Applying a Life Cycle Lens to India's Buildings Sector

A reflection on decarbonisation gaps and stakeholder roles

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Divya Davis | Ramya Natarajan | Kunal Jagdale | Sweta Bhusan | Kaveri Ashok

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Editor: Shayantani Chatterjee

Designer: Alok Kumar Saha

Bengaluru
No. 18, 10th Cross, Mayura Street
Papanna Layout, Nagashettyhalli
RMV Stage 2, Bengaluru 560094
Karnataka (India)

Noida
1st Floor, Tower-A
Smartworks Corporate Park
Sector 125, Noida 201303
Uttar Pradesh (India)

Tel.: +91 (80) 6690 2500

Email:cpe@cstep.in

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Contributors

1. Dr Sameer Maithal (Independent clean energy and sustainability practitioner)
2. Surjyatapa Ray (Jana Urban Space Foundation)
3. Tarun Jami (GreenJams)
4. Rupa Malireddy (Creaste)
5. Lakshmi Venugopal (EDS Technologies)
6. Sriram Kuchimanchi (Smarter Dharma)
7. Anurag Tamhankar (Biome Environmental Solutions)
8. Vidushi Gupta (Biome Environmental Solutions)
9. Akshatha Narayana (Rainmatter Foundation)
10. Gauri Gore (BBLOX Design)
11. Sandeep Doddaballapur (Environmental Design Solutions)
12. Arundhati Sett (EcoCollab)
13. Sunbul Shafaque (EcoCollab)

This is one of our initial forays in integrating a systemic approach to decarbonising India's building's sector, and we are thankful to Sustainability, Equity and Diversity Fund (SED) for their continued support and collaboration. Going forward, we aim to deepen our engagement by conducting a comprehensive life cycle assessment on the affordable housing sector, encompassing design, material selection, construction practices, operation, maintenance, retrofitting, and end-of-life management. This approach will enable us to better assess the sector's carbon footprint and contribute to its decarbonisation by working closely with concerned stakeholders.


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1. Table of Contents

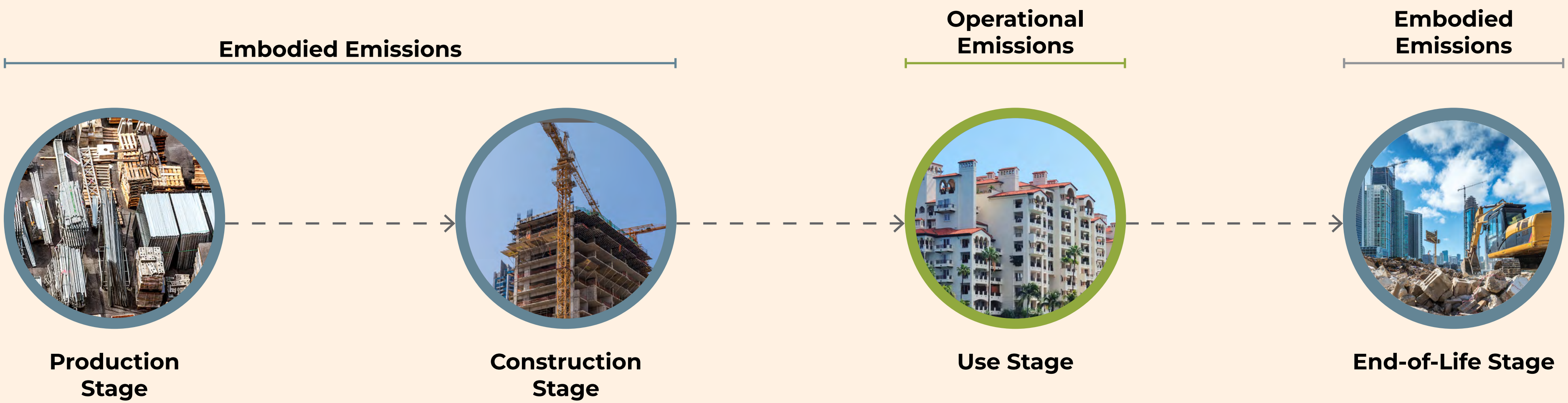
1. Introduction

India's buildings sector currently contributes to 32% of the country's total electricity demand (Ministry of Power, 2024) and accounts for 26% of its greenhouse gas (GHG) emissions as of 2021 (Kumar et al., 2021). The sector plays a pivotal role in the country's development story and is expected to grow exponentially in the coming decades. Driven by rapid urbanisation, demand for new housing continues to surge; the sector must be equipped not only to fulfil people's rising aspirations but also to uphold the principles of sustainable development. Being a major driver of economic growth, the real estate industry was projected to generate employment for about 28 million people by 2025, as per the trends during 2018–2022 (National Skill Development Corporation, 2022), while it already contributes significantly to resource consumption, energy demand, and carbon emissions. In addition to its economic and environmental significance, the buildings sector is instrumental in supporting human well-being by ensuring access to adequate shelter and maintaining thermal comfort, which are increasingly important in the face of rising temperatures and climate variability.

Although the buildings sector offers immense potential to integrate climate action and promote sustainable practices, it continues to face persistent challenges. These include slow adoption of innovative technologies, market scepticism regarding new approaches, fragmented data and information, informal working systems, entrenched systemic inertia, and a frequent disconnect between policy frameworks and their implementation. Addressing these barriers is critical to ensuring that the sector's transformation aligns with the country's climate commitments and future development goals.

2. Understanding the Sector at a Systemic Scale

Understanding the impact of the built environment requires a holistic approach that considers the entire value chain, encompassing all four stages of its life cycle—production, construction, use, and end of life. This life cycle analysis, conducted on a systemic scale, examines the collective patterns, interdependencies, stakeholder roles, and policy levers that shape outcomes across an entire city, a region, or a nation. This macro perspective reveals how decisions in one stage, such as adopting sustainable materials in construction or enhancing passive design in operation, can cascade through supply chains and energy systems. By linking building-level performance to broader economic, industrial, and social systems, this systemic-level approach can enable decision makers and innovators, including investors, building owners, policymakers, industry leaders, and urban planners, to identify high-impact interventions, thus aligning the buildings sector with the net-zero pathway.



3. Scope

The built environment is shaped by intricate dynamics and is characterised by layered interactions and interdependencies across stakeholders, policies, technologies, resource flows, and the spatial contexts in which it is situated, whether urban, rural, or peri-urban. To situate this analysis, we examined the residential buildings sector in Karnataka, which is recognised for its progressive stance with targeted policies in achieving measurable reductions in grid electricity demand and significantly expanding the built-up area under certified green buildings. The total residential built-up area of the state is projected to nearly double by 2050 compared to 2020 (CSTEP, 2025). Focusing on the state's residential segment provides an opportunity to assess the agency of diverse stakeholders, the effectiveness of governing policies, and the systemic challenges that influence the trajectory towards a more sustainable built environment.

This work builds on the knowledge and advances gained during the development of the *Namma* SAFARI (Sustainable Alternative Futures for India) model, Karnataka's first integrated system dynamics modelling framework, developed by CSTEP. The model captures interactions across key sectors, such as power, transport, industry, agriculture, buildings, and land use, and projects the state's energy demand and emission trajectory through 2050.

The model helps explore long-term low-carbon development pathways and supports policymakers and other actors in simulating real-world policies (such as rooftop photovoltaic [RTPV] deployment); assessing cross-sectoral impacts (including land constraints and material requirements); and identifying high-impact levers for renewable energy integration, electrification, and energy-efficiency measures. For instance, in the buildings sector, the adoption of passive cooling strategies, green building codes, and large-scale RTPV can collectively reduce electricity demand by nearly 25% by 2050. Thus, the tool strengthens evidence-based planning and supports Karnataka in advancing its development priorities alongside its climate commitments (CSTEP, 2025).

This report highlights the practical challenges in transitioning to such a (modelled) low-carbon pathway based on engagements with a diverse set of stakeholders.



CES Goal: Low Emissions, High Well being




the material's production
and construction phases of
the lifecycle before the
building is occupied.




4. Engaging Stakeholders for a Unified Vision

Acknowledging the responsibility for enabling low-carbon buildings lies with all stakeholders in the ecosystem, from manufacturers, developers, engineers, and architects to end users. There is an urgent need to address the lack of a unified vision for a low-carbon built environment, especially at sub-national levels. To this end, the Center for Study of Science, Technology and Policy (CSTEP) conducted a set of one-on-one consultations and a roundtable event to bring together people representing various stages of the building life cycle to analyse how the gaps and their root causes can be systematically defined and addressed. The session was centred on Karnataka's buildings sector as a case study, structured on the four stages of the building life cycle, and surfaced diverse stakeholder perspectives across these stages. Discussions focused on identifying conflict points, understanding individual priorities, and exploring potential pathways to guide progress towards a sustainable future.

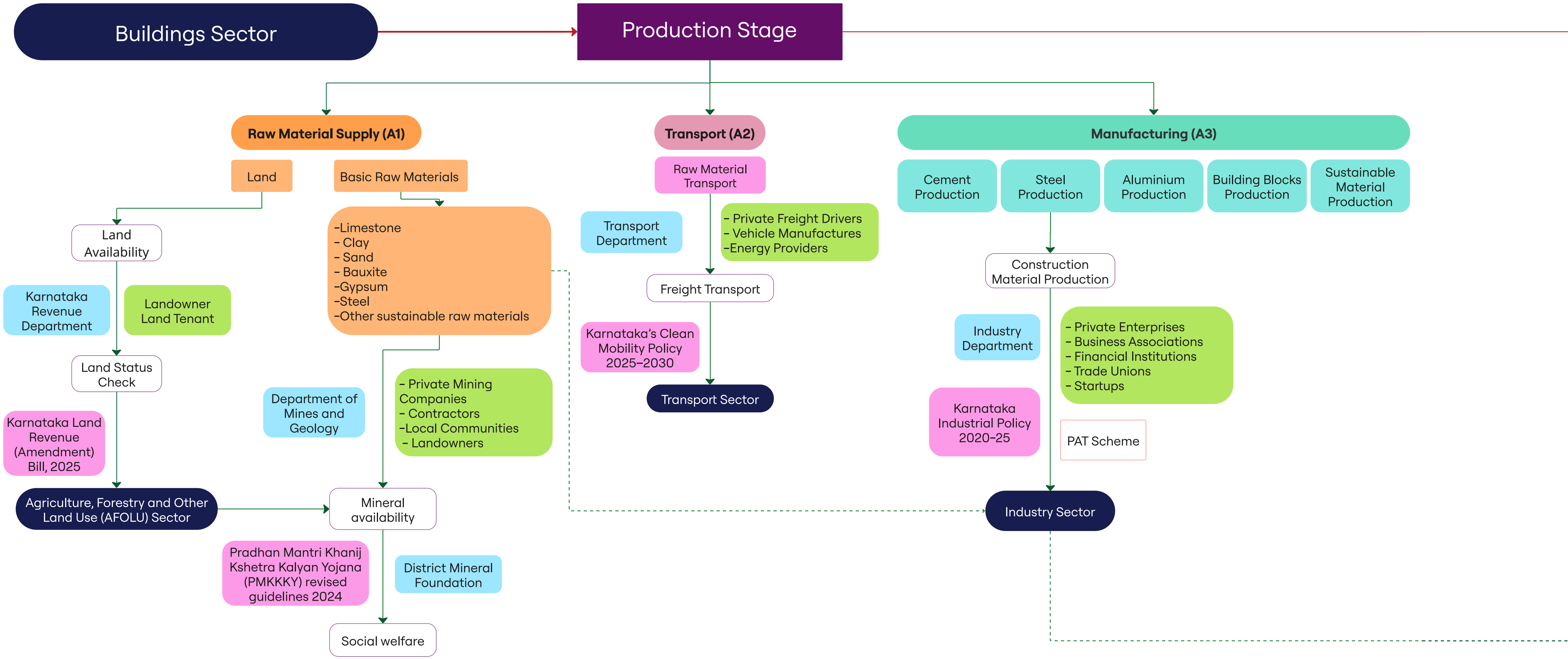
Broader themes of discussion

- **Sustainable materials**
- **Energy-efficient buildings**
- **Mindful consumption**
- **Circularity**

Key stakeholders consulted

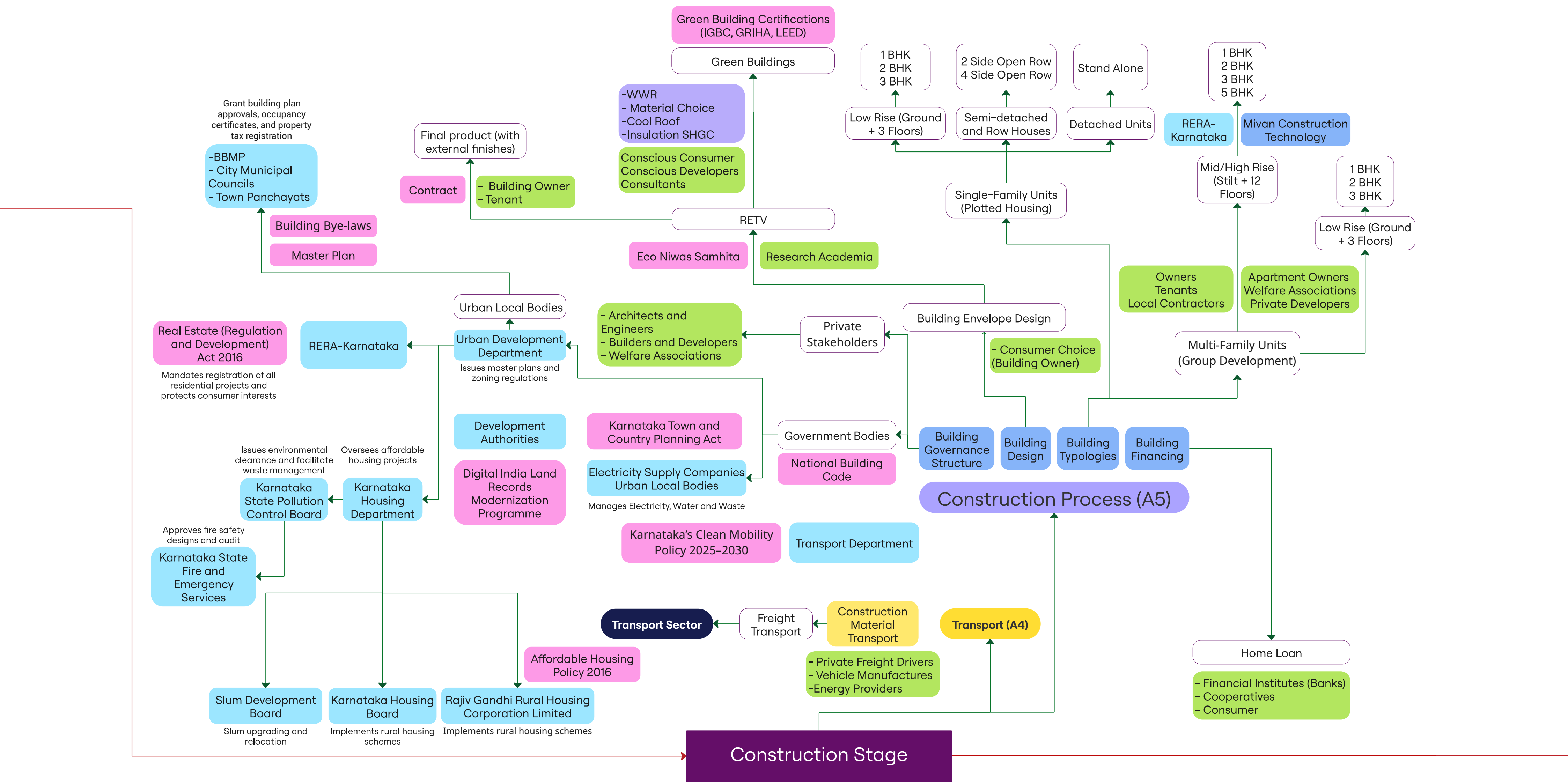
- **Material manufacturers** — Produce sustainable materials
- **Architects** — Design the building envelope
- **Developers** — Work out the business case
- **Contractors** — Manage construction projects
- **Users** — Occupy the building
- **Green building consultants** — Facilitate sustainable practices
- **Researchers** — Create the knowledge base
- **Financing institutes** — Fund the building projects
- **Government** — Formulate policies

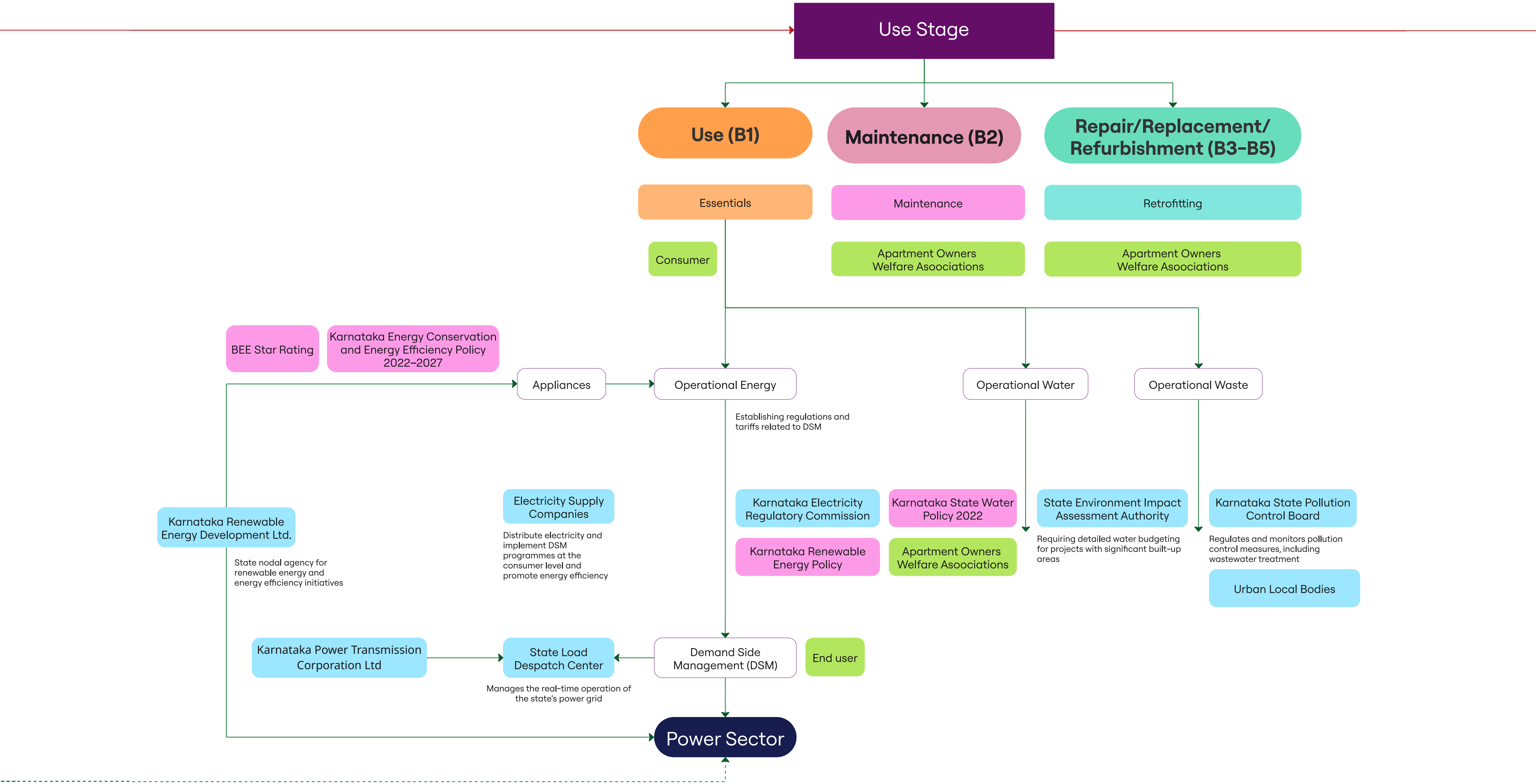
5. Stakeholder Mapping for Karnataka's Residential Buildings Sector

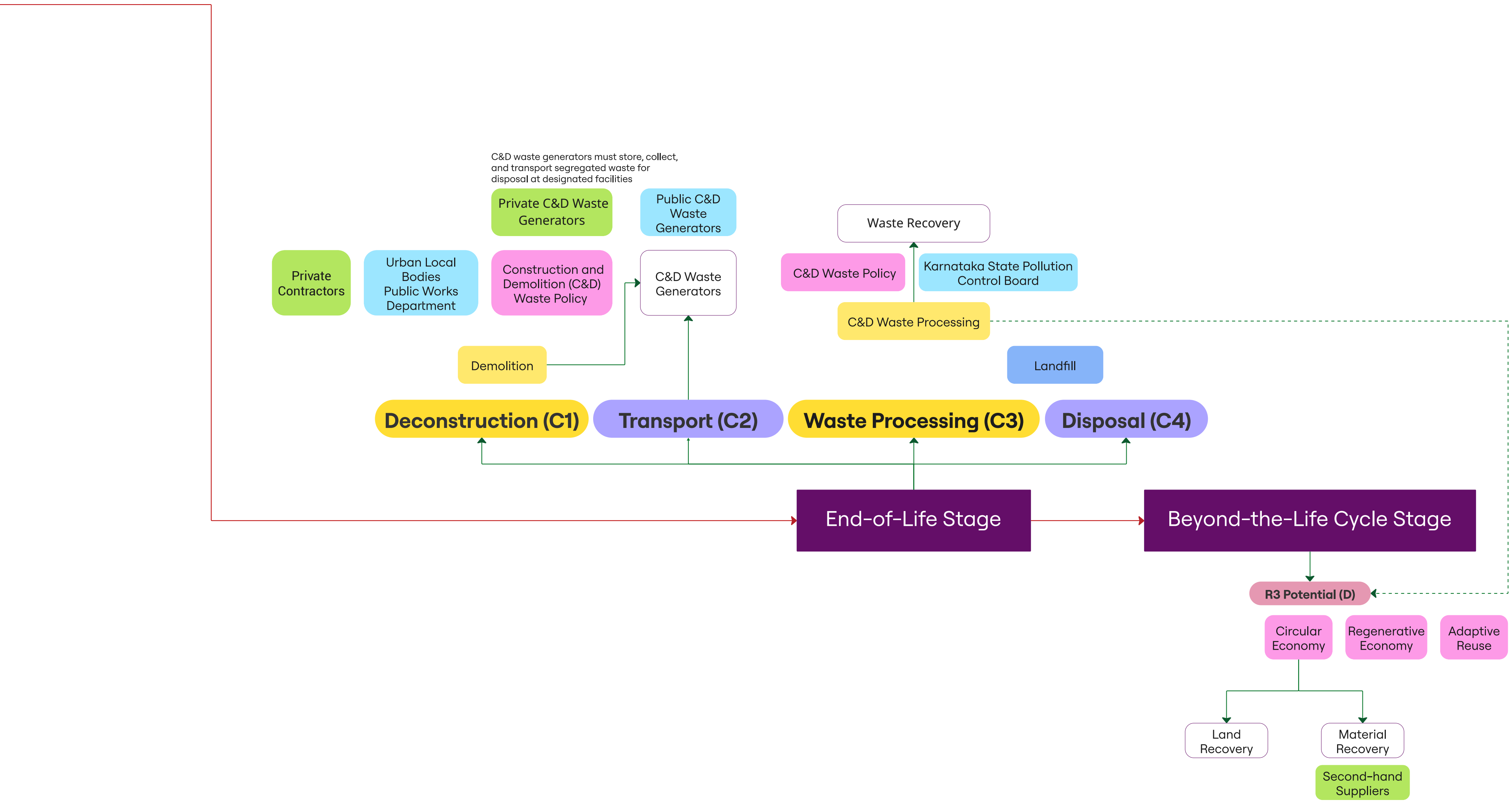


Legend

Government Actors Private Actors Governing Policy


Construction Stage
Construction Process (A5)
Building Governance Structure
Building Design
Building Typologies
Building Financing
Government Bodies
Private Stakeholders
Urban Development Department
Issues master plans and zoning regulations
Urban Local Bodies
-BBMP
- City Municipal Councils
- Town Panchayats
Grant building plan approvals, occupancy certificates, and property tax registration
Building Bye-laws
Master Plan
RERA-Karnataka
Real Estate (Regulation and Development) Act 2016
Mandates registration of all residential projects and protects consumer interests
Development Authorities
Digital India Land Records Modernization Programme
Karnataka Town and Country Planning Act
Electricity Supply Companies
Urban Local Bodies
Manages Electricity, Water and Waste
National Building Code
Karnataka's Clean Mobility Policy 2025–2030
Transport Department
Karnataka Housing Department
Oversees affordable housing projects
Karnataka State Pollution Control Board
Issues environmental clearance and facilitate waste management
Karnataka State Fire and Emergency Services
Approves fire safety designs and audit
Slum Development Board
Slum upgrading and relocation
Karnataka Housing Board
Implements rural housing schemes
Rajiv Gandhi Rural Housing Corporation Limited
Implements rural housing schemes
Affordable Housing Policy 2016
- Architects and Engineers
- Builders and Developers
- Welfare Associations
Building Envelope Design
RETV
Final product (with external finishes)
Contract
- Building Owner
- Tenant
Eco Niwas Samhita
Research Academia
Green Buildings
Green Building Certifications (IGBC, GRIHA, LEED)
-WWR
- Material Choice
-Cool Roof
-Insulation SHGC
Conscious Consumer
Conscious Developers
Consultants
- Consumer Choice (Building Owner)
Single-Family Units (Plotted Housing)
Low Rise (Ground + 3 Floors)
1 BHK
2 BHK
3 BHK
Semi-detached and Row Houses
2 Side Open Row
4 Side Open Row
Detached Units
Stand Alone
Owners
Tenants
Local Contractors
Multi-Family Units (Group Development)
Mid/High Rise (Stilt + 12 Floors)
1 BHK
2 BHK
3 BHK
5 BHK
RERA-Karnataka
Mivan Construction Technology
Apartment Owners Welfare Associations Private Developers
Low Rise (Ground + 3 Floors)
1 BHK
2 BHK
3 BHK
Home Loan
- Financial Institutes (Banks)
- Cooperatives
- Consumer
Transport (A4)
Construction Material Transport
Freight Transport
Transport Sector
- Private Freight Drivers
- Vehicle Manufactures
-Energy Providers


Use Stage
Use (B1)
Maintenance (B2)
Repair/Replacement/ Refurbishment (B3–B5)
Essentials
Maintenance
Retrofitting
Consumer
Apartment Owners Welfare Asoociations
Apartment Owners Welfare Asoociations
BEE Star Rating
Karnataka Energy Conservation and Energy Efficiency Policy 2022–2027
Appliances
Operational Energy
Operational Water
Operational Waste
Establishing regulations and tariffs related to DSM
Electricity Supply Companies
Distribute electricity and implement DSM programmes at the consumer level and promote energy efficiency
Karnataka Renewable Energy Development Ltd.
State nodal agency for renewable energy and energy efficiency initiatives
Karnataka Electricity Regulatory Commission
Karnataka Renewable Energy Policy
Karnataka State Water Policy 2022
Apartment Owners Welfare Asoociations
State Environment Impact Assessment Authority
Requiring detailed water budgeting for projects with significant built-up areas
Karnataka State Pollution Control Board
Regulates and monitors pollution control measures, including wastewater treatment
Urban Local Bodies
Karnataka Power Transmission Corporation Ltd
State Load Despatch Center
Manages the real-time operation of the state's power grid
Demand Side Management (DSM)
End user
Power Sector


C&D waste generators must store, collect, and transport segregated waste for disposal at designated facilities
Private C&D Waste Generators
Public C&D Waste Generators
Private Contractors
Urban Local Bodies Public Works Department
Construction and Demolition (C&D) Waste Policy
C&D Waste Generators
Waste Recovery
C&D Waste Policy
Karnataka State Pollution Control Board
C&D Waste Processing
Demolition
Landfill
Deconstruction (C1)
Transport (C2)
Waste Processing (C3)
Disposal (C4)
End-of-Life Stage
Beyond-the-Life Cycle Stage
R3 Potential (D)
Circular Economy
Regenerative Economy
Adaptive Reuse
Land Recovery
Material Recovery
Second-hand Suppliers

6. Stages in the Building Life Cycle

Production Stage

The production stage of the building life cycle begins with the availability of land and the extraction of raw materials necessary for manufacturing construction products. Land availability is a critical constraint influencing the expansion of built-up areas, directly shaping urban form while also competing with land allocated for other uses. At the regional level, the availability of essential minerals such as limestone, sand, and iron ore is limited in relation to the growing material demand of an urbanising population, underscoring the need to strengthen circular material flows in Karnataka by promoting the use of non-virgin raw materials. In Karnataka, the extraction of essential minerals is regulated by the Department of Mines and Geology (DMG) and conducted in accordance with the Pradhan Mantri Khanij Kshetra Kalyan Yojana (PMKKKY) guidelines. After extraction, these raw materials are transported to processing facilities through freight systems managed by the Transport Department. The state's Clean Mobility Policy 2025–2030, which provides up to 25% capital expenditure subsidies for electric goods carriers and last-mile delivery vehicles, is a progressive initiative that supports decarbonisation in both the transport and buildings sectors. The production of construction materials is further guided by the Karnataka Industrial Policy 2020–2025 and the Perform, Achieve and Trade (PAT) scheme, both of which promote energy-efficient and low-carbon industrial practices. Collectively, these interconnected sectors form a tightly integrated network that drives the material production phase of the building life cycle.

Ecosystem Actors

Public

- Karnataka Revenue Department
- Department of Mines and Geology
- Transport Department

Private

- Land Owners
- Material Manufacturers

Construction Stage

Ecosystem Actors

Public

- Urban Development Department
- Karnataka Housing Department
- Karnataka State Pollution Control Board

Private

- Property owners
- Developers
- Architects
- Contractors
- Labours

The construction stage encompasses both the transportation of construction materials to the site and the execution of construction activities, involving various stakeholders. This phase is influenced by multiple factors, including building typology, design approach, construction technologies, financing mechanisms, and regulatory frameworks, which collectively influence the final built form. In the residential sector, housing is broadly categorised into single-family units and multi-family units, which are further differentiated based on parameters such as building height, number of rooms, and degree of detachment (Bureau of Energy Efficiency, 2021). The building design, including layout, orientation, and structural system (whether load bearing, reinforced cement concrete [RCC], or 3D printed), along with the use of modern construction methods such as Mivan technology, guides the planning and execution process. Incorporating sustainable strategies such as passive cooling, cool roofs, insulation, and climate-responsive design can significantly enhance building performance, potentially qualifying it as a green building certified under established rating systems, including the Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA), or Leadership in Energy and Environmental Design (LEED). Integrating traditional knowledge, indigenous construction practices, and nature-based solutions is equally essential, as these approaches often reflect locally adapted, resource-efficient, and climate-responsive strategies, creating built environments that work in harmony with natural systems. Financial planning is also crucial, as the construction budget directly affects design choices and material selection. Furthermore, all construction activities must comply with local building codes and environmental standards, overseen by a network of regulatory bodies and urban planning authorities to ensure safe, legal, and sustainable development.

Use Stage

The use stage of residential buildings represents a critical phase for advancing sustainability within the sector. This stage is characterised by significant consumption of operational energy and water, as well as notable waste generation. Energy and resource demand can also be influenced by changes in use cases, such as increased occupancy, shifts from single family to shared living arrangements, and modifications in space utilisation. Managing energy demand during this phase remains a persistent challenge because consumption patterns fluctuate throughout the day, making the accurate prediction of the electricity demand load curve essential for efficient grid management. Karnataka has positioned itself as a proactive state in addressing these challenges, with policies such as the Karnataka Energy Conservation and Energy Efficiency Policy (2022–2027) and the Karnataka Renewable Energy Policy (2022–2027), which prioritise energy efficiency measures and the integration of renewables into the grid. The growing penetration of high-efficiency appliances and the widespread adoption of rooftop photovoltaic (RTPV) systems further support the state's efforts in decarbonising the buildings sector.

While water consumption and waste management remain integral aspects of sustainability, the primary emphasis here is on operational energy use, considering its direct implications on decarbonisation and grid stability. Moreover, regular maintenance and retrofitting interventions, including the timely replacement of components, are crucial for sustaining building performance and enhancing resource efficiency and resilience throughout the operational phase.

Ecosystem Actors

Public

- Karnataka Electricity Regulatory Commission
- Karnataka Renewable Energy Development Limited
- Karnataka Power Transmission Corporation Limited
- Electricity Supply Companies

Private

- Users

End-of-life Stage

The end-of-life stage of residential buildings in Karnataka is steadily evolving into a key driver for embedding sustainability across the built environment. Shifting from the traditional process of demolition and landfill disposal, which is typical of a linear economy, this stage is now governed by the state's Construction and Demolition (C&D) Waste policy, which sets a target of recycling at least 50% of the C&D waste generated by municipal corporations by 2026 and urban local bodies by 2027 (Government of Karnataka, 2024). Such interventions aim to reduce the dependency on landfills while scaling up C&D waste processing to ensure material recovery, thus catalysing the transition towards a circular economy. Furthermore, processes such as retrofitting and adaptive reuse can help reduce waste generation while supporting second-hand suppliers and local reuse markets in their efforts to initiate a move towards regenerative practices that reimagine buildings as material banks. Thus, innovations on the end-of-life stage of buildings will position the state to move beyond linear disposal and embed resilience into the building life cycle.

Ecosystem Actors

Public

- Karnataka Public Works Department
- Urban Local Bodies
- Karnataka State Pollution Control Board

Private

- C&D recycling companies
- C&D waste collectors
- Contractors
- Developers

7. Understanding System Behaviour

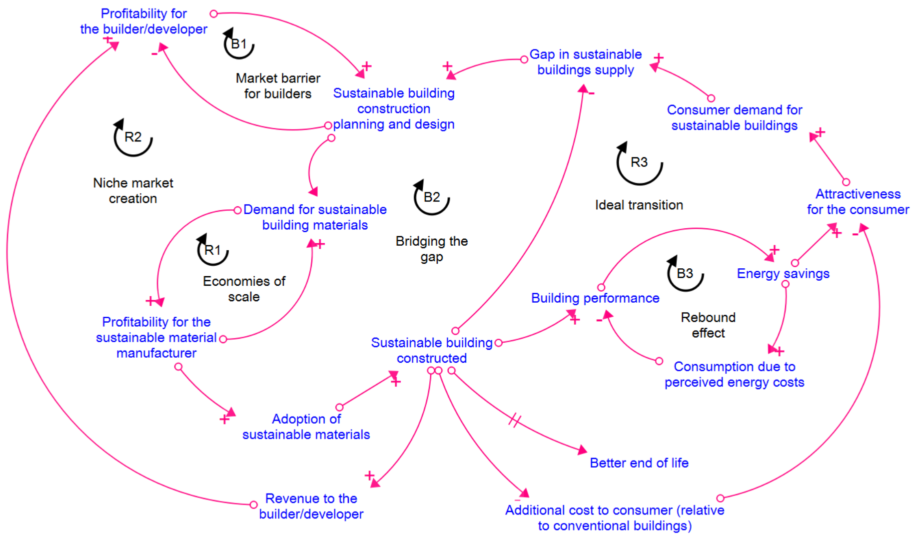
The four stages of the building life cycle do not operate in silos, but rather heavily influence each other. Therefore, a systems-level understanding of the sector is important for devising effective decarbonisation strategies and enables a holistic approach to the sector. Several sustainability challenges exist across the building life cycle, and it is essential to understand the causality behind current practices to identify leverage points and carefully craft interventions for targeted impact. While the stakeholder mapping and engagements were anchored at the Karnataka level, the findings could be applied to India's buildings sector. A comprehensive understanding of such system dynamics can equip stakeholders to co-create a unified vision for the buildings sector.

By applying the concept of systems thinking to the buildings sector, a causal loop diagram was developed as a visual tool to represent the cause-and-effect relationship among key variables in the system, as shown in Figure 1. It represents the system as a set of reinforcing and balancing feedback loops that interact to shape the sector dynamics and drive it over time.

- **Reinforcing loop (R):** It creates a snowball effect, where one action sets off a chain of actions, thus amplifying the change over time. For instance, when the demand for sustainable buildings increases, it becomes more profitable for manufacturers of sustainable materials to remain in the market. This, in turn, boosts their visibility and further drives demand.
- **Balancing loop (B):** It acts like a thermostat, which resists any change and brings the system to equilibrium over time. For example, a leading developer may invest in sustainable buildings, but high associated capital costs reduce profitability, which limits further investment and stabilises the system.

Delving into sector dynamics

Figure 1 : Causal loop diagram of the buildings sector



Here, the positive (+) sign shows a direct relationship, whereas the negative (-) sign shows an inverse relationship. The arrow shows the direction of influence.

8. Status Quo of the Sector

The framework illustrates the interaction that shapes the adoption of sustainable building practices in residential buildings sector at a systemic scale. The current rate of adoption of such practices is low and the efforts are fragmented, as balancing forces such as high upfront costs, limited consumer awareness, associated risks, and lack of targeted policy support restrict their demand. In the status quo, customers prioritise affordability over sustainability, whereas builders focus more on risk mitigation, while sustainable material manufacturers lack the scale to reduce costs. This combination acts as a balancing force, causing the system to stagnate at a lower equilibrium of adopting sustainable practices.

In such a scenario, sustainable building practices are initiated by early adopters, who are the first to embrace a new technology or product based on long-term advantages. As frontrunners, they are likely to encounter certain challenges associated with adoption. These challenges include a lack of trust in new materials due to safety concerns about material performance, limited availability of skilled labour capable of offering quality workmanship, and additional costs incurred in establishing supply chains, all of which reduce their profitability (B1).

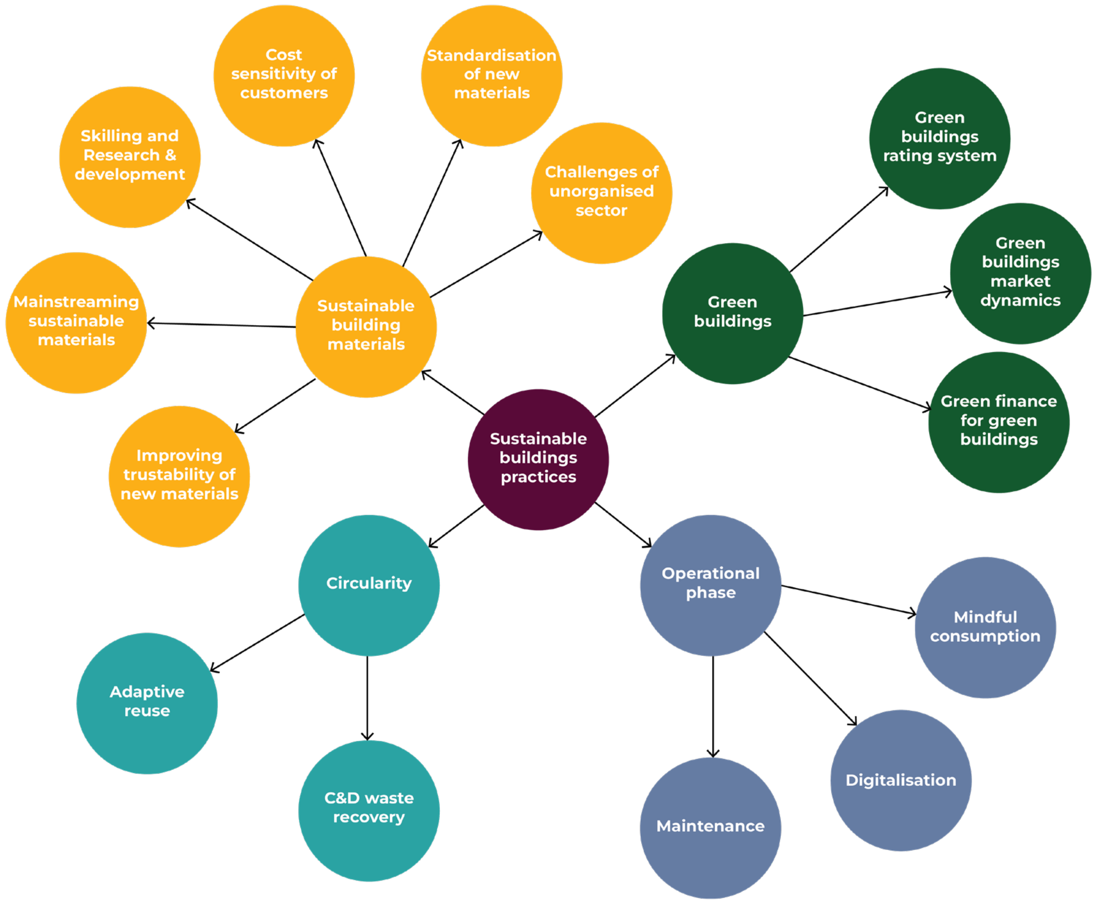
This decelerates the demand for sustainable materials in the market, restricting material manufacturers from achieving economies of scale and thus affecting their profitability. As a result, customers face higher costs, which lowers the adoption of sustainable materials. This, in turn, is a key factor that slows the rate of sustainable building construction. Consequently, the gap in the supply of sustainable buildings widens, hindering the overall adoption of sustainable building practices (B2).

Additionally, when the green premium for sustainable buildings on a developer continues, it drives up the sale price of the property, resulting in higher costs for customers compared to conventional buildings. This reduces the appeal of such innovative approaches, further lowering customer demand for sustainable buildings. Thus, the mainstream adoption of sustainable building practices is hindered because the majority lack strong motivation to transition to these new methods, causing them to remain niche markets.

Further, during the operational phase, early adopters who proactively install efficient appliances may tend to use more devices, believing their energy consumption to be lower. This can drive non-conservative consumer behaviour, adversely impacting the building's energy performance. This leads to a rebound effect, where efficiency improvements cause an unexpected increase in overall consumption, undermining the expected economic and environmental benefits (B3).

9. Catalysing Sustainable Building Practices

Figure 2: Topics of discussions covered across the building life cycle



10. Building a Positive Momentum for the Sector

Adoption of sustainable materials

With most of India's required housing stock by 2050 yet to be built, every building constructed without adequate consideration is a missed opportunity, as the materials and energy get locked in throughout the building's lifespan. To capitalise on this critical period, it is essential to address existing challenges, implement targeted measures, and ensure that sustainable building practices gain positive momentum in the coming years.

While conventional construction materials such as burnt clay bricks, concrete blocks, and steel will continue to dominate material demand, there is substantial opportunity to enhance their sustainability. For example, the embodied carbon of bricks can be reduced by shifting to renewable energy sources, and heat gain through building envelope can be lowered by shifting from solid to low-density blocks such as hollow concrete blocks, autoclaved aerated concrete (AAC) along with addition of recycled content. Scaling up these improved conventional materials could bring immediate environmental benefits at a large scale, given the availability of technology, existing industry capacity, and established supply chains. In parallel, the adoption of newer sustainable materials, such as agrocrete and compressed stabilised earth blocks (CSEB), can complement conventional materials over the medium to long term, supporting a gradual transition towards a low-carbon construction sector.

To facilitate the broader adoption of these sustainable materials, building trust is crucial. A major barrier to acceptance is the perceived risk and safety concerns associated with new materials. Ensuring that these materials undergo rigorous testing and comply with safety standards will validate their reliability and build confidence, promoting mass adoption.

Customer experience with sustainable materials (both improved conventional materials and newer materials) heavily depends on the quality of workmanship. Adopting these materials requires enhanced training, skill development, and hands-on experience to increase familiarity among construction workers. This equips them to deliver high-quality craftsmanship, resulting in superior built quality. A positive experience with the materials further boosts customer confidence, leading to broader adoption.

Addressing these challenges will increase the market penetration of sustainable materials, enhancing the profitability of manufacturers. Increased profitability will fuel innovation and capacity expansion, thereby accelerating adoption and creating a reinforcing loop of continuous growth (R1). Additionally, policy support, such as subsidies for sustainable materials, tax incentives, mandating building codes, and introducing financial instruments, can catalyse this transition in the short term by overcoming critical production-scale barriers.

Incorporating sustainable materials also improves thermal comfort and reduces environmental impacts, raising awareness among developers and customers about the benefits of sustainable buildings. This increased awareness drives the sales of certified green buildings, further improving developer profitability and creating another reinforcing loop (R2).

Capturing the role of certified green buildings

The adoption of sustainable practices is encouraged by the existing voluntary green certification market, which includes several green building rating systems such as IGBC, GRIHA, and LEED. These rating systems address various parameters, such as energy efficiency, water conservation, material use, indoor air quality, and waste management, through an integrated approach. Rather than treating these aspects in isolation, viewing the building holistically fosters cross-disciplinary collaboration and helps optimise trade-offs to achieve overall performance. As a result, green buildings deliver synergistic benefits that support both environmental sustainability and occupant well-being (Prof Neeraj Gupta, 2023). These green certifications can increase a property's market value, allowing developers to generate higher revenues and gain a competitive edge (Nallathiga et al., 2021).

At the same time, the presence of multiple rating systems can create confusion among customers, hindering the mainstreaming of such certifications. This highlights the need for standardisation in the sector and regular updates to India's current rating systems while accounting for regional specificities. Standardisation will also enable the flow of green finance, as identifying key performance indicators is crucial for designing appropriate financial instruments to support the transition.

Furthermore, policy support from the government by mandating building codes such as Eco Niwas Samhita across states and ensuring effective implementation through a governing framework can facilitate the sector's low-carbon transition. Government incentives, including additional floor area ratio (FAR) and faster building approvals, further promote voluntary green building certifications, creating customer demand and establishing a reinforcing loop that accelerates broader adoption.

Continuing the intent in the operational phase

The operation stage of a building represents the longest phase in its life cycle and has the greatest impact on energy consumption. Optimising energy use during this phase is vital for reducing costs, lowering carbon emissions, and advancing sustainability goals. However, while the concept of improved energy efficiency may influence consumer behaviour, adherence to energy conservation efforts can vary. Technologies such as the Internet of Things (IoT) can complement these efforts; for example, installing low-cost sensors, water fixtures, and metering devices in building systems enables automation and real-time optimisation of functions.

Such interventions also allow the collection of valuable data on occupant behaviour, which can be instrumental in digitising the sector. This data helps track varying energy demands over time in the residential sector, and predicting the electricity demand load curve can support the development of targeted demand-side interventions, leading to more efficient grid management. Integration of renewable energy sources, such as RTPV systems, should be further accelerated with support from government policies like the Pradhan Mantri Surya Ghar Muft Bijli Yojana, which also drives decarbonisation in the sector.

In addition, building maintenance is a key concern, as performance deteriorates over time. Timely efforts, such as initiating energy audits, can help users identify opportunities for improvement through retrofitting. These efforts can be further strengthened by supportive policy frameworks that encourage and facilitate the implementation of audits.

Embracing circularity

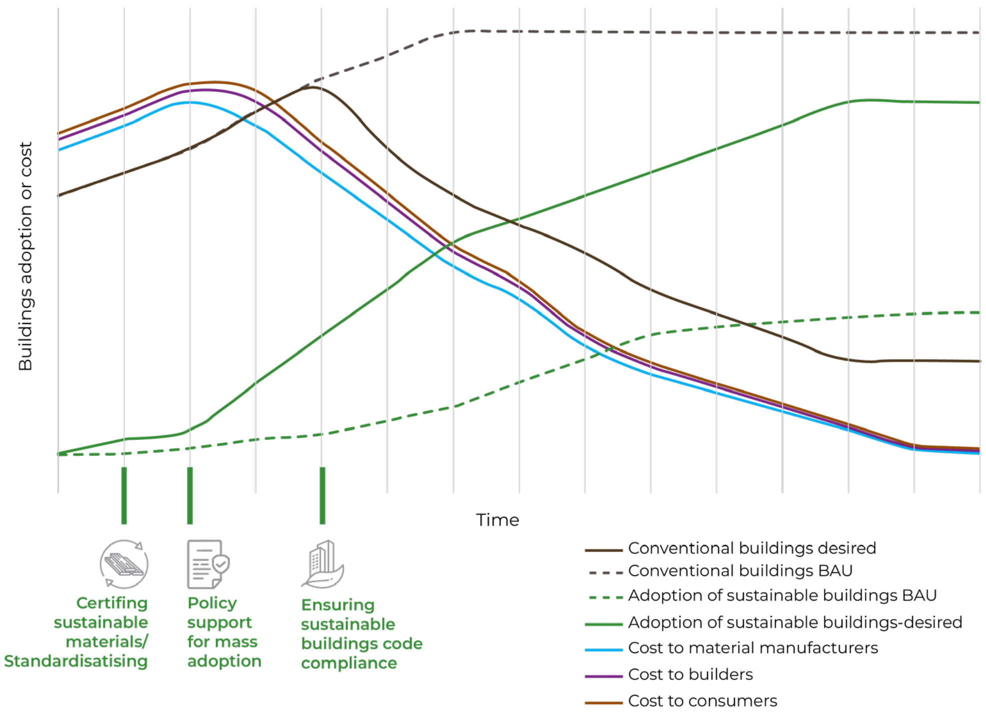
Transcending the concept of sustainability towards the end-of-life phase means embracing circularity, where materials are recovered, reused, or repurposed, minimising waste and extending the value of building resources beyond their initial use. Demolition of existing buildings contributes significantly to C&D waste, and a primary focus at this stage is to prolong the use phase itself. Recognising the vacancy gap in the housing stock offers opportunities for adaptive reuse of vacant buildings. With appropriate policy support and increased public awareness, the efficient utilisation of existing housing stock can become a practical and sustainable solution.

When a building reaches its ultimate end-of-life or is demolished to make way for new construction, it results in increased C&D waste, which places pressure on landfills, especially in regions with land constraints on waste handling. Investing in recycling facilities can boost the supply of recycled materials, reducing reliance on new materials. Simultaneously, incentivising reuse through design-for-disassembly practices and fostering a robust second-hand market further support circularity. This integrated approach not only reduces construction-related waste but also addresses perceived housing shortages, thereby promoting circular economy practices and reinforcing the concept of buildings as material banks essential for sustainable development.

11. System Behaviour

Leveraging the current window of opportunity is critical to steering the buildings sector towards a sustainable pathway. The graph illustrates how targeted interventions can accelerate this transition. Under a business-as-usual (BAU) scenario, conventional buildings continue to dominate, with the adoption of sustainable practices remaining marginal. However, early measures, such as the standardisation and certification of sustainable materials, initially increase costs; however, with appropriate policy support for mass adoption, material costs are expected to decline steadily as economies of scale are realised. Coupled with strict adherence to building codes, these measures can significantly accelerate the adoption of sustainable buildings, making them more affordable and attractive over time. Ultimately, such interventions can shift the sector from conventional dominance to a sustainable mainstream trajectory.

Figure 3 : Structure behaviour of the causal loop diagram



12. Recommendations

Thus, a systemic-level analysis can equip every stakeholder to identify their unique agency in enabling sustainable practices in the buildings sector. Recognising and harnessing multiple leverage points within the broader ecosystem can provide a pragmatic way to initiate the transformation of the buildings sector. Some of the interventions that emerged out of our stakeholder consultations are listed below:

Increasing market confidence of sustainable materials

The adoption of sustainable materials should be supported by a strong policy push from the government, enabling private players to remain cost-competitive in the market. This can be achieved by establishing robust standards and certification systems for low-carbon, resource-efficient, and locally sourced building materials, along with extending procurement preferences for such materials in public housing schemes and policy incentives such as tax rebates for sustainable materials.

Developing an appropriate framework for recognising sustainable practices

In addition to the existing codes, there is a need to establish a comprehensive national framework that defines, benchmarks, and certifies sustainable practices in the residential buildings sector. Such a framework should harmonise existing rating systems (e.g. GRIHA, IGBC, WELL Building Standards and Excellence in Design for Greater Efficiencies [EDGE]) under a common standard while retaining flexibility to recognise context-specific practices, such as passive design strategies and the use of regional low-carbon materials and technologies. To ensure inclusivity, the framework should incorporate a tiered recognition system (basic, advanced, and exemplary) that incentivises incremental adoption and enables participation from small developers and affordable housing projects.

Targeted fiscal and financial instruments, such as green bonds, subsidies, and tax rebates, should be developed for sustainable construction and retrofitting projects. To ensure credibility, these instruments should be aligned with a national climate taxonomy that clearly defines which building practices qualify as 'climate-aligned'. Further, banks and housing finance companies should be encouraged to integrate green performance metrics based on this taxonomy into their lending criteria, thereby mainstreaming sustainability into financial decision-making across the buildings sector.

Digitalisation and circularity

A National Building Sustainability Dashboard should be established to monitor energy use, material flows, and life cycle emissions, enabling demand-side management to optimise energy consumption and reduce peak loads. By treating buildings as material banks, the system can track recoverable materials from construction and demolition, facilitating large-scale reuse and promoting circularity. Coupled with targeted incentives and a national digital platform, this approach will support resource efficiency, evidence-based policymaking, and the transition to sustainable development.

Capacity building and workforce training

To mainstream sustainability in the built environment, it is essential to integrate sustainable design principles and practices into architectural curricula, vocational training programmes, and contractor certification processes. Educational institutions should include modules on energy-efficient design, low-carbon and locally sourced materials, passive cooling strategies, and life cycle assessment in their core courses. Additionally, implementing targeted upskilling programmes on sustainable construction techniques and responsible material handling for masons and construction workers, leveraging national initiatives like the Pradhan Mantri Kaushal Vikas Yojana (PMKVY), can accelerate the adoption of green practices, strengthen workforce capacity, and ensure that sustainable building innovations are effectively implemented on site.

Theme	Recommendations	Key Actions Required	Lead Actors	Key Enablers
Increasing market confidence in sustainable materials	Promote adoption of low-carbon, resource-efficient, and locally sourced materials through national standards and incentives.	- Develop a platform to showcase certified green materials with life cycle performance data. - Streamline testing and certification of sustainable materials. - Introduce sustainability criteria in the procurement of building materials. - Include sustainable materials and practices in the Schedule of Rates (SoR).	Ministry of Housing and Urban Affairs (MoHUA), Bureau of Indian Standards (BIS), NITI Aayog, Academic institutions (such as IITs, CSIR, and NITs)	- Expanding the scope of ECO Mark Certification for sustainable building materials. - Establishing green procurement guidelines for public buildings. -Developing a network of affordable, regionally distributed testing labs through collaborations with academic institutions.
Framework for recognising sustainable practices	Establish a harmonised national framework that benchmarks and certifies sustainable practices across codes and rating systems.	- Create a unified National Green Buildings Rating Platform integrating GRIHA, IGBC, EDGE, and WELL under common metrics. - Develop a tiered recognition system (basic, advanced, exemplary) with performance-based incentives based on building typologies and a post-occupancy evaluation. - Integrate recognition with building permit systems while accounting for region-specific agendas, considering climate zones and material availability.	Ministry of Housing and Urban Affairs (MoHUA), Building Materials and Technology Promotion Council (BMTPC), Bureau of Energy Efficiency (BEE), State Urban Development Departments	- Including sustainable building practices under Mission LiFE. - Integrating sustainable practices in state-level affordable housing schemes and government construction projects. - Granting green certification-linked tax rebates or Floor Area Ratio (FAR) incentives.

Theme	Recommendations	Key Actions Required	Lead Actors	Key Enablers
Targeted climate finance flow	Develop financial instruments (green bonds, subsidies, and tax rebates) for the buildings sector as per the upcoming national climate taxonomy.	- Establish India's climate taxonomy with sectoral definitions for 'climate-aligned buildings'. - Mandate banks to include green performance indicators in loan assessments. - Create a green buildings credit guarantee fund for early adopters. - Tie urban local body (ULB) financing and municipal bonds to sustainability metrics.	Ministry of Finance, Reserve Bank of India, Securities and Exchange Board of India (SEBI), National Housing Bank, and Ministry of Housing and Urban Affairs (MoHUA)	- Developing a climate finance roadmap for the buildings sector. - Imposing SEBI's green bond regulations. - Priority sector lending for green construction / retrofitting. - Implementing a partial credit guarantee facility for low-carbon housing projects.
Digitalisation and circularity	Create a repository for sustainable building projects nationwide to track energy, material flows, and life cycle emissions in a single dashboard.	- Utilise building information modelling to quantify life cycle emissions from buildings. - Develop a national construction and demolition waste inventory and materials passport system. - Link data to India's greenhouse gas inventory for better policy feedback. - Support pilot circular economy zones for construction material recovery.	Ministry of Environment, Forest and Climate Change, NITI Aayog; State Pollution Control Boards; and National Informatics Centre	- Introducing a circular economy policy at the state level (e.g. Karnataka's circular economy policy) - Revising construction and demolition waste management rules - Integrating with the Digital India Mission
Capacity building and workforce training	Integrate sustainable design and construction principles into education, training, and certification systems.	- Embed sustainable practices in architecture and civil engineering curricula to equip students. - Design vocational training for masons, contractors, and site supervisors on green construction methods. - Partner with industry to offer on-site apprenticeship and demonstration projects. - Include women and informal sector workers in training programmes.	MoHUA, Ministry of Skill Development and Entrepreneurship, Council of Architecture, National Skill Development Corporation, and State Housing Boards	- Implementing the Pradhan Mantri Kaushal Vikas Yojana (PMKVY) – Green Construction Track. - Establishing a Centre of Excellence for Sustainable Construction. - Developing corporate social responsibility-based training partnerships. - Integrating with Atal Innovation Mission incubation centres.

13. Conclusion

As India navigates its path towards urban transformation, the buildings sector stands at a critical juncture that will significantly shape the long-term sustainability of the country's development. Although the sector presents challenges such as decentralised governance, a fragmented and informal market, and limited local enforcement capacity, the opportunities for systemic changes are compelling. The sector's growth trajectory offers a unique window to embed sustainability at scale, ensuring that future buildings are not only aspirational in design but also efficient, inclusive, and climate-resilient in function.

Realising this vision requires robust policy frameworks, technological integration, and a cultural shift that prioritises long-term impact over short-term gains. Developing a systems-thinking mindset enables moving beyond isolated fixes to integrated solutions across the sector. By aligning efforts among stakeholders, embracing innovation, and bridging the gap between intent and execution, India's building sector can shift from being a climate challenge to a climate solution by regenerating resources, strengthening communities, and building a resilient future for generations to come.

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CSTEP

Center for Study of Science, Technology and Policy

Bengaluru
#18, 10th Cross, Mayura Street, Papanna Layout,
Nagashettyhalli (RMV II Stage),
Bengaluru – 560094, Karnataka, India

Noida
1st Floor, Tower-A, Smartworks
Corporate Park, Sector-125,
Noida-201303, Uttar Pradesh, India

+91-8066902500 www.cstep.in cpe@cstep.in @cstep_India