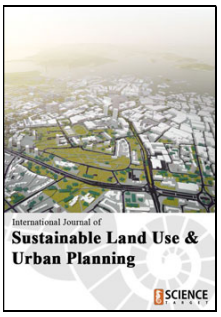
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International Journal of Sustainable Land Use and Urban Planning [IJSLUP]
ISSN 1927-8845
Vol. 3 No. 2, pp. 1-12
(2016)

Adoption of Green Practices in Industrial Buildings: An Action Research on Capacity Building of Stakeholders Towards Green Factories

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Abstract. The Industrial sector, being the most prominent driver of economic growth in India, has significantly contributed to climate change. Consequent negative impacts have been seen on resources, human health and wellbeing. This indicates a need to steer growth towards green industrialization through the adoption of green practices in industrial buildings. The research looked at various aspects of the green factory rating system developed by the Indian Green Building Council (IGBC) as a tool for the greening of industrial buildings. The researcher identified fully operational green factories as case studies. A training programme was developed and implemented for randomly selected non-green factories to generate awareness among managers. Case profiling of green factories revealed newer technologies and practices adopted by management, such as building flush out breakout spaces, entryway systems, high efficiency filters, etc. The training programme helped the managers understand and appreciate how their practices and preferences in their factory buildings can contribute to good working environments, thereby leading to accomplishing the holistic goal of sustainable development. The authors call for sensitization of stakeholders towards green building guidelines so that the green movement can move forward toward the creation of a more sustainable future.

Keywords. *Green factory rating system; industrial sector; Indian Green Building Council; climate change; case profiling; training programme*

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1. Introduction

Due to the increasing concerns about climate change, greenhouse gases and emissions are matter of global concern requiring a global solution. There has been an aggravation of global and local environmental problems caused by the ever-increasing use of fossil fuels, which has posed an enormous challenge to fuelling economic growth in an environmentally sustainable way. It is imperative to consider the impact of climate change on business operations and its potential impacts on sustainability. Companies in developing nations are said to be particularly vulnerable. In India, being one of the largest and most rapidly growing developing countries, the issue of emission needs special focus ("Climate Change Will Increasingly Affect Businesses", 2013; Sahu & Narayan, 2013). The Indian industrial sector is successfully competing in the global marketplace and registering high growth, and it holds a key position in the Indian economy. Industry accounts for 26% of GDP and employs 22% of

the total workforce (Quandl, 2013). According to the United Nations (2014), India's industrial manufacturing GDP output in 2012 was the 10th largest in the world on the current US dollar basis ($239.5 billion). Post reforms period, the share of polluting industries in the total manufacturing sector has gone up from 53 percent in 1998 to 54 percent in 2002 further to 56 percent in 2005, and it has been rising since then (Sinha, 2010). Nearly 21 percent (238 million tonnes) of carbon dioxide emissions are attributable to manufacturing industries (Parikh, Panda, Kumar & Singh, 2009).

Industrial revolution and globalization are increasing the burden of occupational hazards and changing occupations. Introduction of hazardous machinery, toxic chemicals, high rise construction, unprotected machinery, poisoning and burns from manufacturing of chemicals, etc., are the main causes of injuries and deaths in Indian industries— both in organized and unorganized sectors (Technology Information, Forecasting and Assessment Council [TIFAC], 2010).

While buildings and development provide countless benefits to society, they also have significant environmental and health impacts. According to the Whole Buildings Design Guide (WBDG) Sustainable Committee (2010), "Industrial buildings construction and operation have extensive direct and indirect impacts on the environment and human health. They use resources such as energy, water and raw materials, generate waste (occupant, construction and demolition) and emit potentially harmful atmospheric emissions". With rapid industrialization and urbanization in India, construction activities have increased manifold, and their impact on the environment is being felt. In addition, society has become more aware of the negative effects of indoor environment on buildings (The Energy Resource Institute [TERI], 2004; Reis, Bilec, & Needy, 2006). Indoor environmental quality (IEQ) and occupational health in factory buildings directly impacts the human health and productivity of workers. It is one of the major concerns in providing safety and good working conditions in any sector (Kats, 2003).

To foster the green building process and provide a benchmark for green standards, green building guidelines have been developed worldwide. According to Augenbro (1998), the term green building guidelines refers to "the guidelines, which evaluate the environmental performance from the 'whole building' perspective over the building's service life". The United States Green Building Council (USGBC) was the first to come up with one such set of guidelines when it launched the Leadership in Energy and Environmental Design (LEED) guidelines in 2000. Since its formulation, LEED has provided a set of standards for environmentally suitable construction (Pothbore & Syal, 2008). LEED was later adapted to suit the Indian conditions. Thus, the Indian Green Building Council (IGBC) was developed as an arm of USGBC in 2001. LEED-India (developed by IGBC) provides building owners, architects, consultants, developers, facility managers and project managers the tools they need to design, construct and operate green buildings. At present, IGBC has a large number of certified and registered projects across the country. Since its formulation, LEED-India has provided a set of standards for environmentally suitable construction (Natural Resource Defense Council, 2008). India also came up with the formulation of GRIHA (Green Rating for Integrated Habitat Assessment). GRIHA has been adopted by The Ministry of New and Renewable Energy and was developed by The Energy and Resources Institute (TERI). It is an indigenously developed rating system completely tuned to the climatic variations, architectural practices and existing practices of construction and attempts to revive the passive architecture (United Nations Environment Programme, 2007).

The IGBC Green Factories rating system is the first of its kind addressing sustainability in industrial buildings. This rating system would facilitate the development of energy efficient, water efficient, healthy and more productive environmentally friendly factories. To achieve IGBC Green Factory Certification, buildings must meet all mandatory requirements in the Rating System (IGBC, 2009). Table 1 indicates the various levels of the rating.

Table 1

Certification Levels of Green Factory Rating System (IGBC, 2009)

Certification levels	Points
Certified	51-60
Silver	61-70
Gold	71-80
Platinum	81-100

Such rating systems also need to be developed and implemented by other leading rating systems in India and abroad. Figure 1 depicts the types of guidelines formulated in three of the most implemented rating systems in India.

USGBC	IGBC	GRIHA
- Building design and construction - Interior design and construction - Building operations and maintenance - Neighbourhood development - Homes	- Existing Building - Homes - Townships - Green SEZ - Landscape Rating System - New Construction - Green factory	- New construction - Existing Schools

Figure 1: Green building guidelines catering to different types of buildings in three leading rating systems implemented in India (IGBC, 2014; USGBC, 2014, Association for Development and Research of Sustainable Habitats (ADaRSH, n.d)

With the advancement of the green building movement in India, many companies have shown interest in having a holistic green design and construction framework for upcoming factory buildings. Even before the code was formally launched, about ten manufacturing companies, both domestic and international, showed interest in being a part of the pilot initiative to conform to the Green Factory compliance norms. The new norms will help classify factories and manufacturing units as Green Factories ("Now, norms in place for green factories", 2009). Thus, an effort was made in present research to do case profiling of operational green factories to gain insight into technologies used, benefits accrued and challenges faced with reference to IEQ credits. The paper also focuses on conducting an intervention through an awareness program, which was targeted to motivate management of the industries to implement potential improvements in the working conditions in their factory buildings.

2. Objectives

The study was undertaken with the following objectives:

- Do case profiling of operational green factories
- Study the awareness of stakeholders vis a vis green factories
- Develop and conduct a need-based training program regarding green factories with reference to indoor environment quality and occupational health

Study post-training changes in awareness among stakeholders regarding green factories

3. Materials and Methods

It was observed that the number of factories under Green Factory certification is very limited. These factories were contacted according to their willingness to take part in the study. Two factories were subsequently selected and developed as case studies for understanding the Green Factory Rating system certification better and to gain insight into specific technologies used for IEQ, including benefits accrued and the ideology behind adopting the rating system certification. Both the buildings (Grundfos Pvt Ltd, Chennai and SKF India Ltd, Haridwar) were registered under the Green Factory Rating System. The sample consisted of architects/ architectural designers of the building and managers of the building involved in the process of taking the certification.

Case profiling was used as a base to develop a need-based training programme to use as an

intervention to generate awareness among managers of non-green factories regarding green factories, with special reference to IEQ credits. The intervention was conducted in non-green factories in the National Capital Region (NCR) of India. A listing of all the non-green factories located in the Capital and National Capital Region was done. The factories were contacted through mail, and the purpose of the study was explained. Out of the factories that confirmed participation, two were selected randomly. The sample was comprised of top and middle level managers who were deputed by the organization for training. The intervention study was conducted in three phases: pre-test, intervention and post-test.

Data for case profiling was collected using a checklist and a questionnaire to elicit in-depth information of the project with special reference to IEQ credits. For intervention, a training programme was developed comprised of awareness-raising training modules, which were conducted with comprehensive tools. The awareness level of participants in the training program was enhanced by building their knowledge and perception towards green factories. The knowledge level and perception was measured by administering a knowledge testing questionnaire and interview schedule, respectively, for both pre-training and post-training. The difference between the results of the pre-test and post-test provided evidence regarding any knowledge and perception change during the training. A tool for training evaluation was used to get feedback on the overall reaction of the managers to the training program. Reliability and validity of tools and material developed by the researcher was checked prior to the finalization.

The information obtained through the case study was interpreted and evaluated qualitatively. Pre-Intervention and post–Intervention tests were analyzed by applying two sample t-tests and level of significance.

Table 2

List of IEQ technologies installed in the green factories

Indoor Environment Quality Credit points		Technologies implemented for achieving credit points
Mandatory Requirement 1	Tobacco Smoke Control	– Smoking was prohibited inside the factory area. – Signage was placed in building campus to educate occupants and visitors.
Mandatory Requirement 2	Minimum Fresh Air Requirements	– Sensors were used to monitor the carbon dioxide level. – High efficiency filters at main HVAC intakes was used. – Air conditioner system meets ASHRAE guideline of 20% more fresh air.
Mandatory Requirement 3	Avoid Use of Asbestos	No Asbestos is used in the building
IEQ Credit 1	Building Flush Out	The plant was flushed after construction to remove contaminants and clean indoor air.
IEQ Credit 2	Day Lighting	– Light shelves and skylight was used. – Lights are equipped with occupancy sensors.
IEQ Credit 3	Low VOC Materials	The adhesives, sealants, paints and coatings used in the building are low VOC (volatile organic compounds), thereby having minimum organic emissions.
IEQ Credit 4	Reduction of Workmen Fatigue (Break out spaces)	Outdoor breakout spaces, including the canteen, sitting space, toilets etc., are provided for at least 5% of the regular employees per shift.
IEQ Credit 5	Eco-friendly Housekeeping Chemicals	– The use of chemically-reactive and toxic cleaning products is avoided. – Audits are conducted for maintenance of air conditioners, air ducts and vents.
IEQ Credit 6	Gymnasium	A gymnasium has been provided to cater to a minimum of 2% of the occupants in the factory campus.

4. Results and Discussion

a) Case Profiling

IEQ Technologies

The case studies were analyzed on the basis of the IEQ credits and the benefits accrued from their implementation. An attempt was also made to understand the ideology behind going green. The selected buildings, Grundfos Pvt Ltd (Chennai) and SKF India Ltd. (Haridwar), adhered to norms as given by the IGBC green factory rating system and applied for Gold certification. They had undertaken special initiatives to maintain optimum IEQ in their factory setups as indicated by Table 2

Benefits accrued from implementation of the rating system

The building management was asked to rate the benefits they perceive to have experienced due to implementation of indoor air environment credit under the green factory system compared to non-green factories based on percentages (5-10%, 11-20%, 21%-30%, 31-40%, 41-50%) as indicated by Table 3**.** It was seen that both factories experienced a 20-30% reduction in energy consumption and a 10-15% reduction in employee absenteeism and incidence of sickness. They also perceived to have experienced an increase of 10-20% in productivity of workers. Thus, the management perceived that working green factories had a positive impact on them.

Table 3

Perceived benefits from implementation of IEQ credit by the green factories.

Perceived benefits from implementation of IEQ credit	Percentage Grundfos Pvt Ltd.	SKF India Ltd.
Reduction in Energy Consumption	20-30%	20%
Reduction in Incidence of sickness	10-20%	15%
Increase in Employee productivity	10-20%	20%
Reduced Incidence of employee absenteeism	5-10%	15%

Ideology behind implementation of the rating system

Commitment to reducing environmental impacts and ensuring a good workplace for their employees was cited as one of the most important factors in making decisions towards going green by both the companies.

Both the factories used various technologies to maintain an optimum indoor environment. This contributed to their ultimate goal of providing a good work environment for the workers.

b) Training Programme

Intervention was a training programme consisting of awareness-raising training modules and comprehensive tools. The training programme developed is discussed with respect to its content and delivery.

Content of training programme

To meet both the aims and objectives and the differing levels of knowledge and expertise of the target audience, three modules have been formulated which each having three sessions as indicated by Figure 2.

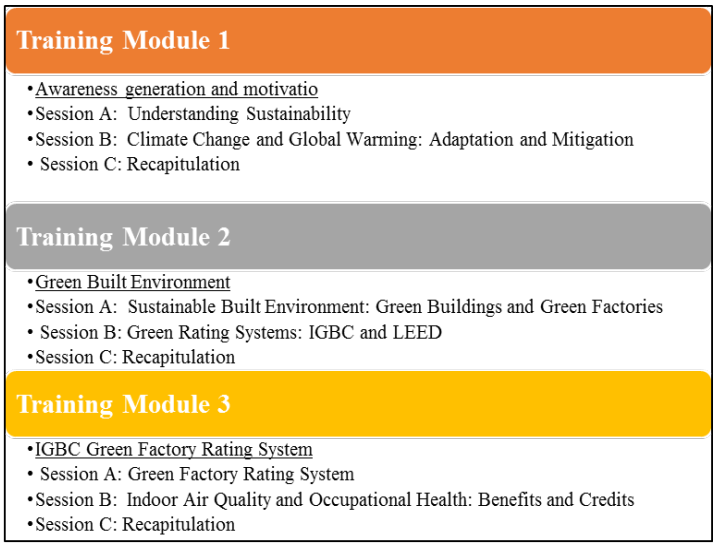


Figure 2: Content of training programme

Delivery of training programme

The training program was framed into three elements as follows:

- Introduction – The respondents were made familiar with the subject matter though informal discussions and presentations.
- Content – The subject matter was delivered using various tools that include:
  - Presentations and videos
  - Session summary handouts
  - Pamphlets
  - Training manual
- Recapitulation – Recapitulation was recognized as an essential part of the training programme. It was administered with the purpose of helping respondents to recapitulate the content at the end of each session. For this, recapitulation exercises were developed for each session.

Intervention Schedule

The intervention schedule was planned in a systematic manner by taking prior appointments from organizations. The flowchart in Figure 3 explains the intervention schedule.

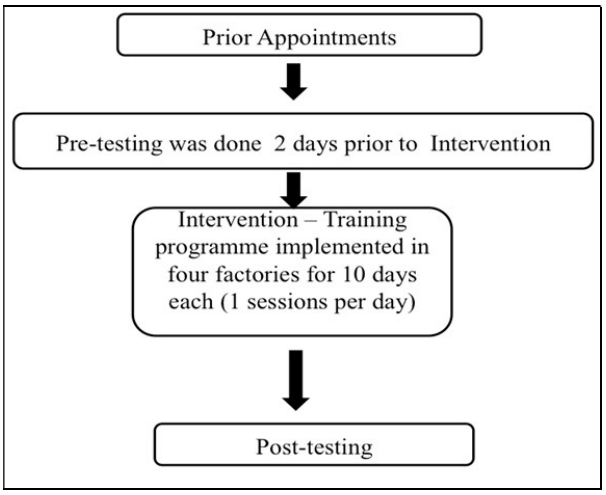


Figure 3: Intervention Schedule

c. Intervention

The respondents were assessed for their knowledge and perception on various issues before and after training. Issues include sustainable development and global warming, green built environment, green rating systems, green factory concept and IEQ.

Sample Profile

The sample of the study consisted of managers of non-green factories largely in the age group of 41-50. The representation of males was higher (85%) compared to females. The majority (90%) was middle managers and a meager portion (10%) was top managers. All of the respondents were holding decision-making positions. The majority (35%) of respondents had 5-10 years of experience in the organization and had good familiarity with the manufacturing corporation. They could compare the comfort conditions in their building and a green factory building; hence, this was seen as a facilitating factor in the adoption of the rating system.

Pre and post training change in Knowledge

It was observed that respondents had a fairly good idea of the term "sustainable development", but they not could not relate it to other options like green building movement and 4R's use of low cost materials. Respondents had fairly good ideas of the issue of global warming as seen in the pre-test. Three fourths (75 percent) of the respondents could identify its correct meaning. However, in the post-test, nearly all (90 percent) respondents chose the right option as indicated by Figure 4. Participants showed interest in understanding the role of the manufacturing sector in global warming so that they can take suitable actions for mitigation and adaptation.

Figure 5 indicates that in the pre-test, 65 percent of responses were received for green buildings being associated with specialized high-cost construction. This was the case even though the respondents belonged to large manufacturing corporations. Surprisingly, 15 percent of responses received were relating green buildings with a building green in color.

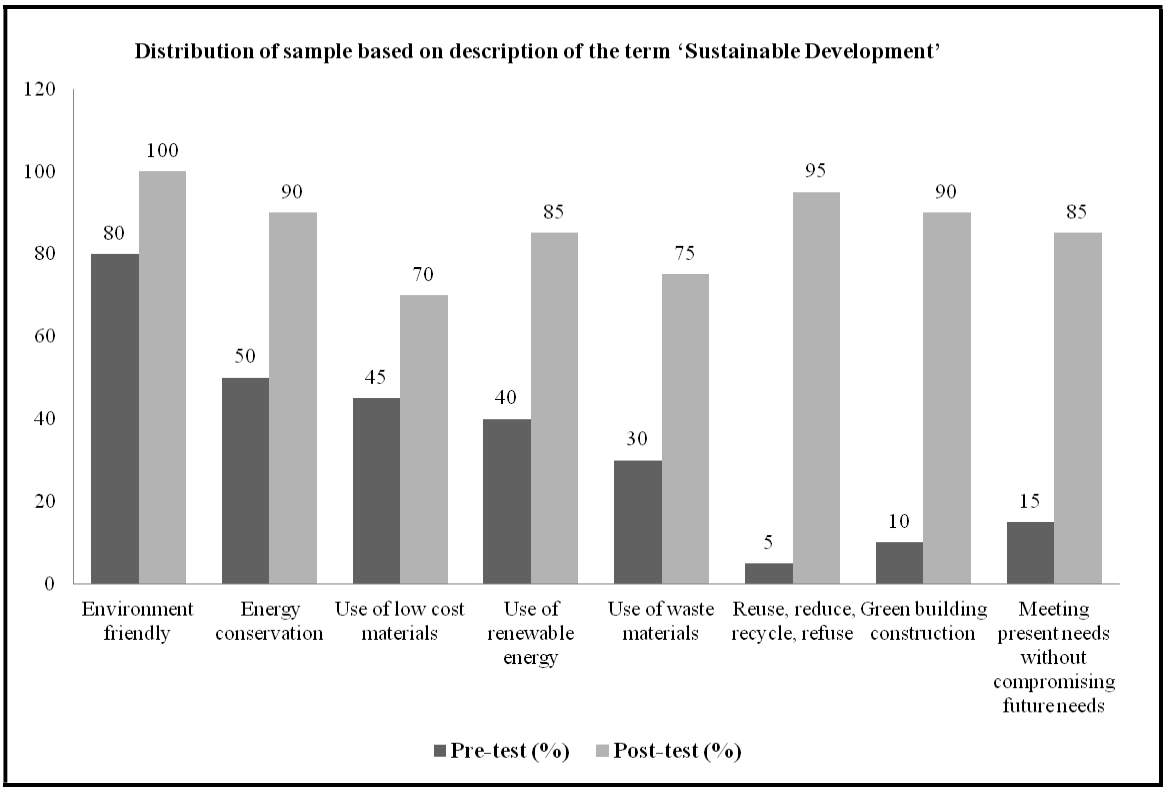


Figure 4: Distribution of sample based on description of the term "Sustainable Development" (N =60). Total percentage is greater than 100, as more than one response was obtained.

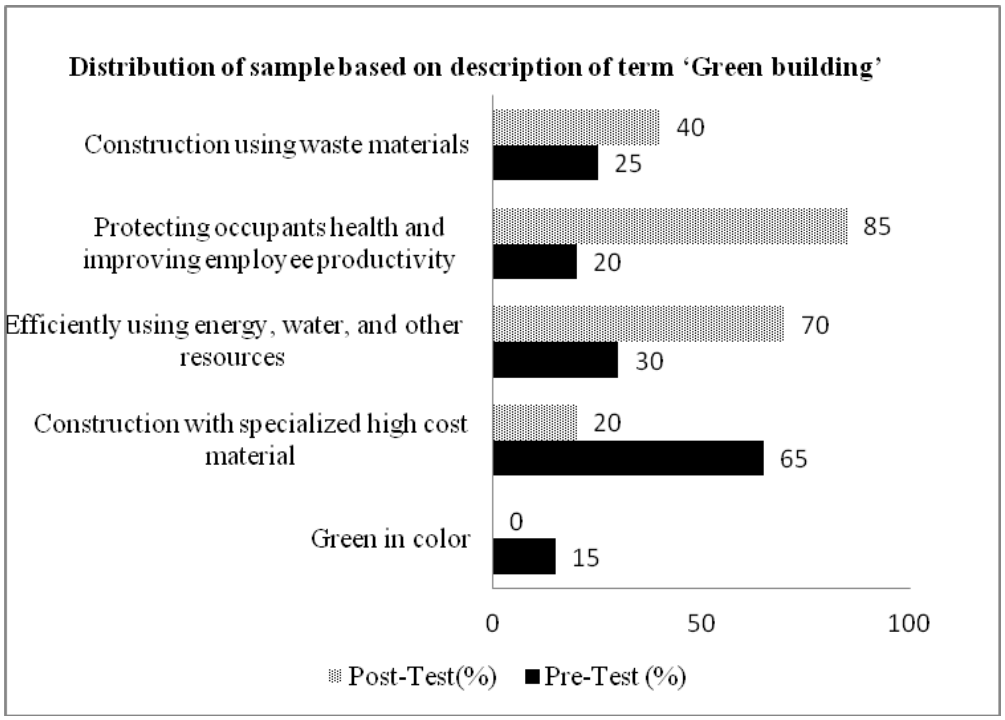


Figure 5: Distribution of sample based on description of the term "Green Buildings" (N = 60). Total percentage is greater than 100 as more than one response was obtained.

However, these misconceptions were dealt with in the training programme, and respondents were made aware of the fact that green buildings are high-performance building providing economic, human and community benefits as well as reduced environmental impacts. In the post-test, respondents were able to comprehend the same as the majority of responses (85 per cent) were obtained for "protecting occupants' health and improving employee productivity". Also, respondents could recognize the resource efficiency of green buildings since 70 percent of responses were relating it to "efficiently using energy, water and other resources", and 40 percent of responses were received for waste materials for construction.

In the pre-test, respondents could not comprehend the green factory concept. To change the level of knowledge, many examples were cited from operational green factories, wherein a special emphasis was laid on IEQ credits employed. Participants were made familiar with the IGBC green factory framework, which caters both to existing and new factories. Ensuring proper IEQ is one of the most pertinent components of the rating system. In the pre-test, only 20 percent of responses were received for this option, whereas in the post-test, the percentage of responses increased to 95 percent as indicated by Table 4. During training, in order to provide a better understanding of the terminology, examples were drawn from operational green factories on how they have implemented these credits and how benefits accrued through their implementation. Also, the percentage of respondents that could identify green rating systems increased from 10 percent in the pre-test to 100 percent in the post-test.

Knowledge about IEQ technologies was seen to be quite low amongst respondents in the pre-test. Respondents also were oblivious to the technologies like airflow and Air Changes per Hour (ACH). Less than one fourth responded correctly. Respondents were made aware of the adverse health effects of not maintaining an optimum airflow and ACH in a factory set up. In the post-test, 85% responded correctly. Respondents also lacked knowledge regarding VOCs and breakout spaces. They were acquainted with these two concepts and their importance by drawing examples from existing green factory set ups where implantation of these credits has led to reduction in the incidence of sickness and greater satisfaction among workers.

Table 4

Distribution of sample with regard to the knowledge about features of a green factory rating system (N = 60)

Features of a green factory rating system	Pre-Test percentage	Post-Test percentage
Site Selection and Planning	0	35
Water Conservation	25	50
Energy Conservation	45	80
Material Conservation	15	60
Indoor Environment Quality	20	95
Innovation & Design Process	15	50

Total percentage is greater than 100, as more than one response was obtained

Pre- and post-training change in perception

A five-point Likert-type scale was developed to evaluate the perception of respondents towards sustainable development and climate change, towards self as a factor in an ecosystem green built environment, indoor environment quality and occupational health. The scale included a set of statements with the option to select strongly disagree (=1), disagree (=2), unsure (=3), agree (=5) and strongly agree (=5) regarding their perceptions.

A shift in the average scores from low to high indicated a perceptual change towards sustainable development and climate change. Pre-training respondents were seemingly oblivious to the seriousness of climate change, as they perceived it to be exaggerated. After post-test training, their perception changed, and they showed interest in knowing the contribution of the manufacturing sector on climate change. They also showed a positive perception post-training towards sustainable development, as they were interested in knowing how they can access workshops and seminars related to these issues. Prior to training, respondents perceived the concept of green building to be very

complex, involving highly specialized construction. However, these perceptions shifted during training, which is evident through high average scores in post-training. They could perceive green buildings to be energy efficient construction and designs that minimize the total environmental impact while enhancing user comfort and productivity.

Pre- and post-training motivation

A five-point Likert-type scale was developed to gauge the motivation of respondents regarding environmental issues and green factory adoption. The respondents appreciated the efforts made by green factories and were motivated to adopt the certification by observing the benefits perceived by these two organizations. Figure 6 indicates the rise in motivation from pre-training to post-training. During pre-training, only 10 percent were motivated to adopt the rating system. Post-training, 65 percent of respondents were motivated to adopt the green factory guidelines. Respondents became aware of the benefits, technologies and importance of all these aspects under the green factory system and were thus ready to bring about a change in their existing environment by adoption of a green factory certification system.

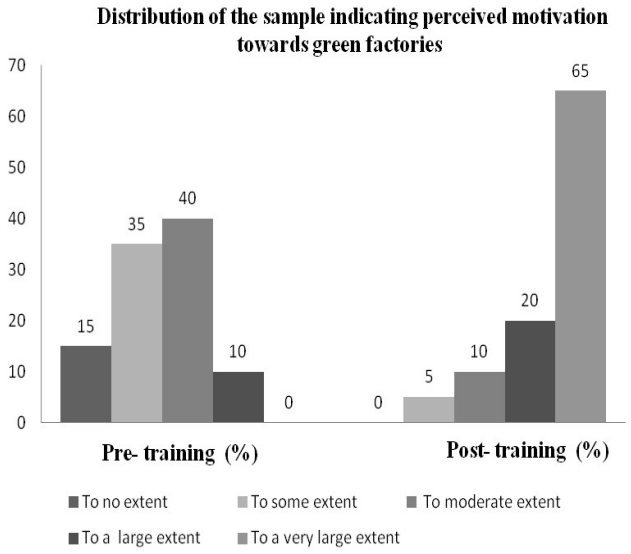


Figure 6: Distribution of the sample indicating perceived motivation towards green factories (N = 60). Total percentage is greater than 100 as more than one response was obtained

Perceived barriers

Lack of knowledge and awareness was perceived as a major barrier towards adoption of green factories as indicated by Figure 7. This training module can be of immense utility for pioneer organizations promoting sustainability. Such interventions and training strategies can be undertaken to generate awareness and promote the noble cause of sustainable development through adoption of green building practices. Lack of an institutional framework for effective implementation of green factories was one of the major barriers. Respondents also pointed towards educating developers and constructors so they can make meaningful suggestions towards green construction to both owner and management.

Satisfaction of workers with indoor environment in factory buildings

The majority of respondents were not satisfied with the indoor environment quality in their work area. This indicates the possibility of improving the indoor environment through adoption of a green factory rating system.

Comparison of pre-training and post-training scores

Scoring was done based on the responses obtained in the knowledge test. Categories were created and scores were arranged under these categories to determine the number of respondents scoring high or low in the pre-test and post-test. Figure 8 indicates a considerable amount of difference between the pre-test and the post-test scores of managers. The paired t-test was calculated for knowledge scores. The means of pre-test and post-test were found to be statistically significantly different as indicated by Table 5.

Table 5

Paired t-test for knowledge scores (N = 60)

	Post-test Pre-test Difference in Mean	t	Level of significance
Knowledge	49.15	18.34	0.00

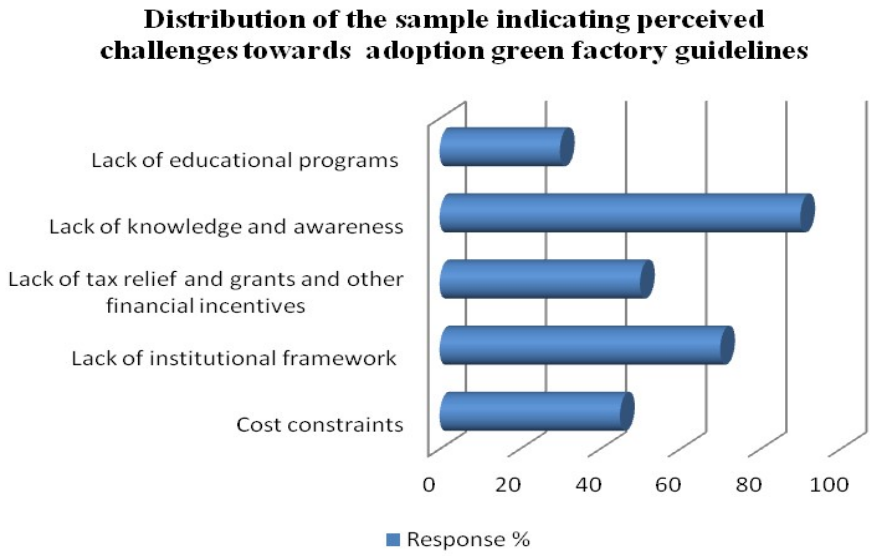


Figure 7: Distribution of the sample indicating perceived challenges towards adoption of green factory guidelines (N = 60)

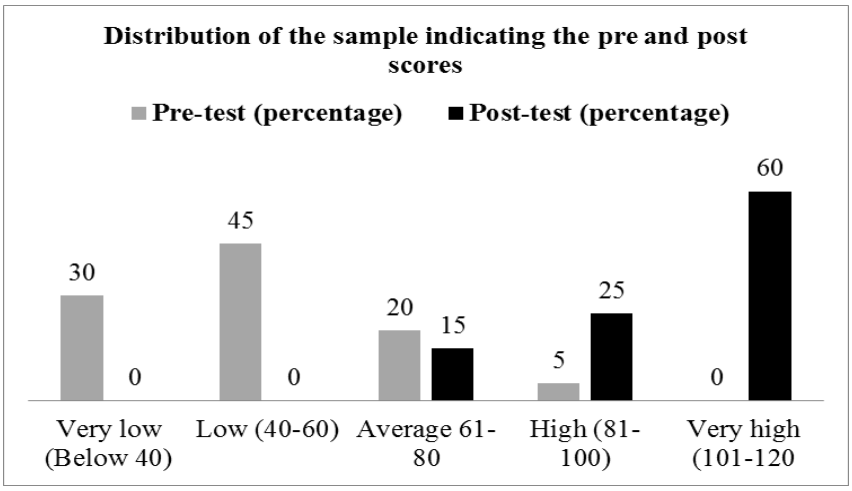


Figure 8: Distribution of the sample indicating pre- and post-training knowledge scores percentage (N = 60)

It was inferred that overall training did have an impact on the knowledge level and perception of managers. The training programme helped stakeholders to understand and appreciate how their practices and preferences in their factory buildings can contribute to a good working environment, thereby leading to a holistic goal of sustainable development.

5. Conclusion

Business will face challenges as never before if climate change impact is not better understood and no steps are taken towards appropriate solutions. The need for sustainable development is picking up pace, with one of the major concerns being to provide a healthy environment for citizens to live and work in. Corporate leaders need to rethink their business models, business priorities, and business sustainability very carefully. Industries, being prominent

drivers of economic growth in India, have a significant contribution to the annual GDP. However, rapid industrialization has led to massive pollution, significant greenhouse gas emissions and degradation of the natural environment, which has resulted in an impact on resources, human health and wellbeing. This indicates a widespread need for the development and adoption of green building rating systems in the industrial sector, which will help in steering growth towards sustainable industrialization. To address this, IGBC has developed a new rating system for green factories and industrial structures.

The study was carried out in two buildings, both of which are registered as IGBC green factories. These two buildings were developed as case studies. The managers and architects were interviewed to gain an insight into the technologies that they implemented under IEQ category and the benefits derived from its implementation. The technologies employed by existing green factories, as revealed by the study, were building flush out, entryway systems, high efficiency filters and more. Also, the management perceived that green factories had a positive impact in terms of reduction in energy consumption, reduction in employee absenteeism and incidence of sickness. Perception and awareness of stakeholders was studied regarding a green factory rating system and related issues, which revealed the gaps in awareness. To fill these gaps, a training program was structured, using the case profile of existing green factories as a guiding framework. The training program gave a holistic overview of the green movement, particularly the green factory rating system, eliciting in-depth information with special reference to IEQ credits and the benefits accrued through its implementation. IEQ and occupational health in factory buildings directly impacts the human health and productivity of occupants. It is one of the major concerns in providing safety and good working conditions in the industrial sector (Kats, 2003). Therefore, IEQ credits were given importance so that managers can be motivated to provide a good work environment for their fellow workers through green factory adoption. The training was statistically tested using two sample t-tests and was found to be statistically significant in bringing about knowledge and perception change. The training program was instrumental in generating awareness and motivating employees, which was characterized by the willingness of the majority to adopt a green factory rating system and to take suitable sustainable initiatives for their factory buildings to provide a better work environment to the workers.

Such interventions can be adopted on a wider scale to motivate stakeholders to address the health concerns and productivity of workers along with other environmental concerns through adoption of green factory guidelines. Training programmes can be used as a catalyst in accelerating this adoption. Moving forward towards the ultimate goal of sustainable industrialization, a green factory rating system can be incorporated in policy frameworks to promote greater willingness on the part of industries to adopt green practices for their factory buildings. Such interventions are fruitful for targeted beneficiaries as well as society as a whole and can be used to have far reaching applications to address the issue of sustainability. To achieve the goal of sustainable industrialization globally, it is imperative that such rating systems for industrial buildings are developed and implemented by other leading rating systems like LEED (US), BREEAM (UK), CASBEE (Japan), Gold Star (Australia) and so forth. Future generations can also be empowered towards the goal of green industrialization by incorporating the knowledge regarding the same in school curriculum. This is in view of the fact that future generations will take on the role of the industrialist, entrepreneur or the workforce in any organization. Hence, the knowledge of green industrialization will help them in addressing sustainable development in a more responsible manner.

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