

ARTICLE

Green building codes for sustainable housing development in India: progress review and future pathways

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Abstract

Given the rapid urbanisation, acceleration of the anthropogenic transformation of landscapes and the escalating ecological imperatives facing India, robust and effective green building codes have become paramount in ensuring sustainable housing development. This paper reviews the effect of the development of green building codes on sustainable housing across India, especially as far as their compliance with SDGs. While prior literature targets policy formulation, more attention should be paid to researching the policy impacts and the difficulties in the corresponding policies' implementation. To evaluate the effectiveness of the Green Buildings codes, the study uses systematic review of literature and policy documents, which works hand-in-hand with qualitative analysis. The research hypothesis posits that in regions having policies closely aligned with SDGs, there has been greater development of policies of sustainability and these areas exhibit enhanced development of policies and sustainability outcomes as evidenced by development of codes on maintaining resilience, environmental performance, and socio-economic equity. This relationship is basis of the study hence the question; what factors enhance the potential for improved sustainability outcomes in green building codes aligned with SDGs? Research evidence indicates that despite intended high ambitions in formulation

of codes, the eventual effectiveness is negated by weak operational compliance and geographical inequalities. This research forms part of a broader investigation into specific sections of the green building codes, covering energy efficiency, material utilisation, urban planning, and green space development. The study offers policy implications to policy makers and maps out a general guideline to enhance the implementation of sustainable features in housing delivery systems across the country.

Keywords: sustainable urban development, housing policy, India, sustainable development goals, policy implementation, urban planning, literature review, green building codes

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1 Introduction and background

The UN projections reveal that India will add 416 million people to its urban population between 2018 and 2050, and this rapid urbanisation holds a range of challenges and opportunities for the sustainable development of housing and construction practices. Expanding the urban centres in India demands more housing structures, which puts great pressure on the available processes of infrastructure construction and management and its sustainable design [1]. Therefore, the need to transform conventional building practices into sustainable approaches must be addressed. In this context, green building codes appear as a tool

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to regulate environmental governance and sustainable development [2].

The Indian government has realised the need for incorporating sustainable construction practices and has developed measures to encourage green building codes. During the preliminary development of the ecology of green building codes in India, the Energy Conservation Building Code (ECBC), 2007, provided a document that prescribed new commercial building constructions related to energy and greenhouse emissions. The Ministry of Housing and Urban Affairs also started the Smart Cities Mission in 2015 to promote the adoption of green buildings in urban infrastructural projects [3]. Even though these policies have been popularized and implemented through organised procedures and encompass futuristic strategies, their impact has yet to be distinctly documented in the local spheres -this may be as is because the effects of the green building codes are limited by developmental growth, economics, and compliance-and documentation requires investment of fiscal, temporal and other resource factor availability. Enforcing and adopting green building standards in expanding urban centres is challenging due to bureaucratic structures that slow the implementation and the various interests of different stakeholders [4–6]. The reflected diversity in the green building codes is theoretically advantageous, and the real implementation requires measuring the effectiveness of promoting sustainable housing development in India. The current situation entails putting pressure on conventional construction practices and making them embrace environmentally friendly practices. In this regard, green building codes become essential tools to advocate for preserving the environment and sustainable construction. The main aim of green building codes is to reduce the effects of construction on the environment. Other effects include using more energy-efficient ways, limited use of natural resources, and improved life standards [7, 8]. The old-world regulations, on the other hand, were limited to safety and efficiency.

This paper examines the current state of green building codes in India, focusing on their role in promoting sustainable housing development amid rapid urbanization and ecological challenges. While these codes are designed to align with Sustainable Development Goals (SDGs) and foster environmentally responsible construction practices, their practical implementation across different regions reveals significant variability. This study systematically

reviews existing literature and policy documents to assess how effectively these codes are being applied and identifies the opportunities and challenges they present. The paper aims to provide a comprehensive picture of the operational landscape of green building codes in India, as they stand till 2024, offering insights into their impact, areas for improvement, and future pathways for enhancing sustainable housing practices.

1.1 What are green building codes

Sustainable or green building codes aim to pursue responsible conservation and efficient construction resource management. Through a collection of government-approved policy recommendations, urban design guidelines and sometimes legislation, the development of green building codes is based on various factors such as energy efficiency, waste handling and disposal efficiency, water treatment efficiency, internal and environmental quality control efficiency, and sustainable materials. The main purpose of the codes is thus aimed at minimising the effects of the quality of building design and construction and even harmful effects on the environment. The process of formulating green building codes is dynamic and comprehensive, encompassing the participation of the government and the private sector, environmental groups, and the public. The codes' lifecycle describes identifying the sustainability codes concerning the environmental, social, and economic reachable goals. Secondly, the process of establishing performance standards and criteria for measuring it. Third, the progressive formation of a rating scheme aimed at evaluating and certifying buildings after they have been compliant [9, 10]. Finally, the continuous update of the code to integrate new technologies, standards and other emerging sustainability concerns. It is important to understand that the concept of green building has changed in recent decades [11]. The first attempts were made mainly in energy conservation due to increased energy prices and the negative effects of using fossil fuel resources. Moreover, it is crucial to note that the green building codes encompass a broader city regulation than the regular construction industry regulations and cover waste management, sustainability, resource conservation etc. [12, 13]. Table 1 lays out the current green building code ecology in India, along with the aligned SDG and similar International green building codes present elsewhere.

Indian Building Code	Aligned SDG Goals	International Standards Alignment
Energy Conservation Building Code (ECBC)	SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action)	Aligned with ASHRAE Standards, LEED, and BEE Star Ratings
National Building Code (NBC)	SDG 11 (Sustainable Cities and Communities), SDG 9 (Industry, Innovation, and Infrastructure)	References ISO and BIS standards for construction and safety
Green Rating for Integrated Habitat Assessment (GRIHA)	SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action)	Aligned with BREEAM and LEED standards
Indian Green Building Council (IGBC) Green Homes	SDG 11 (Sustainable Cities and Communities), SDG 6 (Clean Water and Sanitation)	Aligns with LEED, WELL Building Standard
Bureau of Indian Standards (BIS) - Water Efficiency Standards	SDG 6 (Clean Water and Sanitation)	Aligns with ISO standards on water efficiency
Eco-Niwas Samhita	SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action)	Aligns with ISO standards for energy efficiency and climate resilience

Table 1. Alignment of Indian building codes with SDG goals and international standards

1.2 The Indian legal and policy environment of green building codes in India in 2024

India has successfully promoted green building practices through various policies and advanced regulatory structures. A list of key developments in the Indian context include:

1.2.1. Energy conservation building code (ECBC) 2017.

This code sets the minimum requirements for energy performance standards in new commercial buildings and substantial modifications to existing structures. It includes the building envelope, heating, ventilation, air conditioning, interior lighting, and electrical services. This code applies to all buildings/commercial buildings with an electricity connection load of 100 kW or more / or a demand of 120 kV or more, and its objective is commercial. Thus, a building constructed for private residential purposes will not be covered.

1.2.2. GRIHA (green rating for integrated habitat assessment).

GRIHA is a rating tool for green buildings in India introduced nationally. It evaluates the stock of commercial buildings and assesses them in areas like energy efficiency, water use, waste, and indoor air quality. The assessment system is carefully developed to focus on the structural design and evaluation of newly constructed buildings or buildings still in development (The Energy and Resources Institute [TERI], n.d.). The assessment process is based on the evaluation of the building on the entire life cycle i.e. from its start of construction to operation. The assessment process is also divided into three different stages for evaluation:

- (i) *Pre-construction stage:* assessment of the nearest transport facility, condition and type of soil and land, location of the property, etc.
- (ii) *Building planning and construction stages:* The improved usage of natural resources such as water, air, energy, greenery and the occupants' quality.

- (iii) *Building operation and maintenance stage:* According to the third phase, the operational and maintenance procedures of its building systems and processes, measurement and documentation of energy usage, indoor environmental quality and health concerns, and issues related to the global and local environment.

1.2.3. Leadership in energy and environmental Design (LEED) India.

LEED India uses the LEED rating system that is used globally with little modifications to fit the Indian environment. This policy aims to develop a system of green building certification based on a sustainability index. The LEED INDIA rating system provides the path to navigate through all the processes of measurement and documentation of success for all types of buildings and every stage of their life cycle [14, 15]. Many new and under-development buildings in India have applied for a LEED Green Building Rating. The buildings that seek a LEED rating include IT Parks, offices, banks, airports, convention centres, education institutions, hotels, and residential structures. Notably, these are just some of the buildings. LEED-INDIA also contains the New Construction & Major Renovations Code i.e. a Green Building Rating System for Implementing High-Performing Commercial Buildings [15].

1.2.4. Smart cities mission.

This is the Government of India's flagship program that seeks to encourage sustainable processes for building development in urban areas. It gives cash bonuses and support to cities to promote environmentally friendly construction. The key economic principle is sustainability and inclusion; in essence, it is about identifying compact areas and a replicable concept, and the plan is to be a model and inspiration for other cities that also aspire to become 'smart'. The Smart Cities Mission is to act as a benchmark which can be implemented from within and outside the Smart City to encourage the establishment

of more Smart Cities in different zones and areas of the country. The basic support structure that ought to underpin any Smart City would be access to clean and safe water; reliable electricity; sanitation and efficient means of waste disposal (including, but not limited to, solid waste collection); mobility through access to efficient means of transport including public transport; access to affordable housing, including that for the economically disadvantaged; interactive digital infrastructure through hi-tech networks; responsive and accountable system of governance, especially where e-Governance is inclusive. There are four types of them: city improvement (retrofitting), city renewal (redevelopment), city extension (Greenfield), and Pan-city, in which Smart Solutions are applied on larger parts of the city [3].

1.3 Strategies executed by the Indian government for green building ecology

1.3.1. National action plan on climate change (NAPCC). The NAPCC, initiated in 2008, also acknowledges Energy Efficiency in buildings and lays down measures for Green Buildings promotion.

1.3.2. National building code of India 2016. NBC has provisions for energy efficiency measures, fire safety measures, and structural design measures, which can be used to encourage sustainability.

1.3.3. Model building bye-laws 2016. These bylaws give local authorities an idea of how to regulate construction activities concerning energy efficiency and Environmental sustainability.

1.3.4. State-level building bye-laws. Most states usually have adopted building bylaws containing green building provisions, for instance, rainwater harvesting, solar water heating and waste management.

Table 2 outlines the key national initiatives, their primary features, goals, and the challenges faced in implementing sustainable housing practices at the national level.

The Indian government has taken significant steps in recent years to promote green building codes through various policy interventions and regulatory frameworks. However, there is still a need for greater awareness, capacity building, and enforcement to ensure the widespread adoption and effective implementation of these codes across the country [16, 17]. This research adds to the existing academic literature concerning sustainable development utilising policy evaluation in green building practices. This is important for

critiquing policy implementation and translation from documents to practice, especially in a developing country, as in the case of the current study. Further, the results of this research can contribute to policy changes and make suggestions for improving the functionality and effectiveness of the green building codes. Therefore, the study contributes to the rippling social implications because construction practice reflects set social goals on sustainability and climate change, sustainable urban development, and reduction of environmental impacts. Sustainable construction also gets the spotlight in matters concerning climate change and the growing rate of urbanisation. As a party to numerous international environmental treaties, India has signed and ratified several sustainable development goals that call for efficient compliance frameworks [1, 2, 15, 18].

The construction industry is one of the leading consumers of material and a producer of carbon-dioxide and hence this sector is a significant area of focus. When considering the development of environmental policies, adoption of green building codes is one of the most practical and preventive solutions in tackling environmental questions while at the same time promoting the development of its economy, which entails better stocks, standards, and welfare of the rapidly growing urban facilities and residents. For the purpose of developing the policy and planning the urban areas, the results of the study will be useful, for the developers and other related parties of the construction industry, the study would help them realize the benefits of adopting green building practices.

1.4 Literature review: The dilemma of green building codes

Green building codes are designed to deploy the practice of sustainability in the construction of buildings and the management of the buildings. They focus on increasing energy efficiency, reducing construction-waste, and utilizing material that is not held harmful to the environment. India has seen the preparation and enforcement of many such codes over the last decades like Energy Conservation Building Code (ECBC) which was launched in 2007 with a new version in 2017 which was developed to upgrade energy rating in non-residential buildings. The Bureau of Energy Efficiency (BEE) is centred to establish standards necessary in reducing energy requirements of buildings [19]. The stringency and the degree of influence of the Green Building Codes varies greatly in different parts of the world. For example, the LEED of America and BREEAM of the UK use guidelines of

Initiative/Policy	Key Features	Goals/Objectives	Challenges
National Building Code of India (NBC)	Provides comprehensive guidelines on building standards, including sustainability	Promote energy efficiency, environmental sustainability, safety	Fragmented enforcement, varying adaptation by states
Energy Conservation Building Code (ECBC)	Mandates energy efficiency standards for commercial buildings	Reduce energy consumption, decrease greenhouse gas emissions	Limited awareness, compliance, and enforcement
Real Estate (Regulation and Development) Act (RERA), 2016	Regulates the real estate sector for transparency and consumer protection	Increase transparency, protect consumer rights	Limited focus on sustainability, varying implementation
Smart Cities Mission	Initiative to promote sustainable urban development, including housing	Enhance urban living, incorporate green technology	Focus on technology over fundamental sustainability principles
Pradhan Mantri Awas Yojana (PMAY)	Affordable housing scheme with provisions for eco-friendly materials and designs	Provide affordable housing, promote sustainable construction	Scale of implementation, ensuring sustainability in designs
Green Rating for Integrated Habitat Assessment (GRIHA)	National Green Building Rating System	Encourage sustainable building practices to reduce environmental impact	Voluntary adoption, limited enforcement mechanisms
Housing for All by 2022	Comprehensive housing scheme aimed at providing affordable housing to all	Address housing shortage, integrate sustainability in designs	Balancing affordability with sustainability, large-scale implementation

Table 2. National government-level initiatives in sustainable housing

practice, which are also implemented as international standards for the different territories. The assessment done by [20–22] also present evaluations where it is stated that though the codes of a country such as India, such as the ECBC have laid down several requirements but they are in current form, incomplete in approach and need upgradation of performance and other parameters. International standards are complete in their approach where performance-based and other indices are also included.

1.5 Effectiveness of interventions and barriers to implementation

Although there is increased recognition of the possible advantages of these codes, their application takes work. One such challenge is the need for more awareness and minimal training among construction industry professionals. Another is the government’s need for more encouragement in motivating professionals towards sustainable construction and poor policy implementation mechanisms [23, 24]. Third, it is essential to recognise that these codes require modifications for different climatic conditions in India, which are not considered in general guidelines for the whole country. Evaluating the effects on the economy of adopting green building codes is one of the more temporally relevant research fields- these typically involve primary costs and although high, the life cycle analysis frequently reveals considerable savings in energy and remediation costs and reduced environmental impact charges [18, 25]. But again, the initial cost of implementation plays a big role, especially in markets sensitive to the price tag, such as in India. From the environmental point of view,

energy conservation results in reduced carbon emissions and is therefore beneficial from the standpoint of the international treaties India has signed in the climate change domain. However, the on-ground benefits could be even better because adopting this model could be faster, and organisations often need help with compliance [26, 27].

This aligns with cultural influences shaping the approach to green building practices. Transferring it to India, where traditional ways of construction are still in practice, there is always a certain degree of scepticism that receiving new technologies and ideas seen as ‘modern western’ or not yet tested in the local environment invites scepticism. Other important issues include social, labour market, and socio-economic effects. Research by [28–30] shows that embracing knowledge and practice from established building practices (may sometimes be traditional) could improve the acceptability and practicality of Green Building. Reporting on deficiencies of prior literature, the authors also highlighted the need for sufficient research on the enduring effects of green building codes, specifically in the residential sector. It is worth noticing that most of the works are concerned with commercial buildings only, and the results of the interventions are assessed within a short-term span. It is also imperative to have integrated evidence that links the enforcement of these codes to concrete environmental enhancements; this is occasioned by the relatively youthful intake and slow adoption ratio. In addition, it is still important that existing knowledge of environmental building codes should be linked with the other factors of comprehensive sustainable urban development, which include transport and public amenities, all equally

important in determining a city's total sustainability [17, 31]. This literature review recognises a need for a better coherent approach to appraising green building codes in India. It shows that theoretical evidence for the advantages of these codes is extensive, but practical realisation is lagging because of sundry economic, cultural and bureaucratic factors. The subsequent sections of this paper shall further describe and analyse these issues, including ideas for efficiency improvement and the prospects of policy strengthening of green building activities in the country. Based on the literature assessed, some of the emerging bottlenecks within green building code have been highlighted in Table 3.

2 Analysing India's housing policy landscape

India's sustainable housing approach is framed around a multi-level regulatory system involving several levels of government, from local to national administration, each contributing differently to the housing standards and sustainability goals. The National Building Code of India (NBC), which incorporates environmental sustainability and energy efficiency provisions, provides a broad framework for regulations that states and local bodies tailor to their respective regions and locations [32]. However, the success or failure of these standards depends on how well they are enforced and integrated into various state-run building codes that differ greatly. The division of responsibilities among different agencies creates fragmentation in coordination, thus making it difficult to implement sustainable housing policies in India. Such fragmentation is responsible for the need for uniformity in enforcement. Conversely, [22, 31] research has shown that though the intentions behind such policies are good enough, the regulators need more resources and training, whereas an uninformed public has undermined and impaired their effectiveness. Moreover, compliance incentive structures could be enhanced as non-compliance penalties remain unenforced due to poor regulation enforcement mechanisms.

To increase transparency and protect consumers, The Real Estate (Regulation and Development) Act in 2016 commonly known as RERA changed the Indian Real Estate and Housing policies. But research on how and whether it has supported sustainable housing or not remains limited. Sharma [33] has identified that RERA has helped in the development of clarity of norms in the real estate sector however, its focus still remains unclear regarding sustainability. This act provides guidelines to address the complaints regarding

construction but it doesn't necessarily motivate the developers to construct in accordance with the green building codes. Smart Cities Mission implemented by the government of India is an initiative towards creating urban sustainable environments. This mission involves enhancing the quality of residential lives in the urban and rural communities by means of Greentech housing solutions for dwellings and optimal augmentation and management of urban and rural resources [3]. However, some authors continue to argue that many of the projects under the mission have failed to give adequate attention to the fundamental aspects of sustainability such as containing the urban sprawl and enhancing connectivity of public transport systems that are essential for long term sustainability [34, 35].

State-level initiatives, such as Maharashtra's policy on green buildings, provide interesting case studies for evaluating the effectiveness of localised regulatory frameworks. These policies often offer incentives such as tax benefits and expedited permit processes to encourage developers to adopt green building practices [36]. While these incentives have spurred some positive developments, they remain limited in scope and are often overshadowed by broader economic pressures favouring rapid, cost-effective construction over long-term sustainability. Table 4 has listed the main development across the Indian States in developing localized green building codes.

Besides Maharashtra, Rajasthan and Karnataka, other states such as Haryana, Punjab, Kerala, and Tamil Nadu have also formulated policies and measures to encourage green buildings and energy-efficient residential constructions. Generally, these states use payments, penalties and incentives, and information dissemination schemes to encourage the uptake of health information technology solutions. Although some of these schemes have been implemented, the level of achievement tends to differ immensely based on the capacity and involvement of the local regulators [18, 22]. For instance, though, like other States, Haryana offers additional FSI and property tax incentives that could have had more consistent implementation because of a need for more enforcement capacity.

2.1 Learnings from the state-level efforts

2.1.1. Incentive-based approach. This may include but is not limited to financial: Extra FSI rebate/bonus, tax credit rebates; non-financial: fast-track approvals. Although the current incentives approach has been proven to work, it can only really support the long-term use of technology if the backing of regulation

Green Building Code	Objectives for Sustainable Housing	Main Bottlenecks
Energy Conservation Building Code (ECBC)	- Reduce energy consumption in buildings by 25-40% - Encourage the use of renewable energy sources	- High initial costs; limited awareness and expertise - Lack of enforcement and compliance mechanisms
National Building Code (NBC)	- Promote safety, sustainability, and inclusivity in urban development - Standardize building design, materials, and construction practices	- Complexity in code implementation; outdated provisions - Inconsistent application across states and regions
Green Rating for Integrated Habitat Assessment (GRIHA)	- Minimize resource consumption, waste generation, and carbon emissions - Improve health and well-being of occupants	- Time-consuming certification process; limited incentives - Higher upfront costs; lack of skilled professionals
Indian Green Building Council (IGBC) Green Homes	- Enhance energy and water efficiency in residential buildings - Promote use of recycled and sustainable materials	- Voluntary nature of adoption; lack of widespread awareness - Limited government mandates or financial incentives
Bureau of Indian Standards (BIS) - Water Efficiency Standards	- Reduce water consumption through efficient fixtures and appliances	- Slow adoption; lack of strict regulatory enforcement
Eco-Niwas Samhita	- Improve energy efficiency in residential buildings - Enhance thermal comfort and reduce dependency on artificial cooling	- Resistance from builders; low public awareness - Lack of financial support for implementation

Table 3. Objectives and Bottlenecks of Indian Green Building Codes for Sustainable Housing

State	Key Initiatives	Incentives Offered	Challenges
Maharashtra	Green Building Policy (2017), ECBC Implementation	Tax benefits, expedited permits, additional FSI	Ensuring compliance, particularly among private developers
Rajasthan	Green Building Policy (2019), Solar Energy Policy	Additional FSI, property tax rebates, faster approvals	High upfront costs, limited public awareness
Karnataka	Green Building Guidelines (2011), Renewable Energy Policy	Emphasis on energy efficiency, renewable energy incentives	Lack of enforcement and monitoring mechanisms
Other States	Various initiatives in Haryana, Punjab, Kerala, Tamil Nadu	Combination of financial and non-financial incentives	Inconsistent enforcement, varying regulatory capacities

Table 4. State-level initiatives in sustainable housing

enforcement is strong.

2.1.2. Energy efficiency focus. Energy saving becomes the most prominent issue based on the great potential of energy conservation in buildings. Therefore, almost all state policies include recommendations or requirements for energy efficiency in renewable energy design and use.

2.1.3. Variability in enforcement. There are significant variations in the degree of policy compliance as well as the effectiveness of the agencies in the states that are able to implement the corrective and protective mechanisms. This impacts the overall results and effectiveness of the policies because some of the states have enhanced governance and regulatory frameworks to support the implementation of the policies, while some do not.

2.1.4. Need for policy integration. The immediate need of the hour is to develop an interface of state-level plans with the NBC and Smart Cities Mission. Otherwise, there are possibilities of policy duplication, which might slow down the search for sustainable work environments and organisations. Present housing policies in India reveal large policy-design flaws and may be presented as non-efficient when compared with the standards of developed countries like Sweden or

Canada. These countries have more holistic approaches which include stringent codes of construction together with the principles of sustainability within wide-ranging concepts of urban design and social organisation [22, 33, 37].

The processes linked with development of green building code and its compliance in India can be explained conceptually through the resource dependence theory- it is possible to identify that the problems in the policy measures for housing in India could be then attributed to changes in decisions about resource dependencies of the developers and local governments. The policies could record enhanced compliance levels since they encourage compliance for sustainable policies aside from offering the necessary financial backing, appropriate training and other essential intellectual and material resources. Besides, referring to institutional theory could also be helpful in analysing and/or ‘deconstructing’ formalisation that poses challenges to policy implementation. India has some measurably progressive provisions incorporated in the national housing policies for sustainable measures. The main contention in this respect– is enforcement, coordination with other sectors and alignment with other economic and development policies. Augmenting these policies therefore requires the adoption of

enabling statutes as well as altering the structural and institutional characteristics in the housing market [38]. Future research within this field and the subsequent policy-development should therefore focus on the formulation of an integrated approach that is in conformity within the existing global practice but with some consideration to such issues that are specific to the Indian context. The next section therefore provides details of several localized and community aspects that come up when implementing or developing green building code. The green building codes formulation in India has till date exhibited a top-down approach towards sustainable solutions implementation. The input of community-based solutions, values and suggestions also needs an extended discussion to capitalize on the solutions and suggestions from multiple stakeholders involved in creating sustainable building codes.

3 Stakeholder perceptions and community involvement in sustainable housing policy implementation

Efficient and sustainable housing policies entail strong legal frameworks and engagement of all stakeholders, such as the citizens, private investors and the government. The effectiveness of these policies depends on the degree of public participation during the formulation and the initial stages of the implementation process. However, similar to what was experienced in the United States, there is a regulatory provision for engaging stakeholders and the public through hearings and consultations as provided by laws like the Environment Protection Act of 1986 in India; its implementation might take more work. This research identifies that the issue of information transparency and access is a major challenge in engaging communities in India. Research by some scholars assesses that more information regarding housing projects and their environmental effects should be passed to the public, without limiting the community members' ability to participate fully [11, 13, 25]. However, the stakeholder participation is also characterised by cumbersome bureaucratic processes that may deter average citizens and, largely, those from the economically vulnerable groups that are measurably more affected by these projects.

Particularly, non-governmental organisations partly contribute in bridging the existing gap between the government authorities and the people. They help in raising awareness of the citizens towards their rights as well as the impacts of housing projects on

the environment. Mahadeva [27] points out that where non-government institutions have used reasoning to engage communities into usefully formulating demands for improved non-destructive homes, there has been some movement into changes that respond to Indigenous cultural values. Still, decisions and actions of project proponents and communities themselves, can be limited due to factors such as financial issues and political influence of NGOs. There is some limited information on how community organisation initiated sustainable housing programs have resulted in positive outcomes in several regions of India. Most of these schemes utilize knowledge, which is inherent in sustainable development for indigenous societies. For example, the Kerala Housing model for the community of the same region was in line with environmental sustainability whereby people were encouraged to make their houses using local materials and technologies. These programmes provide green homes and entail involvements of all stakeholders in the decision-making process. In this case it is also important to note that here the perceived opinions are mainly linked with the governments and developers with their leaning towards economic or rational-utilitarian housing programmes. However, such an idea of sustainability is considered important, however, the emphasis is primarily accorded to cost considerations and functionality. Accordingly, [35] have stated that developers' existing beliefs are an indication that while sustainable housing growth has been noted to require significant public support and promotions that are still deficient today, such research should not deter developers from exploring new housing growth strategies.

3.1 Challenges in aligning interests and some solutions

The main weakness of sustainable policy formulation in the housing industry is based on stakeholders' conflicting self-interests. The community may target environmental and cultural conservation, however, the developers and the government organisation are more financially motivated [22]. This leads to the issue of conflicting interests whereby the stakeholders might not have any interest in the development and implementation of sustainable housing practices as well as sustainable housing activities. Policymaking must, therefore, incorporate this self-interest for the following reasons: in order to make sure that the concept of sustainable housing policies is given and understood on the basis of social equity. Consequently, analysis of the interrelationships between various agents involved in the implementation of housing policies can be understood by incorporating theoretical concepts

such as the stakeholder theory would prove useful. The stakeholder perceptions reveal an interconnected web of interests and issues in the sustainable housing domain in India since they shape perceptions and influence the approaches and outcomes of programs and policies. Moreover, in view of the kind of community created in the case of sustainable development, there could be a useful application for theories of social capital to determine the correlation between social networks/ relationships within the community and the support offered to sustainable practices. The various stakeholders have diverse and unique interests and thus these interest-based relationships manifest in the actualization of sustainable housing in the Indian context, as these relationships have an impact on perceptions and determine approaches and results of programs and policies. Nevertheless, several factors arise when it comes to engagement of the communities in the implementation of these initiatives. Hence, information from as NGOS and from community based programmes gives direction regarding the sort of structures, policies and laws that can be employed. However, the economic problems described by developers and bureaucratic problems offered by the governmental measures need to be addressed in order to set the environment for efficient construction of sustainable settlements [33]. This research calls for subsequent studies with the aim of identifying possible cultural and economic frameworks for implementation in the pursuit of the models of stakeholder engagement for future work could highlight the collaboration relations between the public and private sectors regarding the attainment of the sustainable development goals.

Future research on whether digital technologies would improve the clarity in policy implementation and its engagement with stakeholders might open new perspectives for raising the efficiency of housing policies. Therefore, a methodical and analytical way of looking at and assimilating stakeholder perceptions is vital for developing sustainable housing practices in India. To do this, there is a need to be fully cognizant of cultural, environmental and economic aspects surrounding the project and ensure that every stakeholder is free to express his/her views.

4 Policy recommendations and strategic interventions

The effectiveness of housing policies, particularly those that are sustainable in the Indian context, therefore, requires appropriate legislation and regulation that

respond to the multi-faceted nature of sustainable development. While existing policies address sustainability goals, there is a tendency for these policies to be adjusted to be congruent with actual implementation; more so, there needs to be stronger enforcement mechanisms and insufficient incorporation of technological development. This section outlines policy options to modulate the policy framework to enable distinctive and sustainable Housing development practices.

4.1 Enhancing regulatory frameworks

Hence, a foundation to a fit housing policy that will be applicable for the current and future generations is based on legal requirements and policies that force the housing industry to adopt sustainable practices. Chattopadhyay [6] also discovered that Indian housing policies are not very well formulated, and not sufficient in terms of rigidity and coherence to regulate sustainability measures. To counter this challenge, the government may have to alter the National Building Code to contain highly prescriptive measures on sustainability which have to be complied with in any development. They should be clear, measurable and, more or specifically, completely executable and could entail stiff penalties in case of breach. One of the major issues that arises from the general adoption of sustainable developments mainly in the construction of houses involves the notion that a lot of money is spent to initiate sustainable developments while little is actually earned back. In fact, incentives are capable of solving this barrier as illustrated here below. Similarly, the government could offer other incentives to the companies and developers such as tax credits, subsidies and lower fees on permits among others for projects which comply with the set sustainable standards [23, 27]. Special programs may also be started to award developers who are keen in incorporating sustainable measures onto the buildings they develop due to pressure from other developers.

4.2 Integrating smart technology

As pointed out in this work, smart technology incorporated in housing development can improve sustainability. 'Smart' metering and management of energy systems, specifically through the IoT, can slash energy wastage and optimise operations by considerable margins. Smart urbanisation by Randhawa and Kumar [31] will, therefore, pinpoint the necessity of technology in Monitoring and controlling the infrastructure systems. Therefore, such technologies must be encouraged through policies that outline

the manner and funding required to adapt existing buildings and incorporate smart systems in new construction plans.

4.3 Strengthening community engagement

Community involvement plays a major role in sustainable housing as it ensures that the housing development projects adopted meet the real needs of the people and enable people to take more responsibility for sustainable projects. In any case, the management must provide a clear communication framework and ensure that all decision-making involves the employees. Urban planners should arrange weekly and monthly meetings and group discussions with the community to allow them to participate in the planning process of housing projects to increase the chances of effective planning and implementation of the designs. For sustainable housing policies to work, there should be an enlightened pool of architects, planners, developers, and consumers on sustainability matters. This can be made using educational campaigns and informational seminars within the construction and real estate professionals' training framework. According to [33, 37], curricula must seek to incorporate modern sustainable design and construction practices to build and train a new cadre of professionals ready for the sustainable building of growing cities.

4.4 Policy implementation and monitoring

Thus, Monitoring is critical to housing policies as implementation needs to be assessed to check compliance levels and measure efficacy. This includes mechanised assessments and evaluations and integrating tools to monitor project compliance or deviations from sustainable goals. This is in line with evidence from [5, 34], who sought to propose an adaptive policy to enable the modification of regulations depending on real-time data and new trends, ensuring that the housing policies remain effective all the time. The policy recommendations that will be proposed are designed to fill the gaps present in the existing policy framework for sustainable housing in India. These proposals aim to create a conducive environment for sustainable housing practices, through modifications in the existing regulatory intensity; through encouragement, in the form of technical tools, participating and consulting with communities; and through strengthening capacity, and ensuring viable execution and evaluation. Future studies should assess the effectiveness of such interventions in different settings across India, which may result in improved policies. Also, investigating the possibilities of

private-public collaborations in supporting sustainable housing projects may reveal effective partnership approaches to attaining sustainability objectives.

To promote sustainable housing in India, it is essential to consider the interconnected spheres of legal activity modification, technological implementation, citizens' participation, and evaluation. These measures encourage individuals and companies to participate in preserving natural resources, embracing cultural values and finding ways of implementing environmentally sustainable housing projects that will be profitable to implement and occupy.

5 Evaluation of policy implementation and impact

Therefore, the success of housing policies depends on how these have been put into practice and the effects achieved, especially in aspects of sustainability and regulation. For India, particularly when urban sprawl and sustainable development remain matters of concern for the country, assessing the implementation of housing policies offers insights into their efficiency and the aspects that call for improvement. This evaluation includes an assessment of policy impacts against planned sustainability objectives and the effectiveness of the regulatory systems in controlling housing development. A critical review of the literature on housing policy implementation in India finds the following gaps. There exist gaps to be bridged regarding the link between policy development and implementation. For instance, bureaucratic delay, inadequate funding, and restricted mechanised skill policy implementation are examples. Moreover, another structural issue affecting efficient housing policy implementation is a clear lack of integration of governmental levels, including the national, state, and local levels [8].

Policy monitoring is crucial as it helps assess the performance of housing initiatives towards sustainability and compliance with the enacted policies. However, as has been highlighted in some studies, the current monitoring systems require investment in the form of increased resources, and require technology interventions to conduct adept evaluations. It has become particularly important to combine modern data analysis and monitoring tools to improve efficiency for regulators. They should be capable of proactively monitoring progress at all times and generating understandable reports for all the stakeholders. It remains possible to evaluate the housing policies' effectiveness using both the quality and quantity indicators. On the quantitative side, reduction in

carbon emissions, levels of energy consumption, and certification of green buildings under sustainable standards help substantiate the tangible results achieved. On the qualitative side, the enhanced quality of life among the residents regarding green areas and environmentally friendly buildings provides some insight into the social benefits of these measures. Zhang et. al [38] underscore the significance of these measures in capturing the overall impacts of housing policies for sustainability in cities.

Therefore, it is forthcoming that a dynamic approach to managing policies that would address these complexities in urban growth and development is required. This involves the nature and scope of policies to be periodically reviewed and the ability to change the strategies depending on the feedback and the trend. Development of code should be based on the findings from research and feedback from the various stakeholders to ensure these policies are always effective. According to [33, 35], there is also a need to form a unique policy lab for testing and analysing any policy ideas before implementing them across the country. Utilization of big data, AI, and IoT are valuable technologies as they can change how major housing policies are implemented and monitored. These technologies provide the capability of being able to estimate various parameters of cities that are growing today, better management of resources and the capability of monitoring compliance with the necessary standards through the use of efficient systems. For example, real-time monitoring of construction sites can assist in guaranteeing that environmentally friendly techniques are embraced.

The analysis has identified several vital issues that pertain to policy implementation and impact evaluation that deserve attention. Some of the issues raised, and more so the bureaucratic issues, weak supervision, and necessity of the policy changes point to the fact that implementing sustainable housing policies in India requires more than just a plan. Therefore, this calls for a multi-faceted solution to the problems to achieve an optimal solution through improved resource management, increased use of ICT, and a framework for engaging with relevant stakeholders. In addition, analysing the possibilities of technology use during policy implementation presents a viable way of improving the Policy of Affordable Housing outcomes. This, however, needs a considerable capital investment towards the technology enhancement of the regulators. The next steps include identifying further strategies for fitting the technology for the housing policies on

a large scale and investigating the model's feasibility in India's case. Overall, this work underscores the need to build an urgent push towards implementing and improving policy impacts for affordable housing in India to avoid the ineffective practitioner practices that characterise current implementing practices for policies and programmes. Such a strategy will improve policies' effectiveness and guarantee that they are beneficial for sustainable urban development objectives.

6 Conclusion: Discussion on the study's scope, contributions, and strategic implications for sustainable development

The primary aim of this study is to critically evaluate the effectiveness of housing policies in India, with a particular focus on their alignment with sustainable development goals and their ability to meet the socio-economic needs of India's diverse population. By dissecting the implementation mechanisms and assessing the policy-led impacts of these policies, this research contributes to a nuanced understanding of the gaps and opportunities within India's housing sector. It also provides a robust framework for policymakers and stakeholders to re-evaluate and refine strategies that enhance sustainability in urban development. The relevance of this study extends beyond academic circles and policy discussions. It directly addresses India's urgent need for sustainable urban planning—facing rapid urbanisation and environmental degradation. As highlighted by the United Nations Development Programme (UNDP), sustainable urbanisation is critical for achieving the Sustainable Development Goals (SDGs), particularly SDG 11, which calls for making cities inclusive, safe, resilient, and sustainable [2]. The findings of this study offer actionable insights that can drive policy innovations and infrastructural reforms necessary for allowing sustainable cities. The study's findings indicate that while green building codes in India are ambitious in design, their effectiveness is often undermined by inconsistent implementation and regional disparities. These disparities arise from varying levels of awareness, enforcement capacities, and economic constraints across different regions, leading to uneven adoption of sustainable practices. The inconsistent application of these codes across states hinders the overall impact on sustainable housing development, revealing the need for more uniform policies and stronger enforcement mechanisms to ensure that the potential benefits of green building codes are realised nationwide.

The interlinkages between housing policies and multiple

SDGs acknowledge the complex impacts of effective housing strategies. These policies not only influence SDG 11 but also intersect with SDG 13 (Climate Action) by promoting low-carbon housing developments and SDG 10 (Reduced Inequalities) by ensuring equitable access to housing. For instance, integrating green building standards can significantly reduce carbon footprints, supporting broader environmental targets while providing healthier living environments. India's demographic and economic diversity presents unique challenges and opportunities for housing policy. The vast disparities in income levels, urban-rural divides, and cultural variations necessitate tailored approaches to housing that can accommodate varying needs and preferences. According to the World Bank [18], effective housing policies in India must provide physical shelter and ensure access to social services, employment opportunities, and transportation. This holistic approach is crucial for enhancing India's growing population's quality of life and economic productivity.

A critical analysis of the implementation of housing policies reveals a significant lag between policy design and execution. Issues such as land acquisition disputes, funding discrepancies, and regulatory bottlenecks often derail progress, impacting the speed and effectiveness of housing delivery. As noted by scholars like [22, 35], streamlining regulatory processes and ensuring transparent, accountable governance are imperative for overcoming these hurdles. Advancements in technology offer transformative potential for scaling up sustainable housing practices. Digital tools, such as Building Information Modeling (BIM) and Geographic Information Systems (GIS), can enhance planning accuracy and operational efficiency. Also, smart housing solutions incorporating energy-efficient materials and IoT-based management systems can revolutionise the sustainability of housing infrastructures, aligning with SDG 9 (Industry, Innovation, and Infrastructure). The scalability and transferability of successful housing models from this study to other regions in India or globally pose challenges and opportunities. While local adaptations are necessary, the underlying principles of community involvement, sustainability, and integrated planning can form the basis of universal guidelines for sustainable urban housing. This approach encourages a participatory dialogue among global urban planners and policymakers, allowing a collaborative environment for addressing common challenges.

7 Future research directions

Future research should focus on longitudinal studies that track the long-term impacts of housing policies on urban sustainability and resident well-being. Additionally, comparative studies between different states or countries can provide in great detail insights into the effectiveness of various policy frameworks and cultural adaptations. Such research can enrich the global discourse.

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