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Eco-friendly "Good Bricks" for sustainable construction, advancing sustainable urban ecosystems through cleaner, resource-efficient building solutions.

From Innovation to Impact: Advancing Sustainable Urban Systems

Content

The views expressed in the articles in this newsletter are those of the authors and not necessarily those of Development Alternatives.

Editorial Team: Shaila Sam, Bharti Kapoor, Payal Choudhary, and Garima Garg
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B-32, Tara Crescent, Qutub Institutional Area, New Delhi-110016
Tel: +91(11) 2654 4100-200
Fax: +91(11) 2685 1158
Email: library@devalt.org
Website: www.devalt.org

Indian Brick Sector needs System change

Workers at a brick kiln factory

India's brick sector sits at the intersection of extreme poverty and environmental degradation. With over 1.4 lakh kilns producing more than 250 billion bricks annually, it consumes nearly 50 million tonnes of coal and emits 66 to 84 million tonnes of CO_2 every year. It is also a major contributor to air pollution across the Indo-Gangetic plains. At the same time, the sector supports the livelihoods of over 10 million workers, many of them from vulnerable communities. This dual reality makes decarbonisation as much a development challenge as an environmental one.

Why Decarbonisation Matters for Sustainable Urban Ecosystems

India's urban growth is directly linked to the brick sector. Bricks remain one of the most widely used construction materials, which means the environmental footprint of cities is closely tied to how bricks are produced. As cities expand, demand for construction materials is rising sharply. This translates into higher emissions, increased coal consumption, and growing pressure on natural resources such as topsoil and water. Brick kilns are often concentrated around urban and peri-urban areas, making them significant contributors to local air pollution, land degradation, and declining air quality. Decarbonising the brick sector is therefore critical for building healthier and more sustainable cities. Reducing emissions from kilns can directly improve air quality, while shifting to resource-efficient materials can help reduce pressure on land and ecosystems.

At the same time, the sector is deeply linked to livelihoods in urban and peri-urban economies. Any transition must, therefore, balance environmental goals with employment, income security, and working conditions. For urban ecosystems to be truly sustainable, construction practices must align with climate goals. This means moving towards low-carbon materials, cleaner production systems, and more efficient resource use, while ensuring that the transition remains inclusive. In this context, decarbonising the brick sector is not just an industrial priority. It is central to the future of sustainable, liveable, and resilient cities.

The Real Challenge

Despite its environmental footprint, burnt clay bricks are unlikely to disappear anytime

soon. Alternatives such as fly ash bricks and Autoclaved Aerated Concrete (AAC) blocks are expanding, but can currently meet only a limited share of demand. With projections suggesting that India's brick demand could reach 2000 billion units by 2047, the question is not whether the sector will continue, but how it will evolve.

The sector is often treated as a technological challenge, but it is a highly distributed and largely informal system. Multiple kiln technologies coexist, from highly polluting clamp kilns and widely used fixed chimney kilns to cleaner zig-zag kilns and capital-intensive tunnel kilns. Each has its own constraints, and no single solution can address the scale and diversity of the sector. Emissions themselves come from multiple sources, including fuel combustion, incomplete burning, clay decomposition, and dust handling. This complexity makes it clear that decarbonisation cannot be achieved through technology alone.

What Is the Solution?

Some solutions can deliver immediate gains. Zig-zag kilns improve combustion efficiency and can reduce coal use by up to 40% while significantly lowering emissions. Simple process improvements such as better airflow, improved stacking, and draft control can deliver additional savings without large investments. Fuel shifts towards biomass and alternative fuels also offer potential, although supply chains remain a constraint.

However, deeper decarbonisation will require structural changes. Technologies such as vertical shaft brick kiln and tunnel kilns offer higher efficiency, while material substitution through fly ash bricks, AAC blocks, and emerging options like geopolymer bricks can reduce or eliminate the need for firing. Electrification and hydrogen-based systems represent future pathways. These options, however, demand higher capital, stronger infrastructure, and a more formalised industry.

Technology alone will not drive this transition. Markets need to accept low-carbon materials, and policy must move beyond regulation to active incentives. Finance mechanisms must support small and informal operators who currently lack access to capital. Public procurement, tax incentives, and blended finance can play a critical role in accelerating adoption.

The human dimension is equally important. The sector employs millions of unskilled and

A vertical shaft brick kiln

semi-skilled workers, often with limited access to social protection. Any transition must therefore include skill development, improved working conditions, and better access to welfare schemes. Without this, decarbonisation risks becoming socially disruptive.

Way Forward

A phased pathway is essential. In the short term, the focus should be on accelerating conversion to cleaner kilns, promoting non-topsoil materials, and increasing mechanisation. In the medium term, demand can be driven through public procurement and carbon-linked incentives. Over the long term, the sector must gradually shift towards non-fired materials and low-carbon production clusters.

The brick sector does not lack solutions. It lacks alignment. Decarbonisation will depend on how effectively technology, markets, policy, finance, and people are brought together. The real challenge is not identifying what needs to be done but ensuring that it happens at scale. ❐

A building constructed using LC^3 at the TARAgram Campus in Orchha, Madhya Pradesh.

Dr Soumen Maity
smaity@devalt.org

Reflections on the Brick Sector: Questions We Are Not Asking Enough

A view of a brick kiln based in Patna, Bihar

The brick industry, which employs over 10 million people, is the lifeline of the construction industry and contributes to India's economic development. During the workshop on decarbonising the brick sector, was framed the discussion with a series. Although the brick industry is at the intersection of development, livelihoods, health, and workforce conditions, it remains a sector that has been either left behind by technological change or has not kept pace with it. Despite over two decades of efforts by organisations such as Development Alternatives, many of the same challenges continue to persist.

A Sector Without Clear Data

To illustrate this, some basic questions were asked:

- How many brick kilns are there in India?
- How many bricks are produced?
- How many fly ash brick units exist?

The answers were unclear. Numbers like 1 lakh or 1.5 lakh kilns continue to circulate, but they lack credible sources. Over time, these estimates start to be accepted as facts. This highlights a deeper issue: we are operating without reliable data.

In response to the question, 'Will Red Bricks Disappear?' The answer is that they are not likely to vanish in the next 40 to 50 years. However, by 2050, their share could reduce significantly, potentially dropping to around 20% as alternatives become more prevalent. Globally, in countries like the United States and those in Europe, red bricks are now largely used for specialised or decorative purposes rather than for mainstream construction.

To another question on how technologies actually disappear, the answer was that technologies tend to disappear when new ones enter the market, and people fully embrace these innovations. As a result, older technologies gradually become obsolete and fade away. This situation reflects the natural evolution of the market, where advancements lead to the decline of outdated technologies. In this process, the government plays no significant role.

In other instances, like with kerosene stoves and incandescent bulbs, the transition occurred due to strong government intervention, such as the Ujjwala scheme and LED programmes. However, the brick industry has not experienced similar changes. It lacks both strong market-driven change and effective policy-driven enforcement.

Policy Without Enforcement

While regulations exist in the brick sector, enforcement remains weak.

Simply stating 'do this' is not enough. Without accountability or consequences, compliance remains low. This creates a situation in which rules are made but not followed, and responsibility becomes unclear. Penalties, when imposed, are rarely enforced. In many instances, when regulators ordered organisations to pay penalties, amounting to several crores, these organisations went to courts and had the penalties waived.

Missed Opportunities in Systems

One must also point existing systems. For instance:

- A national-level committee on fly ash management has multiple stakeholders, yet discussions on brick usage remain minimal.
- Restrictions on transporting fly ash across state borders create unnecessary barriers and these need to be removed.
- Data platforms exist but are not accessible to the public.

This raises a fundamental question. If data exists, why is it not being used or shared?

Market Shifts Are Already Visible

Over the past 15 years, alternatives to traditional building materials have been expanding significantly. For instance, AAC blocks have become widely used in large construction projects, especially in Tier 1 cities, and are now gaining traction in Tier 2 cities as well. However, this shift is not uniform; regions beyond Central India still heavily depend on traditional construction methods. Currently, the AAC blocks industry is valued at over Rs 5,000 crores.

The Role of Policy and Market

There is another missed opportunity in the way policy tools are used. For example:

- GST rates remain uniform across all brick categories and alternate materials
- There are no strong incentives to encourage the adoption of cleaner alternatives

A brick kiln factory

As a result, the market is not being directed towards any specific goal.

Using Existing Data Systems

Systems like GST and Udyam registrations could provide valuable insights into the brick sector. These platforms already collect data on businesses and transactions. However, they are not being utilised to gain a better understanding of the brick industry. Even simple questions, like how many brick units are registered, remain unanswered.

The Way Forward

One must emphasis that the goal is not to eliminate one material, but to:

- make better options viable and visible,
- allow the market to adopt them,
- use policy to nudge the transition,

Ultimately, the challenge is not the absence of solutions, but the gap between knowledge and action. It is important for all stakeholders to join hands to enable the construction sector to reduce its environmental impact. ❐

Dr. Bhaskar Natarajan
Clean Energy & Energy Efficiency Specialist
natbhaskar@gmail.com

Enabling Technologies for Low-Carbon Construction Materials

Low-clinker cement technologies like LC^3 reduce emissions and material intensity.

In recent years, India has been shifting towards low-carbon sustainable construction materials to reduce carbon emissions (25%) in the industrial sector. This transition towards resource efficiency, the circular economy, and sustainable materials will help support India in achieving its goal of attaining net-zero carbon emissions by 2070.

LC^3 Cement: A Game-Changer in Sustainable Building Materials

Among recent advancements in low-carbon sustainable construction materials, Limestone Calcined Clay Cement (LC^3) is one of the most promising alternatives to conventional cement. LC^3 is a ternary binder that consists of clinker, calcined clay, and limestone. Compared to ordinary Portland cement (OPC), it requires a lower clinker content (50%) and utilises the locally available low-grade limestone and calcined clay. Using LC^3 in construction can reduce costs and CO_2 emissions by 25% and 40%, respectively, compared to OPC. Moreover, recent studies have shown that compared with conventional cement, the LC^3 binder exhibits comparable mechanical properties and improved durability. Notably, the Bureau of Indian Standards (BIS) has introduced the IS 18189:2023 specification for ternary calcined-clay limestone-based composite cement, supporting the wider adoption of this technology.

Limestone Calcined Clay Cement (LC^3) is one of the most promising alternatives to conventional cement.

Recycled Concrete Aggregates: Turning Waste into Resource

Meanwhile, another category of materials includes Recycled Concrete Aggregates (RCA) processed from construction and demolition (C&D) waste, which have also gained attention as alternatives to natural aggregates, sand, and supplementary cementitious materials (SCMs). Using RCA in concrete systems helps conserve natural resources and reduce illegal dumping. As per BIS 383: 2016, 100% RCA can be used in lean concrete (<M15 grade), whereas its replacement level is limited to 25% and 20% in plain and reinforced concrete (up to M25), respectively. Currently, India has over 35 operational plants processing C&D waste. It is expected to double in the future.

India has over 35 operational plants processing C&D waste. It is expected to double in the future.

Steel Slag in Infrastructure: From Industrial Byproduct to High-Performance Material

Another significant advancement is the use of steel slag, an industrial byproduct of the steel-making industry, as an aggregate in pavement construction. A notable example of this is the use of processed steel slag in the construction of both bituminous and concrete pavements on the National Highway connecting Mumbai and Goa. Incorporation of steel slag aggregate in bituminous pavement reduced the pavement thickness by 28% compared to conventional bituminous pavement. Furthermore, both bituminous and cement concrete pavements are more economical (32% lower cost) and durable.

This project has demonstrated both the economic and the environmental potential of converting industrial waste into high-performance, durable, and eco-friendly construction material, while simultaneously addressing disposal challenges associated with steel industry byproducts. At a global level, efforts have been made to advance low-carbon construction materials, and it is anticipated that growth will increase at an 8-12% annual rate over the next decade to meet net-zero carbon emissions.

The Road Ahead: Scaling Low-Carbon Construction in India

In summary, India's transition towards low-carbon construction materials, anchored by advancements such as LC^3, RCA, and steel slag, demonstrates a strategic convergence of technology, policy, and sustainability. While notable progress has been made, continued efforts in standardisation, infrastructure development, and stakeholder engagement will be critical to scaling these solutions and unlocking their full environmental and economic potential. ❐

Adoption of alternative materials in an on-site construction site

India's transition towards low-carbon construction materials—anchored by advancements such as LC^3, RCA, and steel slag—demonstrates a convergence of technological innovation, policy support, and sustainability goals.

Dr M. Selvam
Assistant Professor
Civil and Environmental Engineering
IIT Patna
(selvam@iitp.ac.in)

Policy Pathways for India's Materials Economy Challenge

Participants in a workshop conducted in collaboration with IITBBS for pathways for decarbonisation for built environment for Odisha

India's development boom has suddenly become a climate concern. With almost 86% of the floor space that will exist in 2070 still to be built, how we regulate and source materials over the next decade will determine future emissions. Emissions from cement, steel, aluminium, bricks, and glass constitute about 48% of total construction lifecycle emissions in India and are expected to increase significantly unless policies prioritise low-carbon materials.

Importance of Materials

Buildings and construction are responsible for an estimated 25-33% of India's greenhouse gas emissions when both operational and embodied carbon are included. According to NITI Aayog's new development strategy [1], materials such as red bricks and clinker-heavy cements will make up nearly half of building-sector emissions by 2025 [2]. Recent sub-national scenario modelling (2026–2070) undertaken at Development Alternatives indicates that the built environment consumes approximately 2.8 tonnes of material per m^2 and is responsible for nearly 0.93 tonnes of CO_2 per m^2, with cement contributing close to 40% of embodied emissions. The analysis highlights that adoption of low-carbon cements and high-performance walling systems can reduce process emissions by up to 50%, while also improving thermal performance.

Despite their advantages, these alternatives are still considered 'alternatives' rather than the norm. The issue lies not in the lack of technical options, but in the absence of clear policy signals and effective enforcement to establish these solutions as standard practice [3]. In addition, limited market demand and inadequate availability of green materials further constrain large-scale adoption, creating a gap between innovation and implementation.

Close the Gap in Policy

India's current regulatory landscape, such as the Energy Conservation and Sustainable Building Code (ECSBC), still primarily focuses on operational energy rather than whole-life carbon [4]. Only voluntary embodied-carbon disclosures are mentioned in policies and standards, and states have yet to adopt the Eco-Niwas Samhita for residential buildings. There is currently no legally binding national framework requiring disclosure of high-impact materials or caps on embodied carbon. Among Indian states, Andhra Pradesh stands out as a frontrunner, driven by proactive policy support, institutional alignment, and early adoption of building energy codes.

A nationally standardised LCA methodology for large projects and a public EPD registry form the basis for an initial policy pathway that would quickly shift from voluntary disclosure to a phased mandatory regime for Environmental Product Declarations (EPDs). Recent insights from NITI Aayog's sectoral reports highlight the importance of enforcing building regulations, integrating low-carbon

materials throughout the value chain, and aligning with industrial policies for cement, steel, bricks, and aluminium. India's long-term Low-Carbon Development Strategy [5] aims to promote Resource Efficiency, Low-Carbon Materials, Circularity, and Carbon Capture, Utilisation and Storage (CCUS) in challenging areas.

Green Public Procurement

India's public works sector is the largest purchaser of concrete, steel, and bricks. The government's material specifications could influence the growth of low-carbon products. Green public procurement can 'supercharge market transformation' for low-carbon materials and high-efficiency goods by offering time-bound fiscal support, according to NITI's buildings roadmap and international practice [6].

Standard clauses can be adopted by central ministries, railways, NHAI, and public housing agencies to prioritise cements with lower clinker factors, require Environmental Product Declarations (EPDs) for key materials, set minimum shares of recycled aggregates and industrial byproduct-based products, and reward bidders who outperform embodied carbon benchmarks [7]. C&D Waste Management Rules 2025 [8] already enable secondary aggregates; linking compliance to tender eligibility will transform these rules from guidelines into a real-world materials policy.

Align Industrial Policy and Carbon Markets

On the supply side, clinker substitution can be increased by substituting with fly ash, slag, and calcined clays such as LC^3. Additionally, the use of refuse derived fuels should be expanded and early CCUS pilots that focus on utilisation in building materials should be initiated. Given that blended cements constitute approximately 70% of the current output, further advancements in standards and regulations are essential. The development of the Bureau of Indian Standards (BIS) guidelines should prioritise performance-based criteria rather than rigid formulations.

A carbon pricing mechanism can support this strategy. The new Carbon Credit Trading Scheme (CCTS) [9] and the proposed

MNIT Jaipur delivering key note lecture on net zero cities under SPARC.

Indian Carbon Market can incentivise manufacturers to reduce clinker-to-cement ratios, boost thermal substitution rates, and introduce verified low-carbon products to the market. Additionally, these initiatives can assist manufacturers in achieving their net-zero targets by enabling energy-efficiency upgrades at the industry and operational levels. Moreover, roadmaps for steel and other industries should align with this approach to meet the demand for low-carbon buildings through a compatible supply-side shift.

Key Features

1. India's construction boom (with 86% of future buildings yet to be built) will significantly drive future emissions, especially from materials.
2. Building materials like cement, steel, bricks, and aluminium account for ~48% of lifecycle emissions, with cement alone contributing around 40% of embodied carbon.
3. Current policies focus mainly on operational energy, with no mandatory rules for embodied carbon, making low-carbon materials optional rather than standard.
4. Green public procurement can accelerate change by requiring low-carbon materials, EPDs, and recycled inputs in government projects.
5. A full-system shift is needed—aligning policy, industry, carbon markets, data systems, skills, and financing to scale low-carbon construction.

Develop the Ecosystem of Data, Skills, and Financing

None of this can be accomplished without improved information and capabilities. Studies indicate that the lack of a strong national building register and data platform poses a structural barrier to measuring energy and carbon performance. A centralised data architecture, managed by the BMTPC/BEE, is critical for policy evaluation, green finance categorisation, and urban planning. This architecture should incorporate project-level data on operational and embodied carbon, EPDs, and code compliance records [10]. It can also facilitate collaboration among sustainability stakeholders, developers, and artists in the field.

Architects, engineers, contractors, and municipal officials require regular training on low-carbon material specification, life cycle assessment (LCA) tools, and circular construction methods. Without this training, even the most standard or regulatory requirements may be met only on paper, lacking practical application. To encourage sustainable practices, incentives such as green credit lines, tax breaks, and blended finance for low-carbon materials, C&D waste facilities, and industrial retrofits could mitigate risks for those taking the lead. This approach would ensure India's construction surge brings development advantages while remaining within its carbon limits. ❐

Workshop for pathways for decarbonisation of the built environment for Bihar in collaboration with IIT Patna

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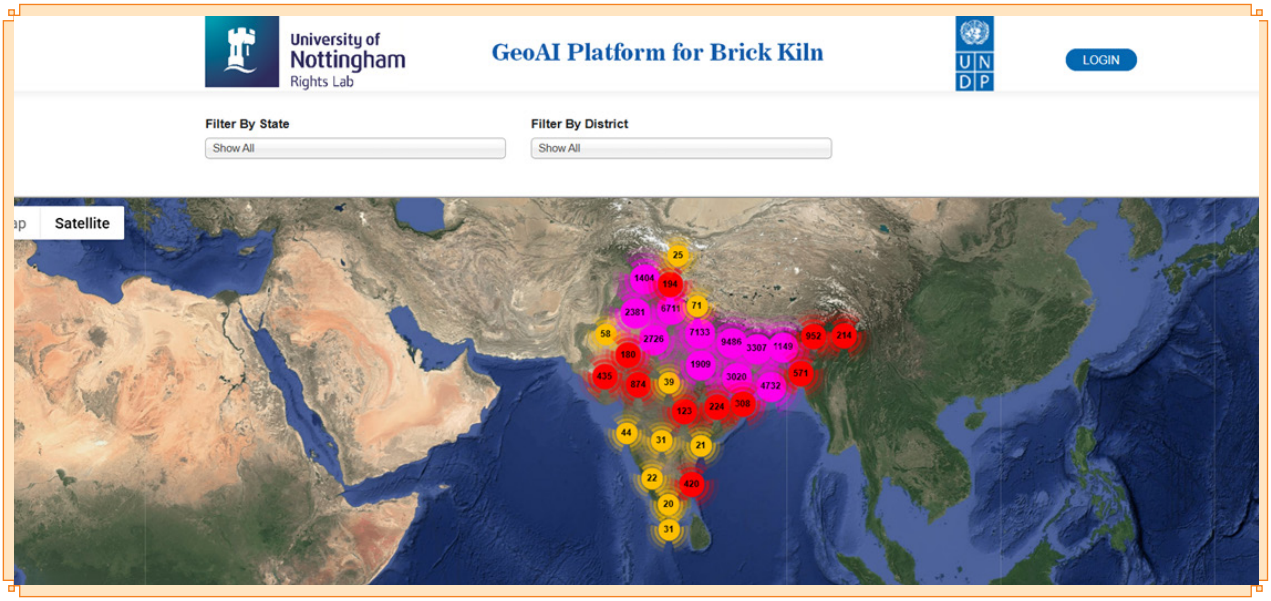
Gyanesh Gupta
ggupta@devalt.org

Technology, Collaboration, and Welfare: Transforming India's Brick Kiln Sector



GeoAI Platform for Brick Kilns, co-created by UNDP India and the Rights Lab, uses spatial science, AI, and machine learning to map and monitor kilns across India.

Over the last three years, the Rights Lab at the University of Nottingham, VSJ in Punjab, and MSEMVS in Uttar Pradesh have collaborated closely with Development Alternatives to improve environmental sustainability and worker welfare at kilns. These two aspects are closely interconnected; improvements in one area help support progress in the other. Our work within this nexus has generated valuable insights, sometimes surprising, that have increased the impact of our efforts. These findings have the potential to benefit not only our organisations but also others in the future.

Collaborative Approach to Sustainable Brick Kilns

The project used a range of technological tools to identify an effective route towards achieving our objectives. This included modelling the climate impacts that are likely to be experienced in the project's states and regions of interest. By engaging stakeholders, including government representatives, kiln owners, kiln owners' associations, and workers, we identified areas of common ground for improvement. Initiatives such as constructing latrines and creating shaded areas to mitigate the effects of intense heat were well-received by everyone involved. Establishing these areas for constructive progress helped improve relationships among stakeholders, and it is expected that this will lead to further advancements in the future. Government officials aim to connect kiln workers with the social welfare schemes to which they are entitled. However, many efforts are hampered by a complex, multi-factor 'last mile gap'.

Leveraging Technology and Partnerships for Worker Welfare

The project's GeoAI mapping provides brick kiln locations. Additionally, the data on the associated platform describes which schemes individuals are registered for and which ones they are accessing. This information enables more effective strategic planning, such as organising outreach camps and evaluating whether a change in approach for specific schemes is necessary. When combined with data and insights on migration, state officials can gain a better understanding of the circumstances faced by workers who have migrated to other states and how to best support them. This may be particularly valuable through 2026 and beyond, as the new Labour Codes underpin an increase in the mobility of welfare schemes between states.

- ✦ **Linked impact:** Sustainability and welfare improve together
- ✦ **Data-led action:** GeoAI and climate insights guide decisions
- ✦ **Aligned stakeholders:** Government, owners, and workers collaborate
- ✦ **Last-mile delivery:** Improved access to welfare schemes
- ✦ **Stronger coordination:** CSOs and government act in sync

Civil society organisations (CSOs) use the tools in similar ways to support their efforts in connecting workers to welfare schemes and undertaking outreach to communities. By using the platform to develop reports and insights, CSOs can strengthen their abilities to inform and align with strategic government interests. This approach enhances their efforts to advance priorities (such as the elimination of child labour in Uttar Pradesh). Additionally, this development has enhanced relationships between CSOs and the government and identified effective methods for collaboration.

Data-Driven Insights and Multi-Stakeholder Impact

When CSOs and government actors collaborate, involving kiln owners, our work has shown that stakeholders communicate more effectively and understand each other better. This collaboration reduces misunderstandings and helps identify blind spots. As a result, there are greater opportunities to maximise the positive benefits for all involved. Although a range of challenges in the sector remain to be addressed, we can use the project's tools effectively to support all relevant parties to work together. This approach can help us advance towards a more improved brick kiln sector that serves the needs of those engaged in it. ❐

Smoke emitting from a brick kiln factory

Laoise Ni Bhriain
Head of Strategic Project Development
University of Nottingham

TARA
Scalable Solutions for People and Our Planet

The University of Nottingham

Development Alternatives
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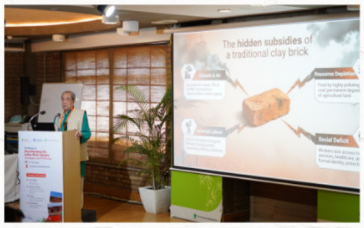
Workshop on
Decarbonising the Indian Brick Industry
Strategies and Pathways

At TARA, we are enabling a transition towards cleaner and more inclusive construction systems.

Building a future where development and sustainability go hand in hand.





Thematic co-partners

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Owner and Publisher: Dr Ashok Khosla on behalf of Development Alternatives

Development Alternatives

B-32, Tara Crescent, Qutub Institutional Area, New Delhi - 110 016
Tel: 91 (11) 2654-4100, 2654-4200, Fax: 91 (11) 2685-1158
Email: library@devalt.org, Website: www.devalt.org