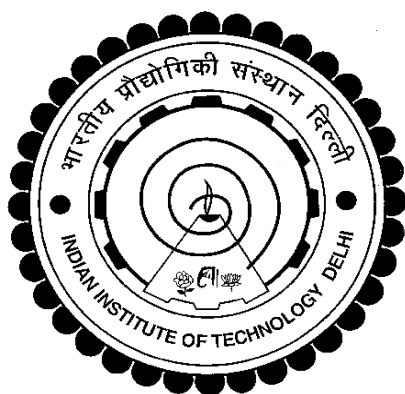


**PROMOTING CLIMATE RESILIENCE OF
HOUSING IN INDIA-
A FRAMEWORK FOR SOCIAL HOUSING**

SUNEET ANAND



**CENTRE FOR RURAL DEVELOPMENT &
TECHNOLOGY
INDIAN INSTITUTE OF TECHNOLOGY DELHI
NOVEMBER 2022**

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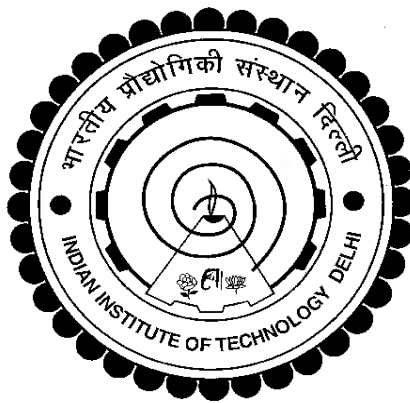
SUNEET ANAND

CENTRE FOR RURAL DEVELOPMENT & TECHNOLOGY

Submitted

**in fulfillment of the requirements of the degree of
Doctor of Philosophy**

to the



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*For my father, and to the rest of my family, whose
indomitable spirit is my biggest inspiration!*

"The dharma of water is wetness. The dharma of honey is sweetness. The dharma of flower is fragrance. The dharma of air is breathe. The dharma of fire is heat. The dharma of place is to sustain the sacred power inherent and manifested therein. The dharma of our culture is to save its heritage ecology"

- Swami Vivekananda

By three methods, we may learn wisdom: First, by reflection, which is noblest; Second, by imitation, which is easiest; and third, by experience, which is the bitterest.

Confucius

CERTIFICATE

This is to certify that "**Promoting Climate Resilience of Housing in India- A Framework for Social Housing**" being submitted by **Suneet Anand** to the Indian Institute of Technology Delhi for the award of **Doctor of Philosophy** is a record of original bonafide research work carried out by him under my guidance and supervision. In my opinion, the thesis has reached the standard of fulfilling the requirements of all the regulations related to the degree. The research report and results presented in this thesis have not been submitted, in part or in full, to any other university or institution for the award of any degree or diploma. I certify that he has pursued the prescribed course of Research.

Prof Vijayaraghavan M Chariar

Thesis Advisor

Centre for Rural Development and Technology

Indian Institute of Technology Delhi

New Delhi- 110016, India

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Suneet Anand

Abstract

Housing is one of the primary needs for survival of human beings. It not only protects us from the external environment, but also serves as a critical asset for social and financial security.

Government of India's Working Group on Rural Housing for the 12th plan estimated the total housing shortfall between 2012-2017 at a little over 39 million houses (Planning Commission, 2012). Over 90 percent of the total shortage pertains to Below Poverty Line (BPL) households. Financial support for rural housing in India is limited and spread over a large geographical area of the country. From time to time, national and state governments have launched housing schemes as a part of their welfare initiatives. However, the country-wide flagship scheme of the Government to support rural housing, namely Indira Awaas Yojana (IAY) now known as the Pradhan Mantri Awaas Yojana – Grameen (PMAY-G), has been in existence the longest. It has had different components such as providing assistance for construction of new houses with a built of 20 sq m excluding toilet. Apart from providing financial and technical support to the below poverty line households living in 'kutchra' houses for construction, house sites are also provided for those who do not have a homestead.

The scheme has resulted in both positive and negative outcomes. It has been observed by some reports that the scheme has reported user satisfaction as it does not consist of any predetermined layout or material requirements and a full subsidy is granted without any component of credit (Raman, 2012). On the other hand, the scheme has been unable to address the housing requirements of the poorest in the community due to inadequacy of funds to build leading to other debts. (Ameya Athavankar, 2013; Raman, 2012). Additionally, the climate impact of using “pucca” or strong / industrial materials in the form of brick, cement, and steel at the expense of the environment have not been considered in the drive for ‘permanent’

construction. Given the huge scale of the programme and its evident precedence for the design of smaller, sub-national / state level housing programmes across India, there is a need for exploring the decarbonization potential of the programme. This is an important fact given the ongoing discourse around climate change. According to the report by IPCC, the building sector is a primary culprit of climate change, contributing to 19% of energy-related Green House Gas emissions, and around 30% of black carbon emissions, while globally consuming 32% of total final energy use in 2010 (Lucon O., 2014). Manufacturing of building materials contributed to 11% of global GHG emissions in 2018 (International Energy Agency, 2019). Building materials that contribute to two-thirds of GHG emissions are concrete and steel, while brick contributes 18% (Zhong, et al., 2021), (Herczeg, 2014), (Müller D. B., 2011). India is estimated to become the largest GHG emitter in the next 30 years, surpassing China(ibid).

To reduce GHG emissions as part of strategies for mitigation of climate change impacts, India needs to adopt policies to discourage the use of building materials such as brick, concrete and steel and explore low energy options especially for large scale housing construction using government funds.

The core question that this research sought to explore was 'Why does social housing in rural India continue to depend on energy-intensive construction materials and what needs to change to make social housing more resilient to climate change ?' The Research was therefore focused on developing an Actionable Framework for Climate Resilient Rural Housing which would be helpful for policy makers and practitioners to contribute to this cause meaningfully. To do so, a detailed study of existing literature on rural housing, to understand the potential of upgrading vernacular construction that is characterized using local materials with low embodied energy. This underscored the need for a framework that brings the above, closely inter-related purposes together. The literature study also brought out the fact that

while vernacular construction still holds a lot of promise, the challenges around the use of the same in mainstream rural housing given the unique context of India are huge.

This study delved deeper into the factors that guide homeowner choices while constructing a house and explore possible avenues for enhancing sustainability of rural housing, especially those that are funded through public money in the form of state sponsored housing. Alongside, a review of the existing literature on climate resilience was undertaken including the potential of vernacular construction to support mitigation and adaptation actions..

A structured analysis of key challenges in the use of vernacular in social housing and their causes in the current context of India was undertaken through a field survey in three States of India, namely Rajasthan, Himachal Pradesh, and Sikkim. Key informant interviews and Focus Group Discussions were also carried out with key stakeholders involved in this problematique. The findings were synthesized through casual loop analysis. Case studies reinforced these findings and provide valuable insights for defining the contours of the framework for upgradation of vernacular construction for promoting climate resilience of social housing. The Climate Resilient Rural Housing Framework was vetted through stakeholder consultations. It was subsequently tested and validated in the state of Sikkim in India. The study also fed into the development of “Pahal I and II” a compilation of upgraded vernacular type designs for different states in India. Based on the upgraded CRRH designs developed as part of the study, Government of Sikkim undertook demonstration of the designs in different parts of the state. The application of the CRRHF in Sikkim was helpful in influencing the state policies on Rural Housing.

कार्यकारी सारांश

आवास मनुष्य के अस्तित्व के लिए प्राथमिक आवश्यकताओं में से एक है। यह हमें बाहरी वातावरण से बचाता है और सामाजिक और वित्तीय सुरक्षा के लिए एक महत्वपूर्ण संपत्ति के रूप में कार्य करता है।

12वीं योजना के लिए ग्रामीण आवास पर भारत सरकार के कार्यकारी समूह ने 2012-2017 के बीच 39 मिलियन से अधिक घरों में कुल आवास की कमी का अनुमान लगाया (योजना आयोग, 2012)। कुल कमी का 90 प्रतिशत से अधिक गरीबी रेखा से नीचे (बीपीएल) परिवारों से संबंधित है। भारत में ग्रामीण आवास के लिए वित्तीय सहायता सीमित है और देश के एक बड़े भौगोलिक क्षेत्र में फैली हुई है। समय-समय पर, राष्ट्रीय और राज्य सरकारों ने अपनी कल्याणकारी पहलों के एक भाग के रूप में आवास योजनाएँ शुरू की हैं। हालाँकि, ग्रामीण आवास को समर्थन देने के लिए सरकार की देशव्यापी फ्लैगशिप योजना, अर्थात् इंदिरा आवास योजना (IAY), जिसे अब प्रधान मंत्री आवास योजना - ग्रामीण (PMAY-G) के रूप में जाना जाता है, सबसे लंबे समय तक अस्तित्व में रही है। इसके विभिन्न घटक हैं जैसे शौचालय को छोड़कर 20 वर्ग मीटर के नए घरों के निर्माण के लिए सहायता प्रदान करना। कच्चे मकानों में रहने वाले गरीबी रेखा से नीचे के परिवारों को निर्माण के लिए वित्तीय और तकनीकी सहायता प्रदान करने के अलावा, जिनके पास घर नहीं है, उनके लिए आवास स्थल भी प्रदान किए जाते हैं।

इस योजना के सकारात्मक और नकारात्मक दोनों परिणाम सामने आए हैं। कुछ रिपोर्टों में देखा गया है कि इस योजना के परिणामस्वरूप उच्च उपयोगकर्ता संतुष्टि हुई है क्योंकि इसमें कोई पूर्व निर्धारित लेआउट या सामग्री की आवश्यकता शामिल नहीं है, और क्रेडिट के किसी भी घटक के बिना पूर्ण सब्सिडी दी जाती है (रमन, 2012)। दूसरी ओर, योजना निर्माण के लिए धन की अपर्याप्तता के कारण समुदाय में सबसे गरीब लोगों की आवास आवश्यकताओं को पूरा करने में असमर्थ रही है, जिससे अन्य ऋणों का सामना करना पड़ रहा है। (अमेय आठवांकर, 2013; रमन, 2012)। इसके अतिरिक्त, पर्यावरण की कीमत पर ईट, सीमेंट और स्टील के रूप में "पक्के" या मजबूत/औद्योगिक सामग्री के उपयोग के जलवायु प्रभाव को 'स्थायी' निर्माण के अभियान में कम दर्शाया गया है। कार्यक्रम के बड़े पैमाने पर और भारत भर में छोटे, उप-राष्ट्रीय / राज्य-स्तरीय आवास कार्यक्रमों के डिजाइन के लिए इसकी स्पष्ट प्राथमिकता को देखते हुए, कार्यक्रम की डीकार्बोनाइजेशन क्षमता का पता लगाने की आवश्यकता है। जलवायु परिवर्तन को लेकर चल रहे विमर्श को देखते हुए यह एक महत्वपूर्ण तथ्य है। आईपीसीसी की रिपोर्ट के अनुसार, भवन क्षेत्र जलवायु परिवर्तन का एक प्राथमिक अपराधी है, जो ऊर्जा से संबंधित ग्रीन हाउस गैस उत्सर्जन में 19% और ब्लैक कार्बन उत्सर्जन का लगभग 30% योगदान देता है, जबकि विश्व स्तर पर कुल अंतिम ऊर्जा उपयोग का 32% उपभोग करता है। 2010 (ल्यूकॉन ओ।, 2014)। 2018 में वैश्विक GHG उत्सर्जन में निर्माण सामग्री के निर्माण ने 11% का योगदान दिया (अंतर्राष्ट्रीय ऊर्जा एजेंसी, 2019)। जीएचजी उत्सर्जन में दो-तिहाई योगदान देने वाली निर्माण सामग्री कंक्रीट और स्टील हैं, जबकि ईट का योगदान 18% (झोंग, एट अल।, 2021), (हर्जेंग, 2014), (मुलर डी.बी., 2011) है। भारत के 30 वर्षों में चीन (ibid) को पीछे छोड़ते हुए सबसे बड़ा GHG उत्सर्जक बनने का अनुमान है।

जलवायु परिवर्तन के प्रभावों को कम करने के लिए रणनीतियों के हिस्से के रूप में जीएचजी उत्सर्जन को कम करने के लिए, भारत को ईट, कंक्रीट और स्टील जैसी निर्माण सामग्री के उपयोग को हतोत्साहित करने और कम ऊर्जा विकल्पों का पता लगाने के लिए नीतियों को अपनाने की जरूरत है, विशेष रूप से बड़े पैमाने पर आवास निर्माण के लिए, सरकार का उपयोग करके धन।

इस शोध ने मूल प्रश्न की खोज की: 'ग्रामीण भारत में सामाजिक आवास ऊर्जा-गहन निर्माण सामग्री पर निर्भर क्यों है, और सामाजिक आवास को जलवायु परिवर्तन के प्रति अधिक लचीला बनाने के लिए क्या बदलने की

आवश्यकता है?' इसलिए, अनुसंधान ने जलवायु लचीला ग्रामीण आवास (सीआरआरएच) के लिए एक कार्रवाई योग्य ढांचा विकसित करने पर ध्यान केंद्रित किया, जो नीति निर्माताओं और चिकित्सकों के लिए इस उद्देश्य में सार्थक योगदान देने में मददगार होगा। ऐसा करने के लिए, कम सन्निहित ऊर्जा के साथ स्थानीय सामग्रियों के उपयोग की विशेषता वाले स्थानीय निर्माण के उन्नयन की क्षमता को समझने के लिए ग्रामीण आवास पर मौजूदा साहित्य का विस्तृत अध्ययन। यह एक ऐसे ढांचे की आवश्यकता को रेखांकित करता है जो उपरोक्त संबंधित उद्देश्यों को बारीकी से जोड़ता है। साहित्य अध्ययन ने इस तथ्य को भी सामने लाया कि जबकि स्थानीय निर्माण में अभी भी बहुत सारे वादे हैं, मुख्यधारा के ग्रामीण आवास में इसके उपयोग के आसपास की चुनौतियां, भारत के अद्वितीय संदर्भ को देखते हुए, बहुत बड़ी हैं।

यह अध्ययन उन कारकों पर गहराई से विचार करता है जो घर बनाते समय गृहस्वामी की पसंद का मार्गदर्शन करते हैं और ग्रामीण घरों की स्थिरता को बढ़ाने के लिए संभावित रास्ते तलाशते हैं, विशेष रूप से वे जो सार्वजनिक धन के माध्यम से वित्त पोषित होते हैं। जलवायु लचीलापन पर मौजूदा साहित्य की समीक्षा की गई, जिसमें शमन और अनुकूलन कार्यों का समर्थन करने के लिए स्थानीय निर्माण की क्षमता शामिल है।

अध्ययन में तीन राज्यों, राजस्थान, हिमाचल प्रदेश और सिक्किम में एक क्षेत्र सर्वेक्षण के माध्यम से भारत के वर्तमान संदर्भ में सामाजिक आवास में स्थानीय भाषा के उपयोग में महत्वपूर्ण चुनौतियों का एक संरचित विश्लेषण शामिल है। इस समस्या में शामिल प्रमुख हितधारकों के साथ मुख्य मुखबिर साक्षात्कार और फोकस समूह चर्चा ने इन मुद्दों की समझ को गहरा करने में मदद की। निष्कर्षों को आकस्मिक लूप विश्लेषण के माध्यम से संश्लेषित किया गया था।

केस स्टडीज ने इन निष्कर्षों को मजबूत किया और सामाजिक आवास के जलवायु लचीलेपन को बढ़ावा देने के लिए स्थानीय निर्माण के उन्नयन के लिए रूपरेखा के रूपरेखा को परिभाषित करने के लिए मूल्यवान अंतर्दृष्टि प्रदान की। क्लाइमेट रेजिलिएंट रूरल हाउसिंग फ्रेमवर्क (सीआरआरएचएफ) को हितधारकों के परामर्श के माध्यम से पुनरीक्षित किया गया था। बाद में भारत में सिक्किम राज्य में इसका परीक्षण और सत्यापन किया गया। इस अध्ययन में "पहल I और II" के विकास पर भी ध्यान दिया गया, जो भारत में विभिन्न राज्यों के लिए उन्नत स्थानीय भाषा के डिजाइनों का संकलन है। अध्ययन के हिस्से के रूप में विकसित उन्नत सीआरआरएच डिजाइनों के आधार पर, सिक्किम सरकार ने राज्य के विभिन्न हिस्सों में उनके उपयोग का प्रदर्शन किया। सिक्किम में सीआरआरएचएफ के आवेदन ने ग्रामीण आवास पर राज्य की नीतियों को प्रभावित करने में मदद की

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LIST OF ABBREVIATIONS

BEES	Building for Environmental and Economic Sustainability
BREEAM	Building Research Establishment Environmental Assessment Method
BMTPC	Building Materials And Technology Promotion Council
BPL	Below Poverty Line
CCA	Climate Change Adaptation
CGI	Corrugated Galvanized Iron
CII	Confederation of Indian Industries
CLT	Cross-laminated timber
CLD	Causal Loop Diagrams
CMRHM	Chief Minister Rural Housing Mission
CPWD	Central Public Works Department
CRRHF	Climate Resilient Rural Housing Framework
DDMA	District Disaster Management Authority
DECoRum	Demolition and construction recycling unified management
DM	Disaster Management
DRR	Disaster Risk Reduction
ECBC	Energy Conservation Building Code
EVALOC	Evaluating Low-Carbon Communities
FGD	Focus Group Discussion

GHG	Greenhouse Gas
GOI	Government Of India
GRIHA	Green Rating for Integrated Habitat Assessment
HK-BEAM	Hong Kong Building Environmental Assessment Method
IAY	Indira Awaas Yojana
ICE	Inventory of carbon and Energy
IGBC	Indian Green Building Council
IPCC	Intergovernmental Panel on Climate Change
IRDP	Integrated Rural Development Program
JRY	Jawahar Rozgar Yojana
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LCI	Life Cycle Inventory
LEED	Leadership in Energy and Environmental Design
MG-NREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MORD	Ministry of Rural Development
NAPCC	National Action Plan on Climate Change
NGO	Non-Government Organization
NREGA	National Rural Employment Guarantee Act
PMAY (G)	Pradhan Mantri Awaas Yojana (Grameen)
RBC	Reinforced Brick Concrete

RCC	Reinforced Concrete Cement
REDRH	Reconstruction Of Earthquake Damaged Rural Houses
RH	Rural Housing
RLEGP	Rural Landless Employment Guarantee Programme
RMDD	Rural Management And Development Department
SAPCC	State Action Plan for Climate Change
SDMA	State Disaster Management Authority
UNDP	United Nations Development Programme
UNISDR	United Nations International Strategy for Disaster Reduction