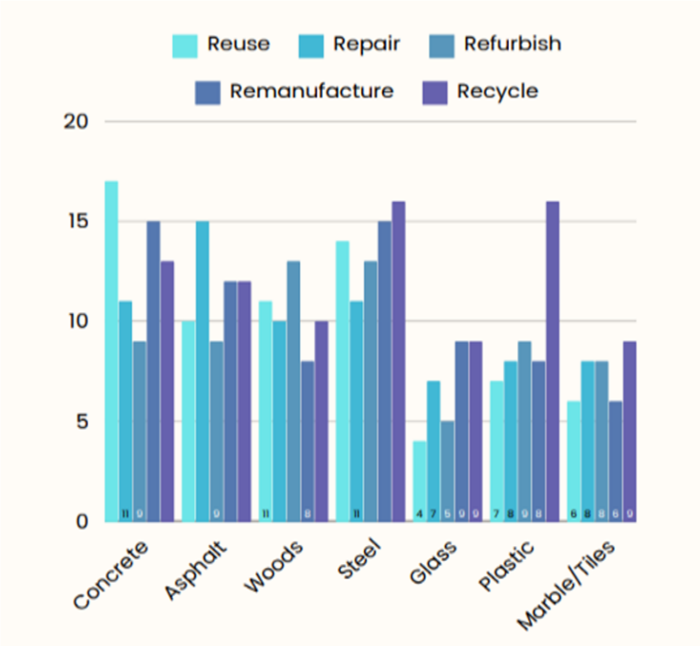

Figure 6 - Application of circular economy r-principles (reuse, repair, refurbish, remanufacture, recycle) across key construction materials

Weaknesses: In Pakistan's building and construction sector, several areas need improvement to fully embrace CE practices. Material reuse and recycling remain limited, as most construction waste is discarded rather than repurposed. There is also a lack of incentives and regulations promoting sustainable practices, making it challenging for builders to prioritize eco-friendly methods. Energy efficiency in buildings needs more attention, with a stronger focus on smart design, insulation, and renewable energy integration. Additionally, water conservation and waste management systems require better planning and implementation to reduce resource wastage.

Investing in training programs and awareness campaigns for architects, engineers, and contractors can help bridge the knowledge gap and encourage the adoption of CE principles across the industry.

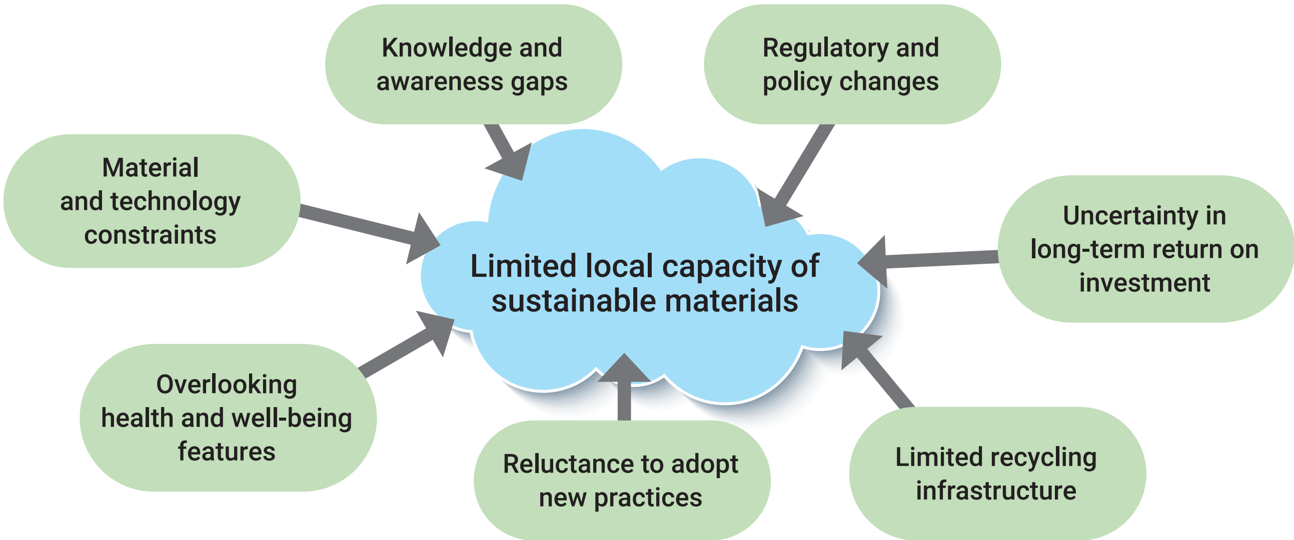

Figure 7 - Key barriers to local capacity for sustainable material supply in the construction sector

Sustainable material supply remains challenging for numerous parts of the world including developing economies because of multiple multidimensional barriers. In the material market survey, and case studies (structured interviews), and online experts survey, the following issues were highlighted:

1. The sustainable material manufacturing sector faces three main restrictions, namely insufficient research quantity, outdated processing methods and insufficient innovation development.
2. The adoption of sustainable materials experiences delays because professionals together with policymakers lack adequate training on sustainable materials.
3. Sustainable material investment is low because regulatory and policy modifications remain fragmented together with non-existent incentives.
4. Uncertainty in return of investment (ROI) – High initial costs deter developers despite long-term benefits.
5. The insufficient development of recycling systems requires communities to use new materials.
6. The influence of sustainable materials on building resident health receives insufficient examination.
7. Professionals in industry avoid new methods because they do not understand them and lack proper expertise.

Implications for circular economy uptake: Based on potential lead interviews, suppliers can play a key role by investing in eco-friendly materials and promoting alternatives to traditional construction resources. At the same time, consumers and investors should push for greener, more efficient buildings, creating demand for circular practices. Education and awareness campaigns are also essential to shift mindsets and encourage innovation in sustainable construction. By aligning efforts and making circularity a financially viable and regulatory-backed standard, the industry can move toward a more resilient and sustainable future. Suppliers also need to partner with other suppliers, recyclers, and designers to create closed-loop systems. During the design phase, collaboration between engineers and material suppliers to select recyclable and durable materials, which directly benefited the construction phase by reducing waste and optimizing resource use.

3.3. Overall assessment and key capacity gaps

The consensus among interviewees is that the CE in Pakistan's construction sector is still in its infancy. CE adoption is limited and largely restricted to a small number of high-profile or internationally funded projects. For most of the construction activity in Pakistan, CE remains a concept with very little actual implementation.

The sector continues to be characterized by a fundamental lack of understanding of the 10R framework, the absence of an integrated collaborative structure, and a pervasive linear mindset. The integration of building lifecycle planning, Design for Deconstruction (DfD), and systematic material tracking remain critical areas requiring immediate and sustained attention from all stakeholders.

Interviewees were united in their view that advancing CE in Pakistan's construction sector requires coordinated, multi-stakeholder action. The following recommendations emerged from the structured interviews:

For Government:

- Enforce green construction regulations and develop clear, binding standards for circular design.
- Provide financial incentives such as tax breaks and subsidies for the use of recycled and locally sourced materials.
- Invest in recycling and material recovery infrastructure to create enabling conditions for a circular construction economy.

For Industry Leaders:

- Champion the early collaboration model between design teams, suppliers, and contractors.
- Commit to pilot projects that test Design for Deconstruction (DfD) and modular construction approaches.
- Educate internal teams and adopt CE practices as standard business practice rather than a project-specific add-on.

For Other Stakeholders (NGOs, Academia, Civil Society):

- Drive awareness campaigns targeted both professionals and clients, recognizing that the industry ultimately responds to what clients demand.
- Support research and development into CE-compatible materials and construction techniques.
- Advocate for policy change that creates a level playing field for sustainable construction practices.

Critically, comprehensive training and awareness campaigns are required at all levels of industry to embed CE principles as regular, long-term practice. Without this cultural shift, circular economic adoption risks remain a niche concern, confined to internationally certified projects and driven by compliance rather than conviction.

4. Case Selection and Analysis

4.1. Criteria for Selection

Relevance: The major criteria of selection were:

- Cases which have or are under the process of certification as green buildings.
- Cases of companies which have past record of sustainable practices.

The screening of the project was done on the basis that it should have demonstrated any practice related to 10R principles during any lifecycle stage of the project from planning to demolition.

Diversity: All types of projects, including public buildings, residential buildings, commercial offices were selected.

All selected case study projects were in urban centers of Pakistan.

4.2. Case Studies

Project Overview:

#	Project name	Key details	Objectives
1	**SGS Pvt Limited Office cum Materials Laboratory**	SGS Pakistan (Private) Limited was established in 1952 as a subsidiary of SGS, the world's leading testing, inspection, and certification company. SGS has more than 2,700 laboratories and business facilities in 119 countries and employs around 99,250 professionals worldwide.	The project focuses on reducing environmental impacts - using double-glazed windows for energy efficiency, reused Air-Conditioned moisture and washbasin water for irrigation, and modular prefabricated components to reduce waste on site.
2	**Lakhani Presidency**	Lakhani Presidency is a major high-rise development, consisting of more than 400 apartments, which promise luxurious, comfortable, and peaceful living while at the same time availing residents with all the necessities.	The project in Karachi is one that incorporates many modern energy-saving technologies, including standby power generators, a reverse osmosis plant for proper water filtration, and large expanses of green spaces.
3	**SC Building**	The Shipping Corporation Building Project is related to the construction of new façade panels and rehabilitation of the basement slab at the 16th floor of the SC building located in Karachi.	Utilization of recycled marine plywood recovered from ships as façade panels exhibits commitment to sustainability and allows for testing scale-up of such approaches in other projects.
4	**Bank Female Hostel Building**	This facility is a ladies' residential building (hostel) that prioritizes comfort, privacy, and safety while meeting expectations for comfort and useful living space. Strategically located in Karachi.	The project focused on a reusable skylight canopy for natural lighting, the use of fly ash in concrete to reduce its carbon footprint, and durable, low-maintenance materials such as porcelain tiles that ensure the building's longevity.

#	Project name	Key details	Objectives
5	**International Financial Institution County Office Building (Name Embargoed) ***	The Office in Islamabad is a key venue for collaboration between the institution and Pakistan. It is LEED v4 Gold certified.	The project has commitment towards environmental sustainability, through energy efficiency, waste reduction, and sustainable use of materials. It also has the aspect of safety and resilience where seismic reinforcements, as well as blast-resistant elements, are in place, as observed and maintained to pass the test for modern safety requirements.
6	**Telecommunication Company Headquarters (Name Embargoed) ***	The Headquarters, located in Islamabad, is an eco-friendly corporate campus that exemplifies sustainability and energy efficiency.	Locally sourced materials, rammed earth walls, solar energy, and water recycling systems are applied in the building, which represents CE principle.
7	**Artistic Garment Industries (AGI)**	Artistic Garment Industries is a textile manufacturing industrial group having multiple facilities located in Korangi Industrial Area, Karachi, Pakistan, one of the country's largest and most important industrial zones. This area is a key hub for textile manufacturing, housing numerous factories that contribute significantly to Pakistan's exports.	This CE case study highlights a LEED-certified industrial facility in Pakistan that sets a national benchmark for green infrastructure. It demonstrates the integration of CE principles using recycled and locally sourced materials, solar energy, water recycling, and eco-friendly systems to reduce the carbon footprint. These sustainable practices ensure the facility meets top environmental and quality standards required by international clients.
8	**SIUT**	Regent Plaza Hotel and Convention Centre which is located on the main Sharah e Faisal in an area of 13,200 square yards, was transformed into a healthcare facility by the Sindh Institute of Urology and Transplantation (SIUT) signifies a pivotal development in the city's medical landscape.	Objectives were to utilize strategic location that offered easy access to patients, making it an ideal site for a healthcare facility. The acquisition aimed to add 1,000 beds, addressing the increasing demand for medical services, particularly in dialysis and transplantation. Repurposing the existing hotel building, thereby conserving resources and reducing construction waste.

* Case studies based on desk reviews

Following are brief summary of CE principles demonstrated in each of the case study projects:

4.2.1. Case 1: SGS Pvt Limited Office cum Materials Laboratory (SGS)

The SGS Pvt. Limited Office cum Materials Laboratory in Korangi, Karachi, demonstrates how a high-performance workplace can embed circular economy (CE) principles without compromising operational needs. Conceived as a testing, monitoring, and certification hub, the project applies "Rethink" and "Reduce" from the outset — optimizing space, standardizing assemblies, and right-sizing systems so that fewer materials deliver the same or better functionality. Modular and prefabricated elements further shrink on-site waste and rework while improving quality and speed of construction. On-site solar generation completes a whole-life approach to resource efficiency, lowering operational emissions and energy costs in a manner well-suited to Pakistan's grid and climate context.

Four lessons stand out from the SGS case. Early design choices are the highest-leverage intervention: by rethinking functions and reducing material intensity upfront, the project locks in lower embodied impacts and smoother future maintenance and adaptation. Modular and prefabricated delivery makes circularity compatible with cost and schedule pressures, while coupling efficiency measures with renewables produces durable operational gains. Finally, people and process matter — aligning clients, consultants, and contractors around CE objectives is essential to translate intent into procurement requirements, site practices, and verifiable outcomes.

Environmental and business impacts are mutually reinforced throughout the project. Prefabricated assemblies reduce construction waste, on-site solar cuts grid dependence, and upfront design choices curb material use — all contributing to a lower lifecycle carbon intensity. On the business side, these measures improve construction predictability, strengthen cost control, and position the asset as a credible sustainability exemplar, enhancing reputation with clients and regulators. The focus on maintainable, adaptable systems also supports occupant well-being and performance, an increasingly material factor for talent attraction in knowledge-intensive operations.

Collectively, the SGS project provides a replicable, context-appropriate blueprint for Pakistan's commercial and light-industrial buildings. It shows that CE can be mainstreamed through clear design intent, procurement alignment, and collaborative delivery — yielding measurable waste reduction and energy benefits while building organizational capability for future projects. For market actors, the practical pathway is clear: embed CE criteria in briefs and contracts, specify modular and maintainable assemblies, integrate renewables where viable, and use collaborative workflows to manage trade-offs.

4.2.2. Case 2: Shipping Corporation Building

The PNSC Building project in Karachi focused on replacing damaged façade panels and undertaking structural rehabilitation of a 17-storey 1970s building on M.T. Khan Road, near a marine environment. What distinguishes the project is its materials strategy: rather than using new reinforced concrete for the façade panels, the team substituted recycled marine plywood salvaged from ships — embodying several of the 10Rs. The 100% saturated recycled marine plywood proved well-suited to weathering conditions in the marine environment while preserving the building's historic aesthetic and functionality. The choice supported resource conservation, reduced demand for virgin materials, and showcased a low-carbon alternative aligned with Pakistan's sustainability objectives.

Several lessons emerge from this case. Maintaining the building's character while upgrading for sustainability underscores how adaptive refurbishment (R5) can meet both conservation and CE goals simultaneously. Implementation required consultant approval of material samples and close stakeholder coordination to resolve logistics for specialized materials — highlighting the importance of verification and collaboration in pioneering reuse strategies. As a precedent, the PNSC project suggests a scalable pathway for reclaiming marine-grade materials for architectural applications in coastal cities.

On the impact side, replacing reinforced concrete with recycled marine plywood reduced virgin material consumption and associated emissions, saved on material waste, reduced carbon emissions from new concrete production, and decreased steel reinforcement requirements. By reusing (R2/R8) material that would otherwise have been wasted, the project delivered a measurably lower ecological footprint while demonstrating how sustainable materials can replace traditional resources to meet the desired functionality and serve broader sustainability goals.

4.2.3. Case 3: Lakhani Presidency

Lakhani Presidency is a high-rise residential development of 400+ apartments on Stadium Road, Karachi, integrating CE principles across its lifecycle. Design choices were pivotal: eliminating chajjas and using "punch" windows reduced energy loss and improved daylight control, while durable finishes, low-maintenance textured exterior coatings, and porcelain tiles cut maintenance and replacement over the asset life. Water stewardship is addressed through a reverse osmosis (RO) plant and artificial turf, significantly reducing potable water demand and irrigation loads — a context-appropriate response to local water scarcity. Sourcing approximately 90% of materials locally reduced transport emissions and costs while supporting regional employment. Delivering in a sensitive urban context near an airbase and cemetery required careful planning and stakeholder coordination.

The project demonstrates multiple 10R levers — reduce, reuse, and recover — showing how circularity can align with resident comfort and developer economics. Circular benefits also accrue at end-of-life, where chosen assemblies facilitate material recovery of aluminium and glass. Together, these outcomes illustrate how mainstream high-density residential projects can combine measurable CE performance with long-term operational efficiency in water-stressed, constrained urban contexts, offering a replicable benchmark for similar developments in Karachi.

4.2.4. Case 4: Bank Female Hostel Building

The SBP Female Hostel in Karachi is a women's residential facility emphasizing comfort, privacy, and safety while embedding CE principles across design, construction, and future end-of-life. The project operationalizes circularity through three key levers: rethink, reduce, and reuse. Embodied impacts are reduced through fly-ash-enhanced concrete, while durable, low-maintenance finishes — including porcelain tiles and wood-plastic composites — extend service life and reduce maintenance waste and cost over the asset's lifetime. Although materials from the demolished structure were not reused, the project plans deliberately for future resource recovery by incorporating modular, reusable components, most notably a dismantlable skylight canopy that simultaneously maximizes natural daylight. Energy efficiency is addressed through double-glazed skylights and reflective window films that markedly reduce heat gain and cooling loads, lowering dependence on artificial lighting and mechanical cooling. Water stewardship is integrated via a dedicated system that repurposes non-potable water for flushing, conserving drinking water — a critical co-benefit in Karachi's water-stressed urban context.

Beyond the technical measures, the project demonstrates the value of embedding circular criteria early in the process. Planning for end-of-life recovery at the design stage increases future salvage value and reduces lifecycle costs, while a flexible layout allows future expansion without major structural intervention, further mitigating future embodied impacts. Local sourcing strengthens regional supply chains and lowers transport emissions, and prefabrication minimizes construction waste while accelerating delivery. Early stakeholder coordination proved important to resolve neighborhood sensitivities and logistical constraints, reinforcing the broader lesson that occupant-centric measures — daylighting, heat-control films, adaptable layouts — and process discipline together make the case for embedding circular criteria in briefs and approvals for institutional housing across Pakistan.

4.2.5. Case 5: International Financial Institution County Office Building

The International Financial Institution Country Office renovation in Islamabad integrates CE principles to achieve LEED v4 Gold, pairing energy and material efficiency with enhanced safety and resilience. Rather than rebuilding, the deep retrofit extended the building's life while minimizing waste and avoiding the embodied impacts of new construction — a core circular strategy. Upgrades included extensive structural reinforcement with seismic and blast-resistant elements aligned with post-2005 earthquake codes, high-efficiency HVAC and lighting, and improved insulation and services, delivering a modernized, durable asset aligned with local codes and global sustainability goals. Local material sourcing further supported the regional economy and reduced transport impacts.

The project demonstrates that safety and circularity reinforce rather than conflict with each other — seismic resilience and energy efficiency were integrated into a single comprehensive upgrade strategy. Energy-efficient systems and an improved building envelope lower operational emission, while structural reinforcements reduce future repair frequency, strengthening lifecycle performance. Multi-stakeholder coordination across government, civil society, the private sector, and regulators was essential to delivering outcomes aligned with green standards, and LEED v4 Gold certification provides third-party validation of performance, enhancing stakeholder confidence and organizational credibility. Early planning for certification and a comprehensive strip-back and upgrade approach are key lessons transferable to public and international organization facilities in seismic regions, where policy-aligned retrofits can cut lifecycle emissions and costs while enhancing occupant experience.

4.2.6. Case 6: Telecommunication Company Headquarters, Islamabad

The Telecommunication Company Headquarters is an eco-friendly corporate campus that integrates CE principles through locally sourced materials, passive design, and regenerative systems. Signature features include 100-foot rammed earth walls — among the tallest of their kind — which demonstrate a durable, low-carbon envelope adapted to local soils and climate, alongside extensive solar PV that reduces utility costs and carbon footprint. The scheme leverages the site's natural contours for energy efficiency, coupling daylighting and natural ventilation with efficient systems to reduce operational loads. Water circularity is addressed through rainwater harvesting and greywater recycling, increasing self-sufficiency and cutting potable demand, while stepwell-inspired water bodies reinforce water stewardship and place-based design. Local sourcing reduces embodied emissions and transport costs while supporting regional suppliers.

The campus exemplifies multiple CE levers — Refuse, Rethink, Reuse, and Recover — showing how circularity can coexist with high performance, comfort, and brand value at campus scale. Stakeholder alignment between the owner, architect, and execution teams was central to maintaining CE objectives through delivery. Key lessons include starting sustainability at the brief stage, continuous monitoring and adaptation during construction, and local material strategies to de-risk delivery. Strategically, the project sets a high-visibility benchmark for corporate sustainability in Pakistan, offering a replicable blueprint for campus-scale developments seeking to operationalize circularity through material choices, passive strategies, and integrated water-energy systems tailored to the country's climate and topography.

4.2.7. Case 7: Artistic Garment Industries (AGI)

AGI's LEED-certified industrial facility integrates CE principles through recycled and locally sourced materials, energy-efficient systems, solar power, water recycling, and operational eco-practices, with the overarching objective of cutting the carbon footprint while meeting international client standards. Site selection leveraged existing infrastructure for sustainable connections, and the project prioritized materials efficiency, modularity, and recovery planning to reduce waste during both construction and operations. Multiple CE levers were applied: Refuse (R0) and Reduce (R2) minimized construction waste; Reuse (R3) of structural components enhanced the longevity of building elements; and a systematic materials management approach targeted the recycling of waste materials arising from construction and teardowns. Recovery elements included solar panels, large windows for daylighting, and wastewater recycling, collectively reducing dependence on conventional energy and water sources. Governance was a distinguishing feature, with strong sustainability leadership, board oversight, and cross-functional coordination across engineering, operations, and procurement creating a robust implementation framework.

The results are quantifiable and significant: AGI reports a 20–25% reduction in energy use, approximately 30% reduction in freshwater consumption, and around 50% waste diverted from landfill. Over 200 workers were trained in sustainable practices, and diversity targets were met — demonstrating that CE implementation can build workforce capability alongside environmental performance. These outcomes translate into lower operating costs, a reduced environmental footprint, and stronger compliance with international buyer standards, enhancing market viability. As a national benchmark for green industrial infrastructure, AGI's integrated water-energy approach, modular materials strategy, and governance framework provide a replicable pathway for scaling CE across Pakistan's manufacturing sector.

The facility's green infrastructure was financed through private corporate capital. AGI is a privately held company and Pakistan's first B Corp-certified organization (B Lab Global, 2024). Its sustainability investments have been driven primarily by the requirements of international buyers, including Gap Inc. and Kontoor Brands (Sourcing Journal, 2024). For the newer LEED Platinum-certified Apparel Park — representing the next phase of AGI's green expansion — the company committed a $30 million private investment for the first phase alone (Sourcing Journal, 2024; TENCEL™ Carved in Blue, 2024). No public subsidy, concessional loan, or development finance institution support has been identified in publicly available sources, underscoring that AGI's green investment model is market-driven, with export-market access and buyer compliance serving as the primary financial incentive.

4.2.8. Case 8: Sindh Institute of Urology and Transplantation (SIUT)

The Sindh Institute of Urology and Transplantation (SIUT) exemplified CE principles through the adaptive reuse of Karachi's Regent Plaza Hotel, converting it into a 1,000-bed healthcare facility. This initiative aligns with the **"Repurpose"** and **"Reuse"** strategies of the CE by transforming an existing hospitality structure into a medical institution, thereby extending the building's lifecycle and reducing the need for new construction materials. Completed in July 2024, this strategic move not only minimized construction waste but also addressed pressing healthcare demands without the environmental cost of building anew. Challenges such as regulatory compliance, structural adaptation for medical use, and community engagement were effectively managed, demonstrating a replicable model for sustainable urban redevelopment.

The acquisition was financed through SIUT's charitable trust model, which draws on public donations, philanthropic contributions, and government support — reflecting the institution's long-standing commitment to providing free-of-cost healthcare. SIUT acquired the Regent Plaza Hotel from Pakistan Hotels Developers Limited (PHDL) for approximately Rs 14.5 billion (roughly $52 million at prevailing rates), with SIUT Trustee Syed Shabbar Zaidi confirming the offer publicly (Geo News, 2024). The project thus demonstrates an alternative financing pathway for CE-aligned adaptive reuse: charitable trust capital mobilized at scale (Arab News PK, 2024).

4.3. Key issue matrix, lessons learned, potential applications and impact assessment of case studies

Key Issue Matrix: The following issue matrix provides key insight into successes and challenges faced in the case study projects.

Table 1 – Key issue matrix for case study projects

Category	Issues Identified	Case Studies Affected	Impact/Remarks
Economic	Higher upfront costs for sustainable materials and renewable systems	All Case Studies	Increased initial project budgets, requiring long-term ROI.
	Rising costs due to market fluctuations	All Case Studies	Creates budget uncertainty and delays project timelines.
	Dependency on international supply chains for specialized materials, causing delays	SGS Pvt Ltd, World Bank Office	Risk of project delays due to import-related challenges.
	Limited budget allocation for advanced sustainable technologies	Lakhani High-Rise, State Bank Women Hostel	Restricts use of innovative practices and technologies.
Material Availability	Limited availability of recycled materials and eco-friendly technologies locally	State Bank Women Hostel, Lakhani High-Rise	Increases reliance on imported materials, affecting cost.
	Challenges in recovering and reusing materials during demolition	State Bank Women Hostel	Adds complexity and cost during deconstruction stages.
	Limited use of modular design	Telenor HQ, Lakhani High-Rise	Reduces flexibility for future adaptability.

Category	Issues Identified	Case Studies Affected	Impact/Remarks
Stakeholder Issues	Resistance to adopting new practices among stakeholders	SGS Pvt Ltd, World Bank Office	Delays project progress and adoption of sustainable methods.
	Limited local awareness about the benefits of circular economy principles	Lakhani High-Rise, State Bank Women Hostel	Slows stakeholder alignment and public support.
	Challenges in achieving stakeholder alignment on sustainability practices	SGS Pvt Ltd, World Bank Office	Requires more time for approvals, potentially delaying execution.
Regulatory	Potential regulatory changes affecting sustainable construction practices	World Bank Office, Lakhani High-Rise	Could require redesigns to meet updated regulations.
	Lack of clear guidelines on circular economy implementation	SGS Pvt Ltd, World Bank Office	Creates ambiguity in planning and execution.
Design Complexity	Potential design complexity increases time required for stakeholder alignment	SGS Pvt Ltd, World Bank Office	Leads to extended timelines and additional design iterations.
Energy and Resources	Limited renewable energy adoption	Lakhani High-Rise, SBP Hostel	Reduces long-term operational cost savings.
	Limited integration of advanced HVAC and passive cooling/ heating systems	Telenor HQ, Lakhani High-Rise	Increases energy consumption and operational costs.
	Noise pollution management inconsistencies	World Bank Office	Negatively impacts occupant well-being and comfort.
Sustainability	No LEED certification achieved	Telenor HQ, Lakhani High-Rise	Fails to meet global sustainability benchmarks.
	Gaps in biodiversity promotion	Telenor HQ, SGS Pvt Ltd	Reduces environmental benefits of projects.
	Limited integration of climate-resilient design	SGS Pvt Ltd, Lakhani High-Rise	Projects may not withstand extreme climate events.
Operational	Inconsistent focus on seismic resilience	Telenor HQ, Lakhani High-Rise	Projects may face structural challenges in seismic zones.

The primary objective of the Key Issue Matrix is to shed light on common challenges by looking at multiple case studies, identifying issues such as higher up-front costs, few sustainable materials available, and opposition from various stakeholders. It can thereby categorize these challenges under its main headings such as Economic, Regulatory, Stakeholder Issues, Design Complexity, Energy and Resources, Sustainability, and Operational issues. Furthermore, by relating these issues to specific case studies, the matrix offers practical recommendations, which may be useful for future projects to identify areas for improvement. The matrix indicates several critical challenges, some of which are given below:

1. **Economic Issues:** The case studies presented a general problem of the high initial investment costs for sustainable materials and renewable energy systems. This also included an international supply chain dependency on specialized materials, bringing delays and the risks of investing.

2. **Stakeholder Issues:** Resistance to adopting new practices and very limited local understanding of the importance of CE principles slowed down the progress in projects as well as stakeholder alignment.
3. **Regulatory Challenges:** Vagueness in guidelines for CE implementation and potential regulatory changes created uncertainty, requiring additional time for approvals and potential redesigns.
4. **Sustainability Gaps:** Low renewable energy adoption rate, lack in biodiversity promotion opportunities, and discontinuity in pursuing climate-resilient design characterizes some inadequacies among projects against overall sustainability benchmarks for the world at large.
5. **Operational Challenges:** Lack of focus towards seismic resilience, and the material recovery stage at the end-of-life have indicated some missed opportunities toward CE goals.

The core challenge highlighted based on the issue matrix developed through case studies is balancing sustainability with feasibility while adopting CE principles.

Figure 8 - Balancing sustainability with feasibility

Sustainability aims to lower environmental effects and encourage long-term resource efficiency whereas feasibility guarantees practical, inexpensive solutions in line with the market trends. This convergence presents many obstacles that need to be addressed for sustainable projects to be significant and impactful. This core challenge/issue is derived from several sub-issues/challenges as evident from the illustration in figure 8. Each of these sub-issues/challenges are explained as follows.

1. Sustainable solutions often will require new technologies, innovative materials and construction methods that come with significantly higher front-end costs.
2. Limited Local Resources often result in many regions not having access to sustainable materials and technologies, thus having to import costly alternatives or makeshift solutions that could compromise sustainability objectives.
3. Resistance from Stakeholders through unfamiliarity, risks, or fears about the return on investment will prevent developers, policymakers, and investors from accepting sustainable practices.
4. Knowledge and awareness among industry professionals and end-users represent the greatest barrier to sustainability adoption.
5. Integrating sustainability into building design involves difficult calculations, material selection, and compliance with the developing standards.
6. There are still many professionals who lack specialized training in green building techniques. This challenge can be addressed by investment in education and skill development programs.
7. The transition of renewable energy sources in construction industry is low, due to the technical limitations and cost implications (see box below).

8. The uncertainty for the businesses and investors is created due to the frequent shifts in the government policies, incentives and regulations, for which it is essential to have a stable regulatory framework for long term planning and investment in green infrastructure.
9. Due to the unavailability of many of the sustainable materials and technologies, there is an increase in reliance on the imports which leads to higher cost and creates vulnerability in the supply chain.
10. The investment in green projects is highly affected by economic instability and fluctuating demand for sustainable products.

Box: Solar power generation at household/buildings level in Pakistan

All components required for solar power generation are currently imported, which is viable in certain cases but not in others. Additionally, the reliance on battery storage for energy raises concerns regarding both the high cost of batteries and the limitations on achievable storage capacity. For on-grid solar systems, compensation through net metering is provided, but it is not equivalent to the per-unit price at which electricity is sold. As a result, from a broader perspective, it is challenging to conclusively determine the feasibility of cost implications. At an individual level, solar systems may be viable; however, the significant upfront investment required for installation poses a barrier, particularly for households with limited financial capacity. Therefore, the matter remains complex and warrants further investigation, which lies beyond the scope of this report.

Lessons Learned: Following are (generally) four key lessons learned from case study projects.

- Case studies highlight both material waste reduction and resource maximization as essential aspects.
- Case study projects exhibited CE practices that included rethinking in design, alongside waste reduction and material reuse and recycling concepts. Operational emissions and energy usage reduction became possible through multiple projects which adopted renewable energy solutions with energy-efficient technologies.
- Water scarcity affects numerous regions thus these projects developed innovative water preservation systems and wastewater recycling solutions to overcome this problem.
- The case study projects tried to incorporate sustainable construction materials and methodologies such as modular construction which extended building lifetime since they required minimal maintenance for lower long-term expenses.

Potential Applications: Following points describe potential application of CE principles and 10R framework in future building and construction projects based on lessons learned from case studies:

- Different construction sites should employ modular construction methods combined with prefabrication techniques as well as using locally obtained recycled materials to achieve lower environmental waste creation throughout their projects. Construction waste presents a significant problem in urban areas, and these approaches can significantly reduce this problem.
- The CE 10R principles can be adopted by different projects through product disassembly planning in design phase as well as selection of recycled materials and component return strategies. The method achieves three goals by using fewer resources while lowering waste generation and sustaining systems for the long term.
- Future building projects should focus on creating designs which adapt to changing requirements through their flexible functionality.
- New upcoming ventures should incorporate renewable generation systems together with energy-efficient equipment like innovative HVAC equipment and heat retention technologies and natural illumination systems to reduce energy requirements and facility expenses. High energy demand locations together with weak power systems require special attention for energy efficiency improvements.
- Several water-efficient measures and water conservation methods must be integrated into water-scarce regions to establish sustainable water utilization practices.

- Future projects should select durable products that maintain well and align with environmental standards. The reduced requirement for maintenance helps decrease operation costs and minimize environmental burden for the structure during its complete life cycle.

Impact Assessment: The following table 2 summarizes contribution of the case study projects towards reducing environmental impact.

Table 2 – Impact assessment of case study projects

Case Study	Location	Key CE Implementation	Environmental Impact
SGS	Karachi, Pakistan	• 600 kW solar panels reducing reliance on fossil fuels • Recycled water for irrigation • Prefabricated modular construction	• Lower carbon footprint • Reduced water wastage • Sustainable material usage
Shipping Corporation Building	Karachi, Pakistan	• Use of marine plywood from salvaged ships. • Not using new reinforced concrete for the façade panels	• Lower material consumption. • Significant CO_2 savings
Lakhani	Karachi, Pakistan	• RO plant for water recycling • Punch windows reducing artificial cooling needs.	• Significant water savings • Reduced energy Consumption.
Bank Female Hostel Building	Karachi, Pakistan	• Double-glazed skylight for natural lighting • Reflective window films reducing heat absorption • Fly ash in concrete for lower carbon footprint • Water recycling for flushing	• Reduced energy consumption • Lower material waste • Water use efficiency
International Financial Institution County Office Building (Name Embargoed) *	Islamabad, Pakistan	• High-efficiency HVAC and insulation. • Improved insulation using locally sourced materials.	• Reduced energy consumption. • Minimal waste generation.
Telecommunication Company Headquarters (Name Embargoed) *	Potohar Plateau, Pakistan	• Solar panels for renewable energy • Rainwater harvesting and greywater recycling systems. • Passive cooling as well as lighting design.	• Reduced energy consumption • Minimized waste • Enhanced water conservation
Artistic Garment Industries (AGI)	Karachi, Pakistan	• Minimize construction waste and use it again after recycling. • Reused structural components • Energy-efficient systems with solar panels, large windows to utilize daylighting and recycling of wastewater. • Advanced resource management while implementing sustainable water and energy solutions	• Reuse and Recycle Construction waste • Energy Efficiency and resource recovery. • LEED Certification (green building certification)

Case Study	Location	Key CE Implementation	Environmental Impact
Sindh Institute of Urology and Transplantation (SIUT) *	Karachi, Pakistan	• Repurpose and reuse strategies of the CE by Transforming an existing hospitality structure into a medical institution	• Extended building lifecycle • Reducing the need for new construction and hence reducing carbon footprint.

* Case studies based on desk reviews

Incorporation of CE principles aspects such as, locally sourced materials, solar energy, and water recycling were part of all case studies. The innovative features include rammed earth walls and stepwell-inspired water bodies. Further best practices are reduced energy consumption through natural lighting, ventilation, renewable energy systems and future adaptability and material recovery plans by reusing steel, wood, light fixtures, dismantling canopies.

5. Contextual Insights

5.1. "10R" Framework Application

5.1.1. Implementation Examples

The following table 3 summarizes the implementation of 10R principles of CE that were implemented in the case studies.

Table 3 - 10R principles of CE that were implemented in the case studies

10R/Case Studies	SGS	Shipping Corporation Building	Lakhani	Bank Female Hostel Building	International Financial Institution County Office	Telecommunication Company	Artistic Garment Industries (AGI)	Sindh Institute of Urology and Transplantation (SIUT)
R0 Refuse		✓				✓	✓	
R1 Rethink	✓	✓				✓		
R2 Reduce	✓	✓		✓	✓		✓	
R3 Reuse	✓		✓	✓		✓	✓	✓
R4 Repair		✓						
R5 Refurbished		✓			✓			
R6 Remanufacture								
R7 Repurpose	✓						✓	✓
R8 Recycle		✓	✓	✓		✓		
R9 Recover	✓		✓			✓	✓	

Summary of CE Principles Demonstration: The case study projects demonstrated the application of all CE principles except for R6 – Remanufacture. The most implemented 10R principles as evident through case studies' analysis, include R2 – Reduce, R3 – Reuse, and R8-Recycle, and R9-Recover. The principles of R1- Rethink and R7 -Repurpose were also evident. Wherever, principles of R2-Reduce, and R3-Reuse were implemented, those were related to material use. Most of the time, the R8 was incorporated through rethinking in design process for probable recovery at the time of deconstruction, while R9 recovery was linked with renewable energy generation, RO Water plant system, and rainwater harvesting incorporated into building design. Furthermore, three case studies were of repurposing of an existing building for a different purpose (abandoned industrial building into a commercial office, hospitality to health institution building), while in case of two other buildings (SC, and International financial institution head office Office), R5- Refurbishment principle was implemented. Altogether, the implementation of 10R principles highlights the potential for sustainable design to reduce environmental impacts while promoting long-term resource efficiency.

5.1.2. Challenges and Solutions

As per case studies, two core issues were identified, i.e. balancing sustainability with feasibility (specifically economic), and limited local capacity of sustainable materials. These issues are derived from various sub issues. As per expert's survey, implementing the 10R framework of CE in Pakistan faces several challenges, primarily due to a lack of awareness, cultural resistance, cost barriers, infrastructure gaps, supply chain issues, and weak policies.

- **Lack of Awareness:** Limited understanding of circular economic principles among stakeholders. Many businesses and consumers are unfamiliar with concepts like Refuse, Rethink, and Reduce, which require a shift in mindset towards sustainability.
- **Cultural Resistance and Mindset:** Preference for traditional, linear methods over innovative, circular approaches. Many consumers prefer new products over recycled ones due to quality concerns and cultural preferences, making it harder for businesses to invest in circular production. Thus, current mindset lacks understanding of key concepts and technical constraints.
- **Cost Barriers:** Higher initial costs for sustainable materials and technologies. Practices are deemed cost and time consuming as they deviate from the traditional or "comfort" way of doing things. Lack of its integration with local building code also is a probable reason for fear amongst designers to think innovatively.
- **Infrastructure Gaps:** The absence of proper waste management systems makes it difficult to collect, sort, and repurpose materials, leading to excessive landfill waste instead of promoting Remanufacturing and Repurposing. There's insufficient recycling and waste management facilities. Therefore, high initial costs and a lack of technological advancement further discourage companies from investing in sustainable solutions.
- **Supply Chain Issues:** Difficulty in sourcing and integrating recycled materials. Another significant hurdle is the limited market for recycled and refurbished products. Moreover, supply chain inefficiencies and outdated manufacturing processes hinder the large-scale adoption of Recycle and Recover strategies. Without proper infrastructure and government support, industries struggle to implement CE principles effectively.
- **Policy Weakness:** Absence of strong regulations and incentives to promote circular practices. There are no strong regulations or incentives encouraging industries to adopt circular practices such as Reuse, Repair, and Refurbish.

To overcome these challenges, Pakistan needs strong policy enforcement, investments in recycling infrastructure, and consumer awareness programs to drive a shift towards a more sustainable and resource-efficient economy.

To bridge the gap between sustainability and feasibility, several key strategies can be implemented:

- Life-cycle assessments enable the evaluation of sustainable investments by showing future expense cost reduction.
- BIM technology optimizes building decisions through resource management improvements while delivering solutions through its integrated system.
- Stakeholders will participate in private-sector operations through the development of policy frameworks that include incentives
- Professional courses designed to establish sustainability knowledge about construction for students and practitioners need to be developed by educational institutions.
- Research promotion is needed for both developing affordable sustainable materials from local sources and sustainably pricing them efficiently.
- Advocating consistent and supportive government policies for green infrastructure.

By addressing these challenges and implementation of strategic solutions we can achieve practical sustainability relationships enabling responsible environmental management and a viably economic development.

With regards to Limited local capacity of sustainable materials, several key strategies can be implemented, as follows:

- Progressive innovation can be achieved by developing sustainable material technologies and practices.
- The government should give sustainable construction advantages through tax benefits and funding support along with stable administrative guidelines.
- A strong and durable local infrastructure for sustainable material production and recycling needs development through established cooperative agreements.
- Reverse environmental consequences are vital and therefore construction professionals must adopt sustainable principles during their academic studies and professional training sessions.
- Strategic improvements to waste material management systems will achieve highest efficiencies in resource consumption.

5.2. Integration Across 6 Stages

Across the construction lifecycle, CE principles can be embedded as an intentional sequence of design and management choices. At the urban planning and zoning stage, CE begins with refusing and rethinking unnecessary new builds by prioritizing adaptive reuse and brownfield-first development, zoning for district-scale systems (shared energy, water reuse) and safeguarding space for reverse logistics and material recovery hubs. During planning and design, teams apply design for disassembly and adaptability, standardize modular grids and dry connections, right-size structures to reduce materials, and use BIM with LCA and material passports to optimize embodied/operational impacts and plan future recovery. In material extraction and manufacturing, circularity advances through recycled and renewable feedstocks, remanufactured components, clean production (renewable energy, water recirculation), and verified traceability to ensure quality and safety. The construction and logistics phase emphasizes lean construction and offsite prefabrication to cut waste, just-in-time deliveries and digital inventory to reduce damage/over-ordering, on-site segregation and take-back contracts for packaging and offcuts, and temporary protection methods that enable future recovery of finishes and components. During operations, facility managers reduce consumption through commissioning and performance tuning, extend asset life via predictive maintenance and repair/refurbish programs, adopt product-as-a-service models with take-back/remanufacture provisions, and engage occupants in circular procurement and waste segregation. At end-of-life, pre-demolition audits identify salvageable components and set recovery targets, selective deconstruction replaces destructive demolition, verified resale channels move reclaimed products back into the market, and reverse logistics connect recovered materials to manufacturers and new projects closing the loop.

Decisions made upstream unlock circular value downstream, and robust data flows bind the stages into a coherent system. Early planning and design choices such as modularity, standardized interfaces, and non-destructive fixings directly determine salvage yields and resale value at deconstruction, while circular procurement commitments (recycled content, take-back) create stable demand that enable suppliers to invest in remanufacturing capacity. Material passports created in design and updated during construction are carried forward into operations for targeted maintenance and safe repairs, then inform efficient deconstruction audits and verification of reclaimed components; BIM/LCA insights guide both operational setpoints and future design templates, creating continuous learning loops. Contracts that include take-back and refurbishment link construction and operational waste streams back to manufacturers, while regional “urban mining” depots aggregate recovered components for designers and contractors, strengthening local secondary markets. Post-occupancy evaluations feed performance data into next-generation specifications, and deconstruction lessons refine design-for-disassembly rules, improving future recoverability. Finally, aligned policies and finance such as recovery targets in permits, tax incentives, and fast-track approvals reinforce circular outcomes across the chain, while capability-building (training installers on reversible connections, early client-designer-contractor-supplier collaboration) compounds benefits at every stage and reduces the perceived risk of using reused or remanufactured components.

Box: Starting points across stakeholder groups

To initiate a systemic change towards a circular building/construction sector in Pakistan, the national government could require pre-demolition audits and minimum recovery rates or have them incentivized or mandated for projects above a certain threshold; furthermore, integration of CE criteria in approvals and public tenders could be promoted, or tax rebates/fee reductions for verified circular content offered; fast-track refurbishment and adaptive-reuse projects.

Industry leaders could initiate to standardize integrated design and design-for-disassembly, include take-back/remanufacture clauses in contracts, deploy BIM/LCA/material passports across major projects, and publish selective-deconstruction and reuse outcomes

Financiers and insurers could expand CE-linked lending and recognize warranties for reused/remanufactured components.

Cities and asset owners could set portfolio-level CE targets and establish urban-mining depots and reverse-logistics hubs.

Academia/professional bodies could co-design accredited CE training and localized LCA databases.

EU programs, especially EU SWITCH-Asia can accelerate these actions through technical assistance for policy and procurement reform, grant-funded pilots and twinning, B2B matchmaking with EU technology providers, and alignment with green finance frameworks to crowd in capital and strengthen cross-border collaboration.

6. Conclusion

Pakistan's construction sector is in a clear transition toward circularity: awareness is high and growing, early pilots are demonstrating feasibility, and market interest is building yet adoption remains uneven due to policy gaps, limited incentives, supply-chain constraints, and capability bottlenecks. Over the course of this project, stakeholders moved from general familiarity with "green" ideas to more concrete applications of the 10R framework, particularly Reduce, Reuse, Recycle, and Recover. Design choices (e.g., modularity, disassembly), smarter procurement, and better data (BIM/LCA/material passports) began to link isolated practices into end-to-end approaches, while dialogues among contractors, suppliers, and designers improved the practical understanding of "what works" in Pakistan's urban context.

Key Takeaways

- Design is the prime leverage point: decisions made early (DfD, modularity, materials, performance specs) determine downstream waste, recoverability, and cost.
- Public procurement can unlock scale: clear CE criteria, recovery targets, and fast-track approvals create predictable demand that the market can organize around.
- Data is the circulatory system of circularity: BIM + LCA + material passports enable optimization in design, informed O&M, and high-value recovery at end-of-life.
- The market for secondary materials exists but needs formalization: Karachi's reuse/recycling ecosystems can be strengthened with standards, warranties, and traceability.
- Capacity gaps, not just costs, slow adoption: targeted training for designers, site teams, and facility managers converts awareness into on-site execution.

Future Directions

To advance CE principles and sustain progress, Pakistan should embed circularity in building codes and public procurement, set phased construction and demolition (C&D) recovery targets, and introduce fiscal incentives for circular content and refurbishment; develop verified markets and take-back/remanufacture agreements with clear quality standards; pair bankable pilot projects with green finance and publish performance data; mainstream LCA and material passports and link them to O&M systems and deconstruction audits; scale continuing professional development and integrate CE into university and vocational curricula; and measure and disclose embodied/operational carbon, waste intensity, and recovery rates to drive continuous improvement and investor confidence.

These insights suggest that aligning policy, procurement, and project delivery around measurable CE outcomes can accelerate diffusion and reduce perceived risk.

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