Upscaling the Application of Low-Carbon and Energy-Efficient Technology in the Construction Sector

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HIGHLIGHTS

- Ecological impacts of construction sector will rise with urbanisation in South Asia.
- Use of low carbon technologies in affordable housing will reduce the impact.
- Policies and codes and guidelines including green mandate should be developed.
- Technical capacity building of government will aid in implementation of policies.
- Knowledge dissemination on the benefits of these technologies is essential.

ABSTRACT The construction sector of India, Nepal and Pakistan are currently seeing a boom in the construction sector owing to growing economy and rapid urbanisation. The growth of the sector has critical environmental implications. Apart from its energy footprint, it also has a high resource footprint. The sector also has linkages to several other industries such as cement, steel, paints, tiles, and fixtures manufacture etc. While extraction of these materials and manufacturing of the final products itself contributes greatly to the emissions released, inefficient technologies result in a larger emission increase, making the use of these materials both resource and energy intensive. In this study, focus has been laid on low-carbon and energy-efficient materials and technologies in the building sector that are presently in use in South Asia. The study thus highlights that the adoption of such materials and technologies requires multi-level interventions that range from public policies, awareness generation, capacity building and skill development to the use of financial incentives for the upscaling of such technologies.

KEYWORDS *low carbon; energy efficient; unsustainable urbanisation*

1. Introduction

1.1 The Construction Sector of South Asia

The construction sector is crucial component and indicator of a country's development. It is the second largest employer after agriculture in India, and accounted for 8.2% of its GDP in 2011–2012 (Planning Commission, 2013). The sector grew at a rate of 18% per annum from 2004–2007 in Pakistan (Neilson, 2010). Along with the social and economic implications, the construction sector has a critical role to play in environmental implications as well. Being an energy-intensive sector, it contributes to around 10–24% of total national greenhouse gas (GHG) emissions in India and Pakistan (Parikh et al., 2009). Besides energy, this sector is also very resource intensive. Cement, concrete and bricks are the most sought after materials in construction. They are produced using inefficient technologies that consume large amounts of coal and release high carbon emissions. The sector has an adverse impact on agricultural yield exerting pressure on food security due to conflicts of use

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of fertile top soil between agriculture and brick making, aggregate mining and sand dredging of rivers for concrete, mortars and plasters.

Economic growth and the geographic reconfiguration of the demands for housing and infrastructure towards urban and peri-urban areas have fuelled the growth in construction activities. However, the urbanisation process has occurred rather rapidly and haphazardly, bringing South Asia to the forefront of an enormous socio-economic shift without adequate thought and planning for defining its environmental future. It has also led to the desperate clamour for more and better urban housing, causing a frenzy of construction. The urban housing requirements range from 18.78 million in India to 1 million in Nepal range from 1 million (Varsha et al., 2015). Apart from the housing shortage, reconstruction due to disasters and extreme weather events along with renovation and aerial expansion of buildings will result in increased demand for materials from the construction sector. For example, floods alone have led to the collapse of over 2 million homes since 2010 in Pakistan. Further, according to estimates by the United Nations Development Programme (UNDP), the earthquake that occurred in Nepal in April 2015 resulted in "immense" damage to 500,000 to 600,000 homes across Nepal (UN, 2015).

Given this context, the impacts of unsustainable urbanisation and the expanding construction sector are high on the global sustainability agenda. Considering the scales of the impacts on environment, it is imperative that the construction sector embeds the concept of sustainability and green economy in its development trajectory.

There are viable opportunities for greening the sector, however, in order to translate the opportunities to tangible benefits, several interventions in the form of public policies, awareness generation, capacity building and skill development, and appropriate financial tools are imperative. This study thus attempts to analyse and highlight the key barriers and drivers that enable the adoption of low-carbon and energy-efficiency materials and technologies and mainstreaming of the same in the overall construction sector.

2. Methodology

The research study caters to this urgent need to increase awareness about the environmental consequences of a massive development of current building practices. It aims to show the way forward for the generalisation of clean technologies in the social housing space, and ultimately, in the housing sector as a whole.

With a focus on low-carbon, resource- and energy-efficient options, a literature study and technology and institutional mapping and profiling has been done for each selected country, namely India, Nepal and Pakistan. A case study approach has been adopted to analyse good practice applications and of conventional applications in each country situation, so as identify the drivers and barriers in the mass scale adoption of these construction materials and technologies (see Table 1).

In addition, a stakeholder mapping process was conducted to identify the key gaps that hinder the adoption of these technologies, thus helping in the formulation of conclusions on the push and pull factors that are essential for the mainstreaming of these materials and the technologies in South Asia.

The regional research also looked at economic, technological, and regulatory and policy frames in the different country situations and attempts to strengthen regional global change research by identifying key gaps and areas for integrative research. While the country situations differ, a common analytical frame binds the overall study.

Analysing policy thrusts and national commitments towards transformation of the sectors helped in identifying the drivers for change within the institutional mechanisms, financing systems, incentives and partnership arrangements and define the critical elements of the ecosystem for promoting low-carbon development pathways. It also examined barriers with respect to technology know-how, regulatory mechanisms, capacities of stakeholders and market promotion. The analysis resulted in identifying strategies that can be employed to successfully mainstream low-carbon options both within the sector as well as draw lessons from other sectors.

Analysis Frame for each country:

- Policy guidelines and regulatory frameworks
- Institutional mechanisms and synergies across institutions
- Partnerships
- Investments/ financing
- Capacities

Country	Prevalent Low-carbon and Energy-efficient Materials & Technologies		
India	Fly ash bricks	Bamboo	Prefabricated concrete slabs
Nepal	Hollow Concrete bricks (HCB)	Bamboo	Compressed stabilised earth blocks (CSEB)
Pakistan	Vertical shaft brick kilns (VSBK)	Bamboo	Hydraulic lime

TABLE 1. Selected case studies on low-carbon and energy-efficient materials and technologies.

3. Results and Discussions

The results from the regional case studies reveal that pathways to sustainability in construction do exist. Cleaner and alternate technologies have been developed that can substantially reduce the ecological footprint of the sector.

In the case of vertical shaft brick kilns (VSBK) in Pakistan, it was found that there was a 30–50% reduction in energy consumption (SKAT EEBP, 2010). While the VSBK is an example of an efficient use of technologies, the use of fly ash bricks is an example of resource efficiency, where the residue of thermal power plants is used to produce building bricks. In India, 163.56 million tonnes of fly ash was generated in 2012–2013 (Central Electrictiy Authority, 2014). Fly ash is now increasingly being used as a resource material rather than a waste. In this regard, fly ash has gained popularity in the manufacture of building materials like bricks, blocks, tiles etc, thus acting as an appropriate alternative to clay based conventional building materials. Fly ash bricks have a low environmental footprint as compared to the clay bricks produced by conventional technologies as greenhouses gases are not emitted during their production as well as conserve top soil. Further, alternative building materials, like micro-concrete roofing tiles, stabilised concrete earth blocks and prefabricated roofing elements can reduce the resource consumption by 25–30% (DA-CDKN, 2013). Energy consumption can also be reduced by 30–80% in new and existing buildings by commercially viable technologies (UNEP SBCI, 2007).

Further, what has been key to this study is the role of stakeholders. In the case of Nepal as seems to be the case for both India and Pakistan as well, it has been evident that policy and regulatory frameworks play a vital role in the mainstreaming of low-carbon construction materials and technologies. For example, compressed stabilised earth blocks (CSEB) are made from a mix of dry inorganic soil, non-expansive clay, aggregate and sometimes a small amount of cement, thus making them a viable alternative to fired bricks. Attempts have been made to introduce CSEB in Nepal since the past decade; however lack of awareness among the end-users has been the main reason for its failure. Hence, strategies for adoption of this material include financial incentives like subsidies, voluntary green building certification systems, building codes etc.

Similarly in the case of fly ash bricks a policy push has been the major driver for the accelerated uptake of the technology in India. The notification numbered S.O. 763 (E) of Ministry of Environment, Forests and Climate Change and the Fly Ash Mission of Department of Science and Technology, Government of India, have played a crucial role in the uptake of the technology through technology demonstration, easy access to fly ash and mandatory use of fly ash bricks in construction.

Case study: Bamboo House India (BHI)

BHI is a social enterprise striving to create a chain of bamboo showrooms across the country to promote and market bamboo based products under one roof,, starting from bamboo pen to bamboo housing structures. It works through a hybrid model with a "for-profit" component and a "non-profit" component. "For profit" activities involve sourcing, designing, retailing, exhibiting and developing markets and "not-for-profit" activities are handled by the "Bamboo Artisan Welfare Society" involving skill training and upgrade, design development as well as capacity building. The organisation is taking an initiative of opening showrooms for bamboo products, artifacts, materials etc. BHI is also encouraging artisans to come up with bamboo-based materials by providing them with interest-free loan for their orders.

Stakeholder	Role
Government	• Streamlining policies to promote the use of low-carbon and energy-efficient construction technologies • Introduce low-carbon materials and technologies in the Schedule of Rates • Encourage preferential procurement by government departments • Ensure quality of materials through eco-labelling / rating systems • Strengthening implementation processes and mechanism • Increased coherence and integration among departments
Private Sector	• Partnerships for strengthening supply chain through aggregation • Enhanced access to finance to provide an impetus to micro-entrepreneurs • Incubation services for commercialisation of technologies • Encourage public-private partnerships for commercialisation of technologies
Civil Society Organisations	• Awareness • Training and capacity building

TABLE 2. Analysis of stakeholders and their roles in upscaling low-carbon and energy-efficient construction materials and technologies.

A broad analysis of all the case studies has helped in the identification of all the stakeholders that play an essential role in creating an enabling environment for the adoption of low-carbon and energy-efficient materials and technologies.

Table 2 provides a clear understanding of the key stakeholders; their roles as facilitators in adopting low-carbon construction materials and their mainstreaming into the construction sector.

Given that the role of all stakeholders is crucial, the study through the analytical frame seeks to further highlight the key drivers that result in up scaling low-carbon and energy-efficient materials and technologies in South Asia.

4. Recommendations

4.1 Policy and Regulatory Norms

The intent to introduce and promote "green" and "low carbon" in the construction sector is gathering focus in India, Pakistan and Nepal. Policies and initiatives of India like the National Housing Policy, the 12th Five Year Plan (2013–2017) and the National Action Plan on Climate Change advocate the use of alternate technologies in construction. However, the translation of the mandate to policies and schemes has been minimal. Outdated policies like the Housing Policy of Pakistan (2001) and absence of codes and guidelines are one of the major barriers in the promotion of low-carbon construction technologies.

To remedy this, guidelines should be developed to include the aspects of low-carbon construction in policies and schemes. The scope of Schedule of Rates should be expanded to accommodate low-carbon building materials. This would enable the government departments to use low-carbon construction techniques and technologies in their construction. Preferential procurement for low-carbon materials would also encourage their use.

The set of codes and standards and monitoring mechanisms that ensure the efficiency and quality of the building materials used is also rather weak. A quality control system should be set in place that is in the form of eco-labelling/rating systems for materials and products. While ensuring quality is essential, it is also crucial to allow flexibility in the design and applicability of these materials. Materials and design should be selected on the basis of local geographical conditions, climate and availability of local materials. Encouraging the streamlining of indigenous, locally produced material, will result in significant economic regeneration within the select communities.

Adaptation and mitigation measures should also be incorporated into local municipal planning and service delivery to promote low-carbon construction practices. Taking carbon considerations into account in risk reduction, relief and reconstruction would also contribute to the potential "greening" of the disaster risk management plans. This is an important dimension for recognising the benefits that a low-carbon economy can bring to developing countries (Urban, Mitchell & Villanueva, 2010). However, there needs to be an institutionalised, collective effort made to mainstream these materials and technology into housing policies, instructional guidelines etc. for widespread usage.

4.2 Technology and Capacity

Currently, the construction sector suffers from lack of appropriate technologies and the support by efficient technology transfer. While research on the development and promotion of low-carbon construction technologies is being conducted by several research institutes, laboratories and civil society organisations in India, there is a glaring lack of any kind of academic and research work in Pakistan. Innovation of low-carbon and energy-efficient technologies is essential for the transformation of this sector. Several aspects need to be addressed for the successful adoption of these technologies. They include collaborative research, technology demonstrations, access to information and capacity building of workforce.

Successful adoption of technologies like the VSBK, HCB, CSEB, and use of bamboo in structural applications can be seen in small pockets across South Asia. While these technologies are available, limited information about the benefit of these technologies, its viability in the local context, and the operation processes hinders its growth. There is a dire need to launch campaigns generating awareness among regulatory agencies, builders/architects, end users and the general public.

The lack of technical capacities is one of the largest barriers facing the sector. Policies should focus on addressing this by organising technical training of masons and engineers on a regular basis. Capacity building of officials for the proper implementation of these policies should be promoted (TARA, 2014).

4.3 Market and Finance

The disaggregated nature of this sector throws up challenges with respect to strengthening the supply chain of materials and services. Continuous supply of construction materials can be ensured by setting up micro enterprises. Fiscal incentives and priority financing for small and medium enterprises should also be initiated to facilitate setting up green building material production facilities. Most of the investors are concerned about a quick return on investment, thereby depending upon traditionally available technical knowhow and manpower. New and low-carbon construction technologies are negatively perceived. Partnerships with banks and other financial institutions should be explored to facilitate easy access of finance to the entrepreneurs.

Quality is a key component in the aggregation of green construction services. Standardised curriculum and a system for certified skills for masons and artisans will go a long way in monitoring and assuring quality.

4.4 Partnerships

Research and development is essential for promoting low-carbon and energy-efficient technologies. However, the research on these technologies remains confined to the research laboratories and institutions, out of bounds for common entrepreneurs. It is essential to strengthen commercialisation of appropriate technologies through propagating incubation services. Such services can act as intermediary between the laboratories and research institutions, and entrepreneurs. Apart from technologies, incubation services can also include other softer aspects of construction like design and processes, capacity building, etc.

It is vital to promote public-private partnerships. In such partnerships, the services are delivered by the private sector, while the responsibility of providing service rests with the government. Public-private partnerships would not only help in commercialisation of low-carbon technologies, it would also aid stricter implementation of these policies.

User acceptance of these technologies is the key to its acceptance. However, popular public perception is that low cost means low grade. There is also lack of readily accessible and reliable information comparing alternative structural materials and systems, the benefit of these technologies, its viability in the local context, and the operation processes hinders its growth. Awareness generation targeting users is the need of the hour.

5. Conclusion

In conclusion, it is evident that the construction sector is a disaggregated sector with complex interlinks among both the public and private stakeholders. But at the same time, one is able to identify the key agents of change whose cooperation as well as coordination can bring about a paradigm shift in the construction sector from a carbon intensive and resource inefficient sector to a more sustainable construction sector.

On one hand, the Government agencies need to work towards streamlining policies to include the "green" mandate, strengthen the implementation processes and mechanisms and increase coherence and integration among departments. On the other hand, the private sector needs to build partnerships so as to strengthen the supply chain as well as enhance access to finance to provide an impetus to micro-entrepreneurs. Finally, the civil society organisations also have a crucial role to play in generating awareness as well as building capacities towards the use of green construction materials. Thus the coming together of all these stakeholders with a universal goal of mainstreaming the use of low-carbon and energy-efficient construction materials and technologies will result in the transition to a green and more inclusive economy.

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