

# Barriers to adoption of green buildings – a review

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## Abstract

The global construction sector accounts for 13.2% of the world GDP. It contributes to the world's economic growth engine and climate changes due to its high energy footprint. Sustainable buildings can reduce the adverse impacts of the construction industry, but their adoption is slow due to hindrances. The purpose of this paper is to extensively review the literature on barriers to green building adoption to date. Also, to highlight the overlapping and unique barriers specific to India compared to few prominent countries, provide solutions and recommendations for future research. The barriers were classified under Economic, Governmental, Organizational, and Social perception, Information, Technology, and material categories. Barriers unique to India and few others developing countries are an extension of project schedules, lack of research and developmental works, lack of public motivation, poor building code enforcement, high payback period, uncertain supply of green materials, improper implementation of policy framework, and performance of GBTs. The green building construction sector is fragmented around the world. Even green building definition is not the same globally, although the environmental aspect is the same. Similarly, there are unique and overlapping challenges in green building adoption globally. Buildings in usage perspectives can be classified into Residential and Non-residential. This study looks only at non-residential buildings due to their homogenous nature. There is a dearth of specific studies related to the adoption of green buildings in India. This study aims to fulfill India's standing in the barriers to green building adoption concerning the developed and developing countries.

## Keywords

Green buildings, Sustainable Innovation, Barriers, Organizational, Social perception

## Imprint

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## 1 Introduction

With the global economy rapidly developing, environmental problems and climate change issues become more pronounced day by day. The construction sector is highly energy-intensive and consumes a huge amount of natural resources. More than 40% of global energy usage and 30% of global greenhouse gas emissions come from the buildings both in the developed and developing nations as per UNEP. Apart from GHG emissions, the construction and building sector also contributes to non-CO<sub>2</sub> GHG emissions, such as halocarbons, CFCs, HCFCs. As a result, to minimize the adverse impacts, the concept of circular economy has been emphasized in the construction sector. The circular economy aims to reduce the consumption and production pattern by closing loops using reusable waste and resources and decelerating the material loop by developing a durable, reusable product, according to Bocken, de Pauw van der Grinten, & Bakker. For example, as Leising, Quist, & Bocken observed, circular economy in the building sector through three case studies was BREEAM certified. As per Nazirah, Yusof, & Othman, sustainable buildings decrease energy demand, costs and better health and productivity of employees, as researched by Eichholtz, Kok, & Quigley, reduces risk (GRIHA Manual, 2010) plus advantageous for developers, occupants, owners (WorldGBC, 2013). By the works of Darko et al., sustainable measures can decrease GHG emissions by 142 Megatons per annum by 2020 and 296 Megatons per annum by 2030.

The green building definition varies across the world according to its history, culture, traditions, weather conditions, different buildings type and ages, environmental, social, and economic factors. World Green Building Council defines GBs, as the means to balance the negative impacts during the building lifecycle on the environment and climate by creating positive impacts on the same. To promote effective GBs in the UK, building energy efficiency labels are

undertaken (Building Research Establishment. Why Choose BREEAM.). Japan is naturally challenged in terms of energy and resources. The government undertook unrelenting efforts to preserve energy security by promoting GB's and energy conservation through various laws, incentives, and policies. China experienced rapid green building growth after the construction boom and fast-paced urbanization. Using both mandates and incentives, China stressed the development of GBs, as researched by Zhang, Wu, & Liu. In India, many Central and State governments are working closely with IGBC to promote the green building movement by doling out incentives, as studied by Manna & Banerjee,

Adopting GBs is gaining momentum due to the rise in global sustainability awareness and various problems like climate change, fast urbanization, population explosion, in an evaluator study by Butera, Gou & Xie. However, some problems hinder the adoption of GBs. Lack of awareness, high capital costs, rules, and regulations across geographies has reduced the adoption of GBs. One of the biggest roadblocks is asymmetric awareness of the various stakeholders and the absence of a comprehensive policy mechanism. According to Li, Yang, He, & Zhao, China does not have a complete technology system to construct GBs. China's GB market is not matured as people's concept towards GBs is not clear, as observed by Liu & Hu. In the US, people remain doubtful that GBs have not achieved what they had promised in terms of energy savings, stated Scofield. There are issues convincing people to buy GBs with added expenses, like certification, technology, and expenditure. Condition in the UK is still better with increased awareness amongst the public. However, there are poorly designed GB projects because of bad architecture, resulting in much more energy usage than buildings, which are not certified, as observed by Zhang et al. In Japan, the mandatory requirement of CASBEE AP the first-class license in architecture limits the reach. This barrier is enhanced by limited GB understandings, e.g., India faces a serious problem of inadequate understanding of GBs accompanied by a lack of compulsory laws regarding mandatory enforcement. The majority of the GBs in India either belong to private companies or the government. The residential demand is low, observed Darko et al., due to higher green premium and tedious certification rules. Thus, we see the GB market is unique and has its barriers; it is important to understand India's barriers

to GB adoption standings concerning the world and improvise solutions accordingly.

### 1.1 Current status of green buildings in india

According to GRIHA Manual, 2010, India is witnessing a construction boom, with the sector growing at 9% and contributing around 6.5% to GDP. Although sustainable construction is still a big question, with 60% of the construction yet to happen, India can make great strides towards sustainable development. According to World Green Building Trends, 2018, survey participants expect rapid green activity growth in the coming three years, mostly powered by the drive for healthier and greener buildings accompanied by environmental rules and regulations. India is at par with the global average to undertake new green building construction (51%) while significantly below the global average for existing retrofits (World Green Building Trends, 2018). India's GB market is still an emerging one and needs enough public awareness and green educated professionals. With systematic identification of unique and overlapping barriers to GB adoption in India versus other countries, identifying solutions can bridge the existing gap, which would be a useful resource for academia and the industry to bolster the GB movement.

### 1.2 Innovation in GB development

Over the years, GB development witnessed many evolutions. There has been a collaboration of green initiatives at various urban scales, using regenerative design, "zero urban heat impact buildings." Innovative sustainable buildings are spread across the globe but lack mass adoption, which becomes a common barrier [1]. There are examples like the Mokoko floating school in Nigeria, structured to adapt to the aquatic lifestyle of the local communities. With the use of indigenous materials like wood, bamboo, etc., architectures are made, signifying the people's culture and needs. Inspiration can be drawn from these and can be implemented. Buildings utilizing bottle construction mechanisms by using plastic glass bottles are an innovation. Bottles filled with sand when used for construction result in good insulation [2]. There are examples of innovations in sustainable materials, e.g., transparent wood usage, which is an environmentally friendly option to glass and plastic. Hydrogels placed between two ceramic panels installed between already constructed walls can give a cooling effect and sub-

stitute to overworked ACs. Instead of steel reinforcement, “bamboo reinforced concrete” is a much greener alternative, which is being used. These innovations are proof that the construction industry is revolutionizing and becoming futuristic. However, more adaption of these is necessary to take a step towards the GB movement [3].

### 1.3 Recent green policy developments

Policies play an important role in the adoption of sustainable measures and GBs across the world. For example, the aviation sector is again energy-intensive and contributes to GHG emissions. In India, the domestic aviation market is one of the fastest-growing domestic markets globally. It is forecasted to have continuous positive growth. Hence, to achieve sustainable and inclusive growth in that sector, the GOI has proposed a “Green Aviation Policy” to develop a regulatory framework to rectify the environmental hazards created by the civil aviation industry by recognizing key policy areas that require guiding principles and regulations. This policy will try to make bio-jet fuels economical and expedite securing clearance for aviation projects in India [4]. The UK government plans to re-launch a “Green Investment Bank” to help finance the climate ambitions of the country. This plan comes amidst the growing concern of investing in green infrastructure to meet the UK’s climate goals and help in reviving the economy. In March 2019, UK Green Building Council (UKGBC) drafted the definition of “Net Zero Carbon” buildings to provide information on ways to achieve net-zero carbon in construction and operation, which would help to formulate policy and regulation [5].

LEED Zero, a new certification program launched by US Green Building Council (USGBC), addressed net zero operations and resources in buildings in 2018. The UK launched Aviation 2050 in order to counter-balance the negative impacts of the aviation sector by ensuring sustainable growth [6]. The prospects of a “Green Port” was studied by Bergqvist & Monios in theory as well as in practice, which can help reduce emissions, e.g., Maritime Singapore Green Initiative (MSGI) launched by Maritime and Port Authority of Singapore (MPA) was one of the first environment-friendly initiative launched in this port and shipping sector. In 2019, their prime agenda was the decarbonization of shipping. The main focus areas of the policy are Green Port Program, Green Ship Pro-

gram, Green Energy and Technology Program, and Green Awareness Program. Thus, it is seen that several policies have evolved over the years, and those are in their initial stages of implementation. It is also seen that effective policies in aviation, port, and shipping transportation augments the adoption of GBs and sustainable measures on the whole [7].

### 1.4 Review

This paper is directed to undertake an extensive literature review of research papers mentioning the barriers to the adoption of GBs till 2019. Identification of barriers and removal of them is the key to conventional sustainable development in the construction sector [8]. The review consists of underscoring various barriers to GB adoption, methodological approaches, identifying the overlapping and unique barriers to GB adoption for India. Furthermore, trying to identify the existing gap and solutions to overcome them as a cue for future research. This study addresses the question, “What are the various barriers to GB adoption till 2019? & how can India overcome them by taking global inspiration” to delve into the area of green building research [9].

## 2 The objectives of this extensive review are

To identify the various barriers to GB adoption.

To identify overlapping and unique barriers specific to India and recommend solutions taking global inspiration.

## 3 Research methodology

The above-mentioned is an extensive review of barriers to GB adoption. It is necessary to undertake a pertinent literature review on the subject, as done by Webster & Watson, to form a definite understanding of a topic [10]. It also helps in the building of theory, which is helpful for both industry and academia. This paper is a combination of peer-reviewed academic papers, conference journals, and related materials from official websites of green building associations worldwide. Relevant papers from the past two decades are chosen and synthesized to develop meaningful insights on barriers to GB adoption specific to India and solutions to overcome them taking global inspiration [11].

To gather pertinent peer-reviewed journals, papers, review articles, and reports, a systematic search is conducted on databases like “Scopus” and “Web of Science” to access reputable publications. An exhaustive

1. Selection of database
2. Preliminary search
3. Review of preliminary search results
4. Selection of relevant articles
5. Synthesis and critically review of articles
6. Identification of :
  - 6.1. Overlapping barriers
  - 6.2. Unique barriers
7. Draw solutions for related barriers
8. Conclusions and recommendation for further research

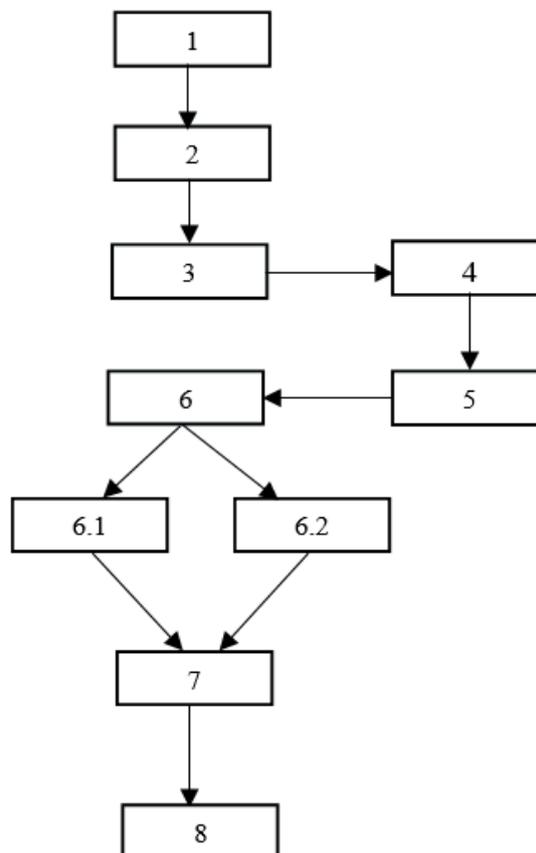


Fig. 1. Overall research flow

Table 1

Coding of GB barriers country wise

| Barrier code | Barrier Name                                  | Description   | Countries                    |
|--------------|---|---|------------------------------|
| B1           | High capital costs                            | Higher initial costs, which might cost more than that of conventional building's accompanied by higher procurement of green products and services   | IND,US,UK,CN,SG,GH,MY,AUS,VT |
| B2           | Lack or misplacement of Government incentives | Incentives serve as an influencer that influences people to act in a certain way. Lack of it or misplacement makes sure the public is not motivated to adopt GB.  | MY,IND,AUS,KU,HK,BR,SP,CO    |
| B3           | Lack of stakeholder's awareness               | Limited know-how regarding GBs from all stakeholders, for example, owners, architects, structural engineers, architectural engineers, construction manager, building operators, occupants, etc., hinders the adoption of GB's | IND,US,CN,GH,MY,VT           |
| B4           | Lack of demand                                | Lack of GB awareness leads to limited motivated demand of GB's from clients   | IND,CN,GH,MX,SA,CO           |
| B5           | Organizational and psychological              | Construction play maker's resistance to change and avocation of perception that sustainability costs more   | US,UK,MY,CN,GH               |
| B6           | Inefficient policy implementation             | GB implementation is poor due to lack of robust Government policy   | IND,CN,GH,MY,VT              |
| B7           | Lack of GBT expertise                         | Limited GBT experience as a result of lack of expertise   | US,UK,MY,IND,GH              |
| B8           | Lack of financing mechanisms                  | Proper credit lines and resources are absent for funding GB projects  | IND,MY,SA,CN                 |
| B9           | Extension of project schedules                | GB implementation requires an integrated approach taking all of the stakeholders, which, if not done swiftly, can result in delay and increase budgets.   | IND,CN,SG                    |
| B10          | Lack of research and development work         | Limited exposure to previous research and development   | IND,SG,VT                    |

| Barrier code | Barrier Name                       | Description  | Countries    |
|--------------|------------------------------------|--|--------------|
| B11          | Lack of public motivation          | There is a requirement to develop a sense of accountability for sustainable building development. The active market participation is not sufficient. | CN, IND, VT  |
| B12          | Unpredictable performance of GBT's | GBT's unpredictable performance maybe incur additional cost and hinders overall performance  | CN, IND, VT  |
| B13          | High payback period                | With higher upfront costs, the payback period for GBs is high, which demotivates the investors.  | IND, US, VT  |
| B14          | Uncertain supply of green products | Green product unavailability is a serious hindrance in the first step to GB adoption.  | IND, MY, UAE |
| B15          | Poor building code enforcement     | Poor regulatory GB code enforcement aids construction playmakers in evading compulsory GB construction rules.  | IND          |

**List of abbreviations:** AP – Accredited Professional; AC – Air conditioning; GB – Green building; GBT – Green Building Technology; WLC – Whole life costing

**Country abbreviations used:** IND – India; US – United States of America; UK – United Kingdom; CN – China; SG – Singapore; MY – Malaysia; GH – Ghana; AUS – Australia; BR – Brazil; CO – Columbia; SP – Spain; VT – Vietnam; HK – Hong Kong; KU – Kuwait; SA – Saudi Arabia; UAE – the United Arab Emirates

search is conducted based on the ‘keywords/abstract/title’ cell present in the databases for document type ‘article’ or ‘review’ published in the past two decades. The keyword which is used to search, includes mainly “green buildings”, “sustainable buildings”, “barriers”, “challenges”, “hindrances”, “obstacles”, “drivers”, “built environment”, “construction”, “zero-carbon”, “LEED”, “energy-efficient”, “high performance” [12].

Figure 1 summarizes the logical sequence of the research flow. It begins with selecting a suitable database, which is then followed by a preliminary search of articles related to GB barriers [13]. The result is again filtered to choose further relevant articles [14]. The selected articles are then critically reviewed, analyzed, and identified with overlapping and unique barriers in India compared with few countries worldwide. Finally, arriving at solutions and recommendations for further research in the barriers to GB adoption space [15]

### 3 Result and analysis

By conducting a thorough and systematic review of the articles dealing with barriers to GB adoption till 2019, findings are documented. Table 1 contains the gist of all the barriers from prominent countries along with barrier codes [16]. It is observed from Figure 1 that there are pertinent factors that hinder the development of GBs. However, amongst all High capital costs, Lack of stakeholder awareness, Organizational and psychological, Inefficient policy implementation, Lack of GB incentives, Lack of GB expertise, Lack of

client demand, and the development of GBs in many countries [17]. There are barriers specific to India, such as poor regulation on building code enforcement, unavailability of green building products and services, lack of pre-existing research and development work, and lack of financing mechanisms. Some of them are also present in few other countries but strongly in India [18]. Further, the paper discusses individual barriers in detail [19].

#### 3.1 High capital costs

Cost-effectiveness is one of the most important parameters regarding the implementation of GBs. Even with the various added benefits, high initial expenditure and added GBT costs plus high price of procurement hinder GB adoption as it is difficult to convince various stakeholders. According to Liu, Low, & He, the high initial cost is a major barrier to GB implementation in China [20]. High green building premium along with GBT costs is still rated as the biggest factor in the US, according to Zhang, Platten, & Shen, Dwaikat & Ali. GBs requires an integrated design approach using GBTs, which costs more than their non-GB counterparts. The leadership faces the utmost challenge while deciding for the GB adoption due to the increased capital costs in the UK, as researched by Hakkinen & Belloni, Opoku & Ahmed. In India, high capital costs are a major pull factor. It draws the investor back from investing into GBs, as observed by Abraham & Gundimeda, Luthra, Kumar, Garg, & Haleem.

### 3.2 Lack of misplacements of government incentives

Policy incentives for GBs from the government are an important factor for promoting GB adoption, which is an instrument that influences people's behavior in a certain way. Financial incentives are mainly monetary, such as tax benefits, financial subsidies, discounts, etc. At the same time, non-financial includes technical guidance, expedited permits, building area permits. Non-financial subsidies are flexible and can be implemented depending on local conditions. According to Hendricks & Calkins, willingness to install more green roofs will increase for residents of Chicago and Indianapolis with the announcement of government subsidies. There are various government-powered incentives to drive GB adoption by stakeholders in the US, Canada, UK, observed Qian & Chan, plus Singapore also has non-financial benefits, e.g., owners with a high level of GBs are entitled to receive an extra 2% of the building area award, according to Choi C. 2009. As per World Green Building Trends, 2018, countries like Brazil, Columbia, Spain struggle with the absence of incentives as a barrier to GB adoption.

### 3.3 Lack of stakeholder's awareness

As mentioned earlier, 'human challenge' is again the biggest impediment, including educating or generating awareness amongst the various stakeholders, as they play an important role. Just like there are exclusive environmental needs for different countries. Similarly, different stakeholders play varied roles in different countries for GB policy implementation, according to the building structure, according to Falkenbach, Lindholm, & Schleich. The various stakeholders involved in a GB project on a global level, by and large, can be classified as – The Government, Developers, Buyers, Tenants, Private bodies, Corporates, Clients. Each of them plays a pivotal part in the GB movement; hence lack of information results in insufficient knowledge, awareness regarding GBs diminishes. In Ghana, stakeholders claimed to be unaware of sustainable measures and alternatives, in a study by Hakkinen & Belloni.

### 3.4 Lack of client demand

The construction sector being client-driven; hence the decision of clients plays a major role in the adoption of green construction. According to Pitt, Tucker, Riley, & Longden, shortage of awareness from the client-side and low demand for sustainable buildings

severely impacts the GB adoption. It was reported by Zhang X. L., Shen, Wu, & Qi that the absence of motivated demand from the customers' end is a challenge, which is required to overcome. As per Ahn, Pearce, Wang, & Wang in Ghana, most clients are self-convinced that there is no need for sustainable buildings. In India, as per Abraham & Gundimeda, more added infrastructure and essential training are needed to create proficiency in GBs. The dearth of proper information and unavailability of green professionals having experience in this particular field becomes an issue; India, Saudi Arabia, Mexico, and China (mainland).

### 3.5 Inefficient policy implementation

Formulation of policies and regulations in line with the GB development is a crucial function of the Govt to ensure wide acceptance of GBs in the market, as studied by Qian & Chan. In many cases, the government initiatives fall short due to improper implementation or, as per Luthra, Kumar, Garg, & Haleem's absence of comprehensive policies by the facilitating body, is a major obstacle to GB adoption in India. Real estate construction managers in China claims that inadequate policy implementation is one of the greatest barriers to GB adoption for residential projects, according to Zhang, Platten, & Shen, which is reiterated by Wu, Jiang, Cai, Wang, & Li, where it claims concerns over industry policy to be a significant challenge. Supervision of GBs in China includes a host of different entities, e.g., government housing and development, environment department, etc. The current policies do not include all the entities hence resulting in overlapping of responsibilities amongst them. Also, in Kuwait, the absence of GB codes and regulations hinders GB adoption, observed Al Sanad. B15 'poor building code enforcement is a real challenge faced in India hence specifically mentioned. According to Abraham & Gundimeda, poor building code regulation is the second most important barrier in India. Code enforcement should be a mandate with evaluation techniques and enforcement mechanisms along with penalization of non-compliance. The non-mandatory nature of ECBC and weak enforcement of codes prevent the adoption of GBs.

### 3.6 Lack of financing mechanisms

Financing is one of the main aspects of any construction project. Hence, in GBs, the lack of proper financing mechanisms is a serious barrier towards

implementation. In China, the application procedure for subsidies, grants, and loans consume much time. It takes extra effort because of the lack of information about related financial support and arduous application process, and building energy consumption data is difficult to obtain for most cities. Hence, providing financial support becomes difficult to evaluate buildings' energy performance, as researched by Hou, Liu, Wu, Zhou, & Feng, Liang, Yu, Hong, & Shen. Also, there is a lack of multi-channel financing and several other financial support, for example, low-interest loans, special funds, rewards, subsidies, as observed by Bao, Zhao, & Zhu, Zhang & Wang.

### 3.7 Lack of research and development work

The solid foundation of an existing research and development work helps build on the present research works and inspire future works, which are needed to bridge the gap between industry and academia. However, in India, according to Luthra, Kumar, Garg, & Haleem, there is a sheer dearth of research and development in GBs, which hinders its development. Similarly, in Singapore, construction professionals and managers claimed that a lack of genuine research regarding the benefits of GB is an important obstacle in their path to pursuing GB projects. Lack of GB research studies in Vietnam is a lacuna, observed Nguyen.

### 3.8 Unpredictable performances of GBTs

GB adopters must have confidence in GBTs, but reliance on the same is hard to find, and this poses a threat to the adoption of GBs. Green methods, for example, implementation of renewable energy, have variable performance as they depend on weather and seasonal changes, which is out of our control, according to Jaafar, Kheng, & Kamaruddin. As discussed earlier, lack of technical knowledge with the barrier "Lack of expertise" is a major hindrance, which is further explained with 'Uncertain supply of green products.'

## 4 Discussions

A variety of barriers were identified, out of which overlapping barriers are High capital costs, Lack of stakeholder awareness, Organizational and psychological, Lack or misplacement of Government incentives, Lack of GBT expertise, Lack of financing mechanisms, Lack of demand. The unique barriers to India and few other countries are lack of public motivation, Unpredictable performance of GBTs, Poor building code

enforcement, High payback period, uncertain supply of green products. The total 15 barriers identified are classified under five main categories, viz., Economic, Governmental, Organizational, and social perception, Information, Technology, and material.

The economic barrier includes the factors that increase the cost. They include B1, i.e., "High capital costs" are prevalent in most countries. The rest of the factors exist partially, specifically in India. It is also seen that in the US, an extension of schedules is a weak barrier due to the adoption of an integrated design mechanism, which allocates enough time for feedback and revision.

The governmental barrier consists of the challenges from the facilitator's end. As per Samari, Ghodrati, Esmaeilifar, Olfat, & Shafiei, the government holds a significant position in finalizing regulations, incentives for the implementations of GBs. This category includes inefficient government policy implementation, lack of government incentives, and Poor building code enforcement. The former two is prevalent in most countries, while the latter is specific to India.

Organizational and social perception barrier includes the various pre-existing mindsets that hinder the adoption of GBs. It includes psychological barriers, i.e., resistance to change the perception that sustainability costs more; also, lack of client demand and public motivation. The GB market is comparatively inert and extrapolatory in the developing countries, which is due to the low public motivation and awareness.

Information barriers arise from the lack of asymmetry of information, including lack of stakeholder awareness, lack of GBT expertise, lack of research, and development works. The latter two is spread unevenly, i.e., contains some of the developed countries too. It was highlighted by Wu, Jiang, Cai, Wang, & Li that advanced GB technological support is not the main barrier in China, as they already have them in place. They need strong cash flow support and policy support along with increased training and education of GBs.

The last barrier, i.e., technology and material, includes the uncertain performance of GBTs, and uncertainty in the green material supply chain is mainly seen in emerging markets, like India and China. World Green Building Trends, 2018 highlights that 21% of the respondents feel there is a lack of availability of green products in India. Spreading awareness about innovative green building materials and implement-

ing the same will help attract public attention towards greener alternatives. Apart from these, the sustainable innovation barrier is a significant one, which hinders the adoption of sustainable methods into the mainstream.

GB adoption still has a long way to go in the Asian markets compared to developed countries. In comparison to the US, UK, Japan, Singapore, China, Malaysia, and Hong Kong, India still have a long road to cover in terms of GB adoption. There is a need for proper implementation of policies. The study also explores how the government is one of the most important stakeholders in GB adoption and takes an “initiator, controller, and moderator.” It was highlighted by Sharma how barriers and challenges are positively related to the government. Hence, the government should formulate effective policies taking into consideration the different entities involved. The policies should be enforced, plus there must be a mechanism to track the same. There must be rules for defaulters, which can attract penalties if found to default. Both Corporate and governments should collaborate and work together towards GB implementation. An integrated design approach should be adopted in GB implementation. The probability of extension of project schedules hence added costs could be ruled out. The informa-

tion barrier that arises from lack of research works on GBs, promotion and publicity, GB awareness, GB education, and training must be diminished. Proper training and GB education, and GB demonstration projects should be undertaken to increase stakeholder awareness. Measures like information distribution using the medium of television, print media, radio, plus dedicated websites to serve as a one-stop database for all standardized GB data can be helpful. Forming partnerships with industry agencies, governments can organize workshops and launch campaigns. With more Government funds allocated to research and developmental works on GBs, India can have a solid base of GB literature helping the industry and academia. India also faces the barrier of inconsistent supply of green products, which can be eradicated by proper Government incentive programs and an active GB market.

Figure 2 is a fishbone diagram of all the barriers to GB adoption under the main categories.

## 5 Conclusion and recommendations

GB movement is gaining importance across the globe. By utilizing the potential of GBs, the negative impacts of the construction sector can be offset. India’s GB adoption has been sluggish. By identifying unique and overlapping barriers, this research empowers var-

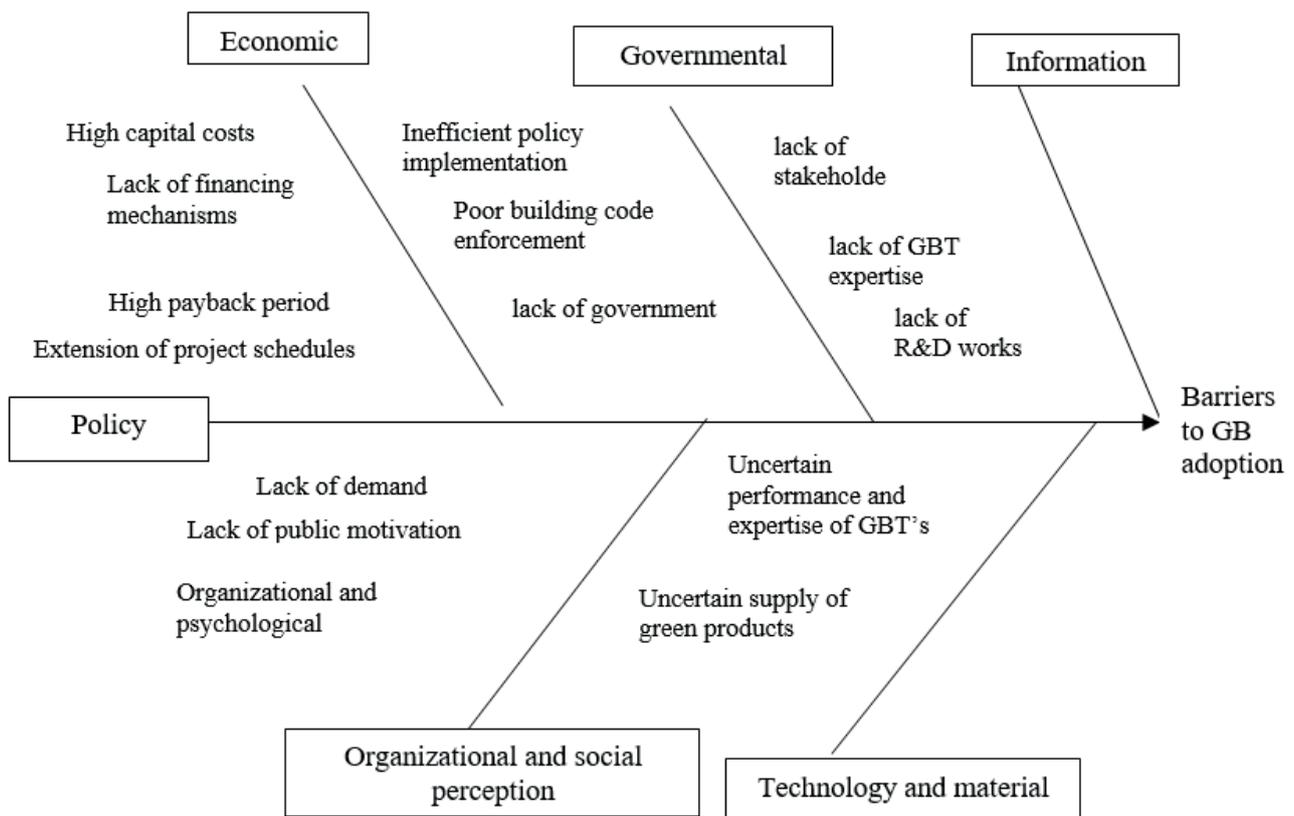


Fig. 2. Fishbone diagram of barriers

ious institutions and Government bodies in India to formulate necessary GB approaches by recognizing the loopholes.

Five consolidated barriers were identified, which were again classified under five categories: Economic, Governmental, Organizational, and social perception, Information, Technology, and material. The research concludes that unique barriers specific to India and developing nations apart from the overlapping ones are - Lack of financing mechanisms, Lack of public motivation, Unpredictable performance and expertise of GBTs, Poor building code enforcement, High pay-back period, and Uncertain supply of green products. It is identified that government plays an important role in mitigating them by doling out tax incentives, rebates, funding R&D work, technology support, proper policy implementation. Effective promotion of GBs and proper training regarding GBTs, GB demonstration projects can help increase public awareness and proper implementation of policies. Focusing on various sustainable innovation techniques and implementing them will create an example for the world and help India become a flag bearer of the GB movement.

### Conflict of interest

None declared.

### Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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