Critical Success Factors for Implementation of Green Building in India

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Abstract. For the sustainable built environment, Green Building technology is the most widely adopted trend worldwide, however, it is in a nascent stage in India. Even though the use of green building technology is advantageous over the lifecycle of the project, people are hesitant to adopt. Therefore, this study aims at identifying the critical factors affecting the implementation of green buildings in India. For this purpose, an extensive literature review was done to identify factors affecting the implementation of green buildings. In total 27 factors were identified which may be critical for the adoption of green building technology widely in an Indian context. The questionnaire was prepared using the five-point Likert scale. The questionnaire was sent through emails to 150 consultants in India and 52 valid responses received in return. The primary data is analyzed using factor analysis. The critical factors found are time and knowledge constraints; technical constraints; authenticity of research and awareness about Green Building. Though the findings of this study are based on the small sample size, it will be beneficial to the policymakers to draft necessary strategies to promote green buildings in India.

1. Introduction
As per the report published by UN DESA by 2050, two-third of the world population will be living in the cities. In 1950 out of 376 million population in India less than 20 percent used to live in urban cities [1] however the urban settlements increased to 286 million in 2001 [2] and then to 377 million in 2011. As per the latest reports the urban settlements in India grew up to 461 million (34 percent) and the number is expected to increase by 416 million by 2050 [1]. As per the report released by the ministry of urban development of India, By 2030, the nation is expected to have 68 cities with a population of more than one million, 13 cities with more than four million residents and 6 megacities with populations of ten million or more, with Mumbai and Delhi among the biggest urban areas around the world.

From the above statistics we can conclude that India is going through the phase of rapid urbanization. This implies that the country would see an upsurge in housing requirements in the urban areas. This leads us to an increase in energy and water demand. In India, the residential sector alone consumes about one fourth of the total electrical energy generated, which would continue to rise. Globally, buildings are responsible for at least 40% of energy use, 36% of all waste generated and 50% of the global consumption of raw materials [3]. Also, building activities contribute an estimated 50% of the world’s air pollution, 42% of its greenhouse gases, 50% of all water pollution, 42% of global water consumption and 50% of all CFCs (chlorofluorocarbons) to the environment.
Rapid urbanization and increased natural resource consumption have created unprecedented environmental degradation. So the need of the hour is ‘green buildings’ which play a crucial role as they are synonymous to both sustainable constructions and assured high performance. Green buildings account for improving environmental footprint by reducing energy use by 30-35%, CO2 emissions by 35%, waste output by 70% and water usage by 40% [3]. According to Indian Green Building Council “Green Building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building”. India is committed towards the sustainability but still it is in the nascent stage. Green movement in India started with a modest beginning of 20,000 sq. ft. in 2003. As of September 30 2017, 4289 projects had been registered with Indian Green Building Council (IGBC) with a green footprint of 4.68 billion sq. ft. [4] however it is only 5% of the total buildings in the country. According to smart city indicator survey conducted by Ireland based multinational, Johnson controls India has only 4% of buildings that can be classified as green’(see https://mercomindia.com/with-4-percent-green-buildings-india-barriers/’.

Even though Green Buildings are highly beneficial what has been stopping their wider adoption in India? Some studies have answered this but they are country specific [5-7] and some studies have done worldwide survey[8], but the percentage of response from India is very negligible.so the overall results cannot be interpreted for the Indian conditions. Therefore this study aims at identifying the critical factors affecting the wider implementation of Green Buildings in India.

2. Factors affecting Green Building

2.1. Cost
In general, the Construction of Green buildings is expensive than the conventional construction. An increase in construction cost is due to the green construction practices that need to be adopted on-site and usage of green materials which cost 3% to 4% more than the conventional material [9]. The investment cost of green buildings is 1% to 25% higher than the conventional, which is due to design complexities and the exhibiting costs needed to incorporate green practices into the project [5]. The United States Green Building Council (USGBC) noted that the initial expenditure can increase, on average from 2% to 7% to incorporate the green features. Not only the initial expenditure, but the overall project cost is also likely to upsurge by the introduction of green technologies, as stakeholders may have to bare the higher investment cost that may be associated with such technologies [8]. Other factors responsible for the high-cost premium of green buildings are cost spent for the search of reliable suppliers of green material and alternatives in case they are not available and for certification of building [10]. High-cost premium is the most critical and indisputable barrier affecting the wider implementation of Green Buildings in the market [7]. High investment cost has become a concern for the owners and developers to implement green features in their projects.

2.2. Technical difficulties
Durability of green materials could be an important barrier preventing the construction industry from implementing the green construction strategies [11]. Green technologies require complicated techniques and construction processes, if the complexities are not well addressed enough then it may impact the project manager’s performance [9]. Study conducted by Wilson and Tagaza [5] suggested that one of the main challenges in Green building is the technical difficulties experienced during the construction process. Design of the Green construction is more complicated than the conventional construction [10]. Study conducted by Eisenberg, Done [12] suggested a lack of knowledge or technological skills and lack of experience with the green material and design as the barriers. The project manager must deliver the project with the required specifications mentioned by the customer, and lack of familiarity with the performance of green technologies may impact his performance [9].
2.3. Time
Green building needs to be planned and executed properly for the on-time completion of the project. The approval process for advanced green technologies and sustainable materials that need to be used are time taking and lengthy. The lengthy approval process throws a challenge to the project team in developing the schedule of the project and the completion of the project as per schedule [9].

2.4. Contractual difficulties
The success of designing and executing a green project depends heavily on the form of contract chosen for project delivery. There has not been any particular form of contract for the Green Buildings. In general hard bid methods which mean the lowest bid is awarded the job are not ideal in case of Green Buildings because green projects would naturally need a team designed for the project's sustainable progress. The type of contract chosen for green projects must incorporate the particulars of a fully integrated green design [9]. If the contractor is informally involved, then Design-Bid-Build (DBB) has a relative potential to provide satisfactory levels of integration for attaining sustainability goals [13]. Schaufelberger and Cloud (2009) recommended Construction Management at Risk (CMAR), which uses cost plus with guaranteed maximum price (GMP) payment, and Design-Build (DB) as the more effective systems for delivering Leadership in Energy and Environment Design (LEED) projects. Korkmaz et al. (2010) recommended that Construction Management at Risk (CMAR) and Design-Build were better than Design-Bid-Build. A traditional construction tender based on detailed design documentation, or a ‘novation’ contract or an ‘alliance’ contract, all could be successfully used for the delivery of green commercial buildings, since sufficient time can be invested at the conceptual design stage [5]. ‘Design and build’ contract, or a ‘public private partnership’ (PPP) arrangement would not successfully deliver a green commercial building due to the design being locked in at an early stage before being fully developed and integrated [5]. Choosing a contract form for the project delivery and incorporation of contract clauses in it has been a major concern for the wider adoption of Green Buildings.

2.5. Management concerns
Top management support plays a crucial role in the adoption of green technologies. If they do not add importance to the green features, there will be no chance for the lower hierarchy members to implement the green features [8]. Absence of effective communication and interest between the project team members also affects the adoption of green practices [14]. Limited availability of reliable Green Building material suppliers and lack of alternatives is also a concern that need to be addressed [11]. Studies reveal that effective communication among the technical experts helps us to contain the cost of construction which is very helpful in case of green projects.

2.6. Knowledge and information
Information about the latest technologies plays a crucial role in acquiring knowledge about them and creating public acceptance about them. Research has shown that green projects management poses a laborious challenge for vendors, engineers, and consumers [14]. Some researchers opined that these laborious challenges are due to paucity in information about green technologies. While some opined that lack of familiarity with the technologies, lack of experienced people in green technologies, paucity in reliable research. However, it can be seen that these barriers are closely related. For instance, the paucity in reliable GB research may lead to insufficient information, insufficient information may hinder awareness, and so on.

From the extensive literature review, various factors that are thought to be affecting the implementation of green buildings in India are identified and tabulated below in the table 1. In table 1 factors are given a code and they will be used in the further sections for the convenience and easy representation in the analysis.
Table 1. Factors affecting the implementation of green buildings in India

| Code | FACTORS                                                                 | [7] | [5] | [10] | [9] | [12] | [11] | [8] | [15] |
|------|--------------------------------------------------------------------------|-----|-----|------|-----|------|------|-----|------|
| F01  | Higher cost for green construction practices                           | X   | X   | X    | X   | X    | X    | X   |      |
| F02  | Technical challenges in the construction phase                        | X   | X   |      |     |      |      |     |      |
| F03  | Unfamiliarity with green technologies                                  | X   | X   | X    | X   | X    |      |     |      |
| F04  | On-site implementation of green practices require                      | X   | X   | X    | X   | X    |      |     |      |
| F05  | The approval process of green technologies is                          | X   | X   | X    |     |      |      |     |      |
| F06  | Shortage of reliable green material suppliers                          | X   |     |      |     |      |      |     | X    |
| F07  | Concern in the performance of green material in                        |     |     |      |     |      |      |     |      |
| F08  | Difficulty in the life cycle analysis of green building                |     |     |      |     |      |      |     |      |
| F09  | Lack of demand on part of the client towards the green building projects|     |     |      |     |      |      |     |      |
| F10  | Resistance to change from conventional                                  |     |     |      |     |      |      |     |      |
| F11  | Complex green building codes and regulations                           |     |     |      |     |      |      |     |      |
| F12  | Inadequate tools to check the green performance of a finished building |     |     |      |     |      |      |     | X    |
| F13  | Inadequate Green Building rating programs                              |     |     |      |     |      |      |     | X    |
| F14  | Absence of communication and interest between the project team members |     |     |      |     |      |      |     |      |
| F15  | Conflicts of interests among various stakeholders in adopting green technologies |     |     |      |     |      |      |     |      |
| F16  | Lack of support from top management                                    |     |     |      |     |      |      |     |      |
| F17  | Paucity in reliable research on green technologies                     |     |     |      |     |      |      |     |      |
| F18  | Difficulty in providing the training to project staff in green technology |     |     |      |     |      |      |     |      |
| F19  | Shortage of skilled labor/ expertise green building                    |     |     |      |     |      |      |     |      |
| F20  | Lack of promotional strategies                                         |     |     |      |     |      |      |     |      |
| F21  | Lack of awareness among public on Green building technologies          |     |     |      |     |      |      |     |      |
| F22  | Absence of information and database about the green technologies       |     |     |      |     |      |      |     |      |
| F23  | Possible ambiguities and conflicts between clauses in contract         |     |     |      |     |      |      |     | X    |
| F24  | Risk due to different contract forms of project                        |     |     |      |     |      |      |     |      |
| F25  | Lack of financial schemes                                              |     |     |      |     |      |      |     |      |
| F26  | Lack of government incentives                                         |     |     |      |     |      |      |     |      |
| F27  | High rental charges and long pay-back periods                           |     |     |      |     |      |      |     |      |

3. Research Methodology

Extensive literature review enabled to identify 27 critical factors that have the potential to effect the wider implementation of Green Buildings in India as shown in Table 1. These are the factors that have been well documented in the previous researches. Well known factors are more appropriate for a research study because respondents will be able to respond easily [8]. Each factor was made into a question and questionnaire survey was prepared. The targets were asked to mark their opinion on a five point likert scale from 1(strongly disagree) to 5 (strongly agree). The questionnaire was distributed by email, providing an internet link to allow online responses. The targets were requested to distribute the questionnaire to any others they thought appropriate. 150 questionnaires were sent to selected segments of architectural consultants, construction engineering consultants and Green Building consultants across the
India who is accredited with Indian Green Building Council. The survey collected 52 valid responses. Table 2 summarizes the profiles of respondents. 52 responses from the respondents can be considered to be representative. According to existing studies, minimum sample size of 30 is considered representative for any group [15].

Data was analyzed by using Statistical Package for Social Sciences (SPSS.25 for windows) software. Primarily, to check the Reliability of the five point Likert scale used in the survey, Cronbach’s alpha coefficient was calculated. Cronbach’s alpha calculation was conducted to test the grouping and internal consistency of the factors. Mean score of the individual factors were determined and ranked. Statistical t-tests of the mean scores against a test value of 3, and at a significance level of 0.05, were used to establish whether each identified factor was significantly critical or not.

| Table 2. Profile of Respondents |
|--------------------------------|
| Profession and Year of experience | Number | Percentage |
|----------------------------------|--------|------------|
| **Profession**                   |        |            |
| Architectural consultant         | 15     | 28.85 %    |
| Construction Engineering consultant | 7     | 13.45 %    |
| Green Building consultant        | 30     | 57.70 %    |
| Total                            | 52     | 100 %      |
| **Experience (Years)**           |        |            |
| 1-5                              | 22     | 42.30 %    |
| 5-10                             | 15     | 28.85 %    |
| 10-15                            | 6      | 11.54 %    |
| More than 15                     | 9      | 17.31 %    |
| Total                            | 52     | 100 %      |

Finally, Factor analysis was carried out to narrow down the large number of factors into fewer components, using only the 20 significant factors in the total sample. For this purpose of study Principle component Factor Analysis with varimax rotation was used. Only components whose Eigen values were greater than one are extracted and to represent significant correlation of the variable with the component extracted at least a factor loading of 0.5 has been considered [16]. The presentation, interpretation, and discussions of the study outcomes are based on the results from the statistical analyses (approach adopted from Rahman [17]).

### 4. Results and Discussion

Cronbach’s alpha calculated value was 0.880 indicating that the 27 factors were internally consistent. Table 3 summarizes the perception of respondents on the 27 factors affecting the wider adoption of Green Buildings in India.

| Table 3. Ranking and significance of Total sample |
|-----------------------------------------------|
| Factor Code | Mean Score | Rank | Significance |
| F21         | 3.81       | 1    | 0.000        |
| F03         | 3.58       | 2    | 0.001        |
| F10         | 3.50       | 3    | 0.003        |
| F15         | 3.48       | 4    | 0.002        |
| F26         | 3.46       | 5    | 0.004        |
| F09         | 3.40       | 6    | 0.011        |
| F16         | 3.25       | 7    | 0.119        |
| F14         | 3.21       | 8    | 0.188        |
| F25         | 3.19       | 9    | 0.229        |
Top five critical factors are Lack of awareness among public on green building technologies and their benefits (F21), Unfamiliarity with green technologies (F03), Resistance to change from conventional construction methods (F10), Conflicts of interests among various stakeholders in adopting green technologies (F15), Lack of government incentives (F26). However it is surprising to notice that Higher cost for Green construction practices (F01) is ranked low (19) which is in contrast with reports in the literature [6-8, 11, 14] and similarly on-site implementation of green practices require a longer period (F04) also ranked low(24) which is in contrast with the reports in the literature [6, 11, 14]. The three least critical barriers are found to be Concern in performance of green material in the longer run (F07), Complex green building codes and regulations (F11), Inadequate green building rating programs (F13) and these are the only factors that have mean less than 2.

Results of the one sample t-test at a significance level of 0.05 are presented below in the table 3 and they indicate that seven factors (F06, F14, F16, F19, F20, F24 and F25) are insignificant, stating that the remaining 20 factors are significant or critical factors. In order to narrow down these 20 factors into meaningful components Principle Component Factor analysis were carried out. However, before factor analysis, the Bartlett test of sphericity and Kaiser-Meyer-Olkin test (KMO) are required to determine the appropriateness of factor analysis for factor extraction and to check the suitability of data to conduct the factor analysis.

The Bartlett test of sphericity is a statistical test for the presence of correlations among the variables, and the KMO is a measure of sampling adequacy. If the Bartlett’s test of sphericity is significant (p < 0.05) and the value of the KMO index is greater than 0.5, the data set is suitable for factor analysis [18]. In this research, the Bartlett’s test of sphericity was significant (p <0.001), and the value of the KMO index was 0.653 (greater than 0.5). The results confirmed that the data were appropriate for factor analysis and the results were presented in Table 4.

|   |   |   |
|---|---|---|
|F06| 3.08| 10| 0.622|
|F19| 2.92| 11| 0.622|
|F20| 2.79| 12| 0.231|
|F24| 2.77| 13| 0.110|
|F27| 2.67| 14| 0.020|
|F17| 2.60| 15| 0.008|
|F23| 2.58| 16| 0.002|
|F22| 2.56| 17| 0.006|
|F08| 2.54| 18| 0.008|
|F01| 2.50| 19| 0.001|
|F12| 2.46| 20| 0.001|
|F18| 2.33| 21| 0.000|
|F02| 2.27| 22| 0.000|
|F05| 2.25| 23| 0.000|
|F04| 2.23| 24| 0.000|
|F07| 1.88| 25\^{a}\ | 0.000|
|F11| 1.88| 25\^{a}\ | 0.000|
|F13| 1.69| 27| 0.000|

\(^{a}\)represents equal rank where next rank is skipped

\(^{b}\)significance levels obtained from one sample t-test.
**Table 4. Factor analysis Results**

| COMPONENTS | CODE | 1     | 2     | 3     | 4     | 5     | 6     |
|------------|------|-------|-------|-------|-------|-------|-------|
| F11        | 0.711| -     | -     | -     | -     | -     | -     |
| F04        | 0.696| -     | -     | -     | -     | -     | -     |
| F12        | 0.687| -     | -     | -     | -     | -     | -     |
| F05        | 0.604| -     | -     | -     | -     | -     | -     |
| F23        | -    | 0.730 | -     | -     | -     | -     | -     |
| F01        | -    | 0.721 | -     | -     | -     | -     | -     |
| F22        | -    | 0.713 | -     | -     | -     | -     | -     |
| F02        | -    | 0.547 | -     | -     | -     | -     | -     |
| F07        | -    | 0.524 | -     | -     | -     | -     | -     |
| F12        | -    | -     | 0.750 | -     | -     | -     | -     |
| F18        | -    | -     | 0.731 | -     | -     | -     | -     |
| F17        | -    | -     | 0.681 | -     | -     | -     | -     |
| F09        | -    | -     | -     | 0.817 | -     | -     | -     |
| F10        | -    | -     | -     | 0.676 | -     | -     | -     |
| F21        | -    | -     | -     | 0.646 | -     | -     | -     |
| F26        | -    | -     | -     | 0.596 | -     | -     | -     |
| F03        | -    | -     | -     | -     | 0.886 | -     | -     |
| F08        | -    | -     | -     | -     | 0.634 | -     | -     |
| F15        | -    | -     | -     | -     | -     | 0.814 | -     |
| F27        | -    | -     | -     | -     | -     | -     | 0.509 |

Eigen Value: 3.015, 2.927, 2.546, 2.352, 1.582, 1.428

Variation: 15.073, 14.634, 12.728, 11.762, 7.910, 7.139

Rotations converged in 8 iterations. Kaiser-Meyer-Olkin measure of sampling adequacy: 0.653. Bartlett’s test of sphericity: chi-squared approximately 445.020, degree of freedom (df) 190, significance 0.000.

Thus, components extracted are critical factors which act as barriers in implementation of Green Buildings in India, they are discussed below.

4.1. Time and Knowledge constraints
This is a first component consists of four factors (F11, F04, F12 and F05) and it focuses on the barriers related to time and knowledge. The overall knowledge spread about Green Building technology and its long term benefit is less among the various stakeholders in India. Even if any client want to use Green Building technology in his project, it is difficult for him to get right consultant who can guide him completely. Very few professionals are working in this field and they are concentrated in metro cities only. Also, no standardize specifications are available for Green Building in India. This poses difficulty for public sector clients for adoption of new technology. Now a day, though many government projects insist green technology but they have to rely only on GRIHA guidelines. So, time delay starts from inception of the project. Also, getting a right contractor who is truly interested in construction of project using green technology through competitive bidding process is a bigger challenge. Availability of green material as per requirement in the nearby market is another challenge. Otherwise contractor has to import it from other markets which slowdowns the pace of construction. Therefore, it is observed that contractors just try to comply provisions in the contract by using similar material. Knowledge regarding the Green Buildings is essential for a better understanding of the provisions that need to be followed and to check...
the performance of the completed buildings. Educating the students during their graduation and practicing professionals time to time about Green Building technology and material is necessary in Indian context.

4.2. Technical Constraints
The second component consists of five factors (F23, F1, F22, F02 and F07) and it focuses on barriers related to technical difficulties that arise during the different phases of the project i.e. contractual phase, procurement phase and construction phase. There has not been any particular form of the contract specifically for green constructions. When the contract has been formed, clauses in the contract should be written with utmost clarity so that they do not cause any misunderstanding between the client and contractor. Therefore, it is necessary that government should develop standardize contract document for Green Building projects just like CPWD general conditions of contract. For procurement of green materials, Government should come up with rating system of materials just like star rating for electrical equipment in energy saving so that the quality of the material is guaranteed. Since the green building design is complex, project manager with experience in green construction is preferred to manage the project so that difficulties in any stage can be handled with perfection. The professionals must publish their experiences about green building projects so that technical case studies will be available for others to study.

4.3. Authenticity of Research
The third component consists of three components (F13, F18 and F17). The authentic research outcomes motivate clients and consultants to choose Green Building technology and material. But such authentic research is not available in Indian context. Presently, most of clients are suspicious about quality of green materials and overall performance of green technology. It is necessary to conduct research on two fronts, first one performance evaluation of Green Building projects and second one on reliability of green materials. If performance evaluation of existing green building projects show successful outcome then more clients will attract to adopt Green Building projects. Similarly, successful outcome of green material research will remove the dilemma of consultants in selection of reliable green materials. This will also provide study materials for training to consultants, project engineers and skilled workers on green technology.

4.4. Awareness about Green Building
The fourth component consists of factors (F09, F10, F21 and F26). There is no demand from the Indian public for the construction of Green Buildings in the market. The main reason for the lack of demand from the public is lack of awareness among the public regarding the benefits of green buildings. Therefore, public is not ready to change from the traditional technologies. The ‘Green Building is costlier affair’; this myth is wrongly fit in Indian public minds. Public need to educate about the advantages of Green Building over traditional technology. The importance of Green Building in conservation of natural environment can be conveyed during school teaching itself. At the same time, the government can provide discount in municipal tax to motivate the public for Green Building construction. Similarly, government can provide incentive to real estate developers for adoption of Green Building project. Presently, eight state governments in India are offering additional Floor Area Ratio (FAR) free of cost for green buildings projects as per certain rating categories.

5. Conclusions
The survey results presented in this paper evaluated various critical factors affecting the implementation of Green Buildings in India. The interpretations and discussions of study outcomes are based on the statistical analyses results. Within the 27 factors considered for study, 20 factors are found to be significant in Indian context. The following are the top five ranked factors: (1) Lack of awareness among public on green building technologies; (2) Unfamiliarity with green technologies; (3) Resistance to change from conventional construction methods; (4) Conflicts of interests among various stakeholders in adopting green technologies and (5) Lack of government incentives. The results of factor analysis
indicated that the significant critical factors can be grouped into few components for better understanding. Thus, the critical factors affecting the implementation of Green Building in India are identified from the factor analysis and they are Time and Knowledge constraints; Technical constraints; Authenticity of research and Awareness about Green Building. From these findings, it can be concluded that people are willing to spend for green practices but the lack of awareness about their benefits is stopping them. We should focus on creating the awareness by educating the public by letting them know the benefits of Green Buildings, that they reduces the operating costs, increases the asset value and payback for additional green investments is also less. With the help of the outcomes of this paper, policy makers would be able to identify specific issues relating to the use of Green Building technologies and come up with suitable strategies to accelerate their wider implementation. The limitation of the study is results are interpreted on the basis of small sample size. In future, the findings over a wider sample size may lead to a better understanding of the critical factors affecting the wider implementation of green buildings in India.

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