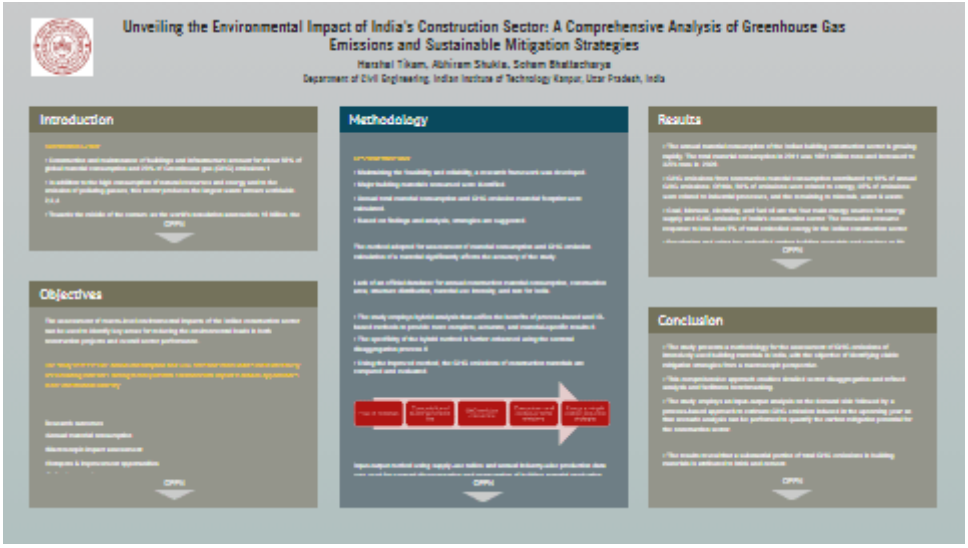
Unveiling the Environmental Impact of India's Construction Sector: A Comprehensive Analysis of Greenhouse Gas Emissions and Sustainable Mitigation Strategies



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ABSTRACT

The construction sector serves as a vital pillar from both social and economic standpoints, fulfilling essential housing needs and contributing significantly to economic growth. However, its environmental impact is notable, manifesting through the release of substantial greenhouse gas emissions, ultimately leading to detrimental environmental consequences, such as global warming and ozone depletion. The global construction industry is a significant contributor, accounting for a substantial 39% of the world's greenhouse gas emissions. Civil construction, particularly in developing countries like India, holds a pronounced economic role. To address environmental concerns, the adoption of sustainable construction practices becomes imperative, not only to curtail greenhouse gas emissions but also to conserve finite resources. Developing economies are compelled to embark on large-scale civil construction and energy production ventures, accentuating the criticality of transitioning to a low-carbon economy, though this poses challenges in the process. To identify potential mitigation opportunities, comprehending the contributions of the construction industry and related activities is vital. Thus, the present study seeks to quantify the overall carbon material footprint of the construction sector in India, with a focus on identifying key contributing supply chains, industries, and products. To achieve this, extensive economy-wide input-output analysis is conducted utilizing economic input-output transaction tables jointly by the Central Statistical Organization (CSO) and Planning Commission. This comprehensive approach enables detailed sector disaggregation refined analysis, and facilitates benchmarking. To assess GHG emissions, the study develops a model based on input-output and process-based life cycle assessment principles. The significance of this in-depth analysis is to provide critical insights for reducing construction-related greenhouse gas emissions in developing countries. The outcome will aid in prioritizing future emissions reduction endeavors, directing targeted solutions toward improving the overall environmental performance of the construction industries.

INTRODUCTION

Construction Sector

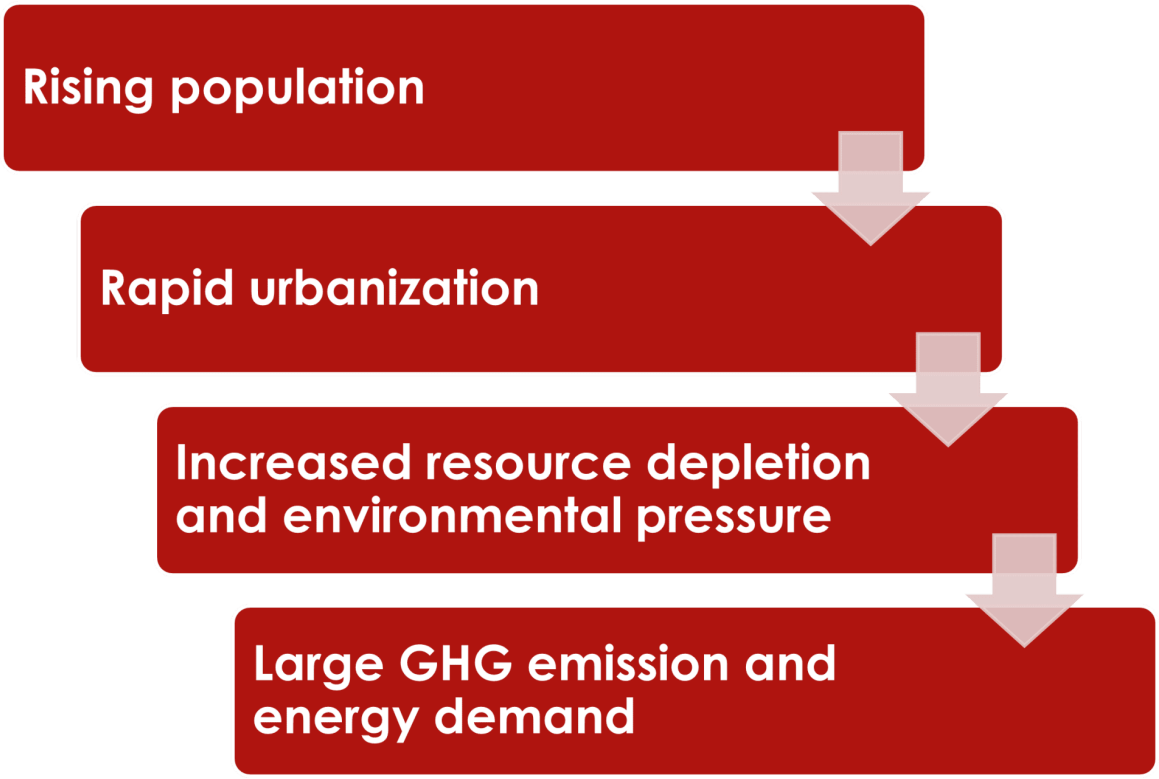
• Construction and maintenance of buildings and infrastructure account for about 50% of global material consumption and 20% of Greenhouse gas (GHG) emissions.1

• In addition to the high consumption of natural resources and energy and to the emission of polluting gasses, this sector produces the largest waste stream worldwide. 2,3,4

• Towards the middle of the century, as the world's population approaches 10 billion, the global building stock is expected to double in size.

• Embodied carbon is expected to account for nearly 50% of the overall carbon footprint of new construction between 2020 and 2050. 5

Assessment of macro-level environmental impacts helps to identify key areas for reducing environmental loads of construction projects and overall sector performance.



OBJECTIVES

The assessment of macro-level environmental impacts of the Indian construction sector can be used to identify key areas for reducing the environmental loads in both construction projects and overall sector performance.

The study assesses the annual consumption and GHG emissions from India's most intensively used building materials, aiming to find potential environmental impact reduction opportunities in the construction industry.

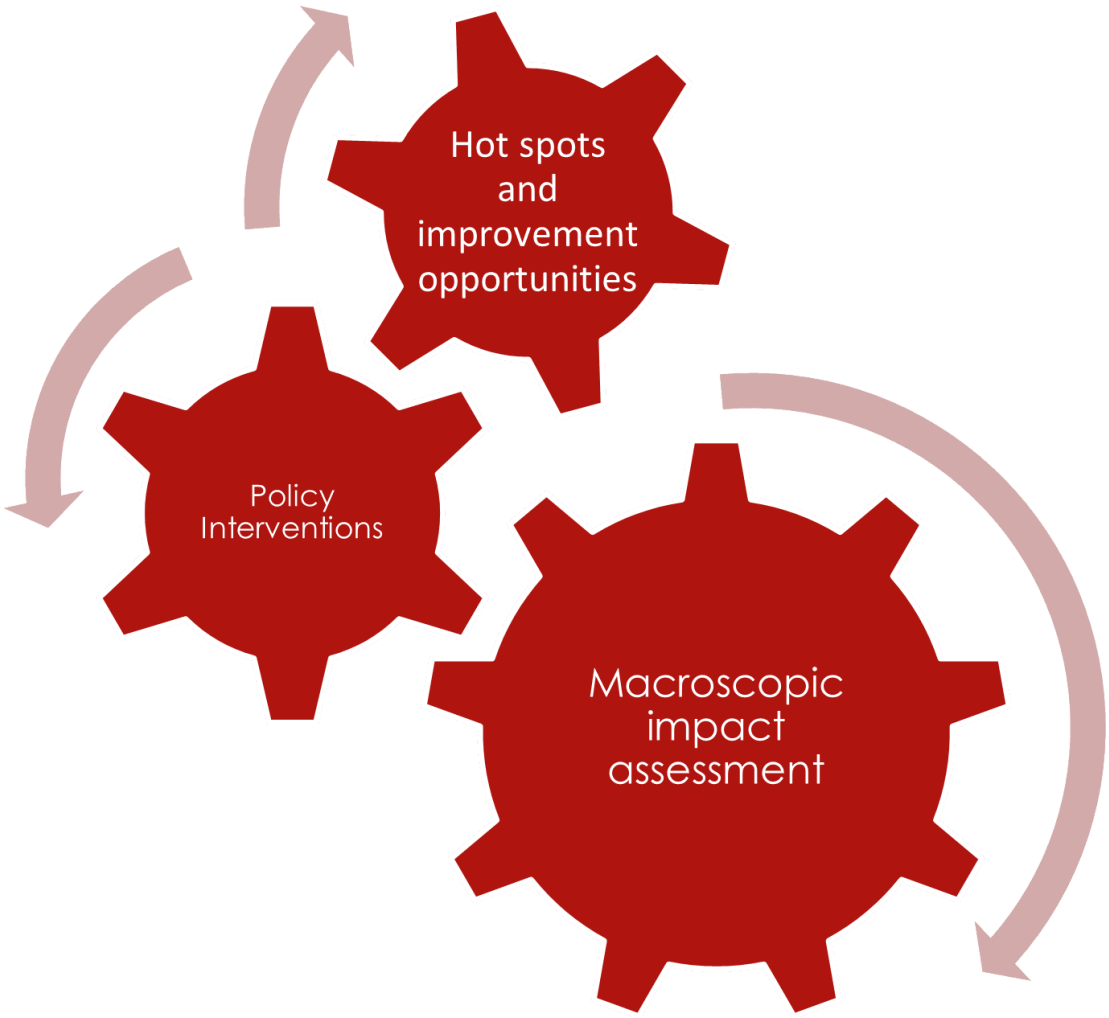
Research outcomes

•Annual material consumption

•Macroscopic impact assessment

•Hotspots & improvement opportunities

•Policy interventions


Hot spots and improvement opportunities
Policy Interventions
Macroscopic impact assessment

METHODOLOGY

Research framework

• Maintaining the feasibility and reliability, a research framework was developed.

• Major building materials consumed were identified.

• Annual total material consumption and GHG emission material footprint were calculated.

• Based on findings and analysis, strategies are suggested.

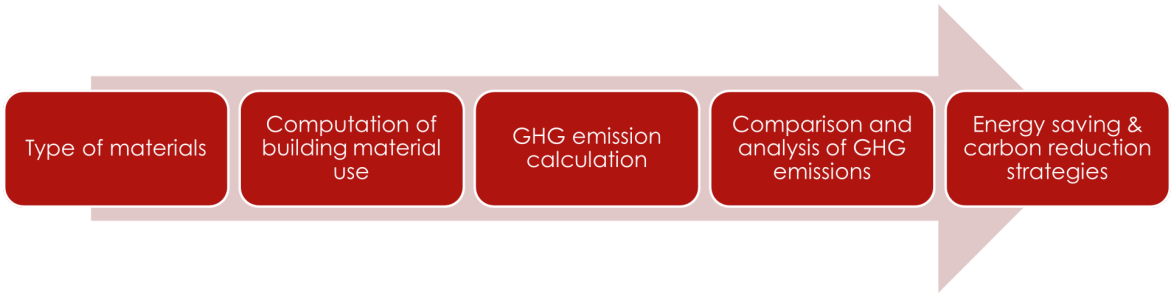
The method adopted for assessment of material consumption and GHG emission calculation of a material significantly affects the accuracy of the study.

Lack of an official database for annual construction material consumption, construction area, structure distribution, material use intensity, and rate for India.

• The study employs hybrid analysis that unifies the benefits of process-based and IO-based methods to provide more complete, accurate, and material-specific results.6

• The specificity of the hybrid method is further enhanced using the sectoral disaggregation process.6

• Using the improved method, the GHG emissions of construction materials are computed and evaluated.



Input-output method using supply-use tables and annual industry-wise production data was used for sectoral disaggregation and computation of building material production and consumption by the Indian construction sector.

The study further investigated the environmental impact of these materials by assessing GHG emission of materials using process-based hybrid method in the Indian context.

RESULTS

• The annual material consumption of the Indian building construction sector is growing rapidly. The total material consumption in 2011 was 1981 million tons and increased to 3274 tons in 2020.

• GHG emissions from construction material consumption contributed to 18% of annual GHG emissions. Of this, 56% of emissions were related to energy, 35% of emissions were related to industrial processes, and the remaining to minerals, water & waste.

• Coal, biomass, electricity, and fuel oil are the four main energy sources for energy supply and GHG emission of India's construction sector. The renewable resource response to less than 5% of total embodied energy in the Indian construction sector.

• Developing and using low embodied carbon building materials and services at life cycle perspective, increasing the energy efficiency of construction machines, and promoting renewable energy use are identified as three main pivotal opportunities to reduce GHG emissions of the construction sector.

CONCLUSION

• The study presents a methodology for the assessment of GHG emissions of intensively used building materials in India, with the objective of identifying viable mitigation strategies from a macroscopic perspective.

• This comprehensive approach enables detailed sector disaggregation and refined analysis and facilitates benchmarking.

• The study employs an input-output analysis on the demand side followed by a process-based approach to estimate GHG emission induced in the upcoming year so that scenario analysis can be performed to quantify the carbon mitigation potential for the construction sector.

• The results reveal that a substantial portion of total GHG emissions in building materials is attributed to brick and cement.

• The findings underscore the importance of enhancing the use of cleaner fuel to achieve substantial short-term GHG mitigation.

• However, significant impact reduction can be realized through material-related initiatives, particularly focused on metal recycling and the adoption of low-carbon materials.

• Further, it advocates balancing urbanization-construction and sustainable materials for environmental commitments. Reforming supply-side incentives, like mandatory carbon labeling and sustainable procurement practices, can offer significant benefits.

• In conclusion, the study sheds light on the significant contribution of building materials towards GHG emission and highlights mitigation strategies that can facilitate sustainable construction.

REFERENCES

1.Gallego-Schmid, A., Chen, H. M., Sharmina, M., & Mendoza, J. M. F. (2020). Links between circular economy and climate change mitigation in the built environment. Journal of Cleaner Production, 260, 121115.

2.Braga, A. M., Silvestre, J. D., & de Brito, J. (2017). Compared environmental and economic impact from cradle to gate of concrete with natural and recycled coarse aggregates. Journal of Cleaner Production, 162, 529-543.

3.Silgado, S. S., Valdiviezo, L. C., Domingo, S. G., & Roca, X. (2018). Multi-criteria decision analysis to assess the environmental and economic performance of using recycled gypsum cement and recycled aggregate to produce concrete: The case of Catalonia (Spain). Resources, Conservation and Recycling, 133, 120-131.

4.Akanbi, L. A., Oyedele, L. O., Omoteso, K., Bilal, M., Akinade, O. O., Ajayi, A. O., ... & Owolabi, H. A. (2019). Disassembly and deconstruction analytics system (D-DAS) for construction in a circular economy. Journal of cleaner production, 223, 386-396.

5.https://worldgbc.org/wp-content/uploads/2022/12/WorldGBC-Annual-Report-2022_FINAL-version_LR.pdf

6. Dixit, M. K. (2015, April). A framework for an improved input-output-based hybrid method for embodied energy calculation. In Proc. 51st ASC Annual International Conference hosted by Texas A&M University in College Station, Texas.