

Chapter– II

REVIEW OF LITERATURE

A survey of literature was undertaken to be familiar with the subject matter concerned with the present research problem, which proved helpful in planning and execution of the study. A green building is a practice of creating structures using utmost natural resources making it environmentally friendly. The green building concept has been gaining prominence in India as well as in other countries too. Various experts and agencies have given definition and meaning of the term “Green Buildings”. There are certain features and benefits of green buildings. On the other hand there are some misconceptions related to Green buildings identified and presented in this chapter. The reviewed literature also highlights builders and consumers motivations factors for going green in buildings. Builders also face barriers in adopting the green building concept which governs their opinion regarding green buildings. The major areas of related literature, survey scholarly articles, books, and other sources relevant to a particular issue, area of research, or theory, providing a description, summary and critical evaluation of each work are presented in this chapter. In order to make the review clear and understanding, the present chapter is divided into following sections:

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2.1 Theoretical Orientation

This section describes the theories related to Green Buildings.

2.1.1 Sustainable Development and Green Buildings

Growing Human activity has increased the concern for sustainability even more in recent times. Sustainability in real estate context is not only limited to energy conservation, but also includes resource usage, impact on the neighbouring environment and working conditions for tenants (Roy and Gupta, 2008). Among the other production and manufacturing sectors, building and construction sectors occupies the first place as the largest contributor to pollution and natural resource consumption (Levine et. al., 2007; Plank, 2008). In order to control the effects of construction on the environment to improve the performance of the built environment in terms of health and environmental aspects, “green” or “sustainable” buildings were introduced

(Kibert, 2012). The green building concept broadly integrates many interests and aspects of sustainability emphasising reduction of environmental impacts through a holistic approach to land and building usage and construction strategies (Roy and Gupta, 2008; Dwaikat and Ali, 2014).

Green building and sustainability are often used interchangeably, but the terms are far from synonymous. Sustainability, a very broad and far reaching concept, is the underlying principle of green building (Timothy, 2010).

A green building uses less energy, water and natural resources than a conventional building. It also creates less waste and provides a healthier living environment for people living inside it compared to a conventional building. Green building incorporates several sustainable features such as efficient use of water, energy-efficient and eco-friendly, use of renewable energy and recycled/recyclable materials, effective use of landscapes, effective control and building management and indoor environment quality for health and comfort. The overall benefits of green buildings mostly depend upon the extent to which the sustainable features are addressed during the initial planning and design. A green building is most likely to succeed in its objectives if sustainable features are envisioned and incorporated right at the design stage. The design has to take into consideration the entire supply chain – from material sourcing, energy modelling, resource reuse, basic amenities and waste disposal to tenant education (Roy and Gupta, 2008).

Over the last several years, there has been a rapidly growing concern about environmental issues and a rising interest in sustainable practices. Sustainability is one of the basic concept that interest people in the field of construction who are trying to apply its technology and strategy according to the architects and industrial progress (Matar, 2015). Companies across all industries have launched Green initiatives to improve their environmental performance and respond to the concerns among their workers, customers and the communities where they operate. The rising environmental consciousness has led to a rapid increase in Green construction. Real estate owners are increasingly interested in Green construction since many recognize that sustainable building features lead to lower operating costs and

improved financial performance. Owners are also finding that corporate tenants are more likely to rent space in buildings that incorporate green features. Green buildings can be less expensive to operate due to their lower energy and operating costs, while workers satisfaction and productivity is higher. Finally, there is the “prestige” factor of owning or occupying a Green building. Investors are also becoming more focused on investing in Green buildings (Turner Green Building Market Barometer, 2008).

There are a number of motives to building green, including environmental, economic, and social benefits. However, modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the retrofitting of an existing structure. Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of new buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off. Many other techniques, such as using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water, are used as well. Green Building requires combined efforts of the government and community (Fazil and Faridi, 2011)

2.1.2 Need of Green Buildings

During the late 20th century, awareness of the impact of technology and the expanding human population on the earth increased. More people are moving to the city causing a significant increase in the construction of buildings and skyscrapers, and hence a booming in the city economy but with great repercussions in the environment (Conte and Yepes, 2012). People started to expand their efforts to reduce their environmental impacts and buildings started to be recognized as major contributors to the world’s energy usage, landfill waste and diminishing green space (IFMA Foundation, 2010). Green building practices are not new phenomena. A handful of buildings integrating environmental design aspects were erected as early as the late 19th and early

20th centuries(Cassidy, 2003).A unified green design movement did not begin to emerge until the 1970s, when design and building practices first became a focus of environmental advocates(IFMA Foundation, 2010).

Buildings are one of the heaviest consumers of natural resources and account for an important portion of the greenhouse gas emissions (Yi-Kai, et. al., 2010). With the growing evidence that the phenomena of global warming and climate change are caused by anthropogenic greenhouse gas emissions, it has become necessary to take immediate action to avoid dangerous consequences for future generation (Taleb and Sharples, 2011). Buildings not only use resources such as energy and raw materials but they also generate waste and potentially harmful atmospheric emissions (Alnaser et. al., 2008).

The Indian construction industry is experiencing a fast rate of growth with a continual increase in gross built-up area of 10% per annum over the last decade (Indian Green Building Council, 2013).Demand for housing, expansion of organized retail, commercial office spaces by multinationals, the setting up of special economic zones (SEZs), are all increasing. Two of the greatest challenges currently facing the global population are climate change and social and economic inequality resulting from resource scarcity. The built environment has a vast impact on the natural environment, human health, and the economy. Significant increases in chemical sensitivity have been linked to volatile organic compounds (VOCs) found in building materials and consumer products. Multiple Chemical Sensitivity (MCS) is a syndrome in which a sufferer experiences multiple symptoms upon exposure to minute amounts of everyday chemicals, producing some level of un-wellness all the time. Although there are a multitude of triggers for MCS, the products related to the building industry include chemicals emitted by carpets, particleboard, and paints, as well as sealants and adhesives.

The examples above illustrate that humans face a range of negative impacts linked to the way buildings are designed, built, and maintained. The construction and operation of buildings, specifically residential buildings,

requires significant input of energy, water and raw materials. Buildings are also responsible for considerable quantities of waste and emissions, including greenhouse gases (Winter, 2008). Energy consumption and associated greenhouse gas emissions will therefore continue to rise unless actions to direct the construction industry towards sustainable consumption and production are taken urgently (Mehta and Porwal, 2013)

Green buildings address these challenges by integrating the key areas of environmental and human health, protection of ecosystems, and preservation of natural resources (including water, agricultural land, timber, minerals, ore, quarry products and fossil fuels), reduction of atmospheric pollutants associated with energy use and materials manufacturing and creation of safe, non-toxic indoor environments. A 'whole-building' approach to residential design and construction combines sustainable site design, water conservation, energy efficiency, environmentally preferable materials and superior indoor environmental quality to achieve a green end product that meets basic human needs for shelter without compromising safety, security and health needs (Environmental Protection Agency, 2010). Green building is not a matter of choice or luxury but a necessity for the environmentally conscious industry professionals, owners, developers, government officials and rest of the stakeholders (Pedini and Ashuri, 2010).

Healthy, low-emitting alternative materials and superior ventilation are two of the characteristics of green buildings that improve the health of occupants, and in turn lessen the financial burden on families, employers, and insurers (Winter, 2008). By adopting green building strategies, we can maximize both economic and environmental performance. Green construction methods can be integrated into buildings at any stage, from design and construction, to renovation and deconstruction.³

At the micro level, the need for green housing may be propagated by an individual's health concerns; on the macro level, the need is driven by the climate change crisis facing humanity, and the social unrest and violence resulting from resource scarcity. When integrated with improved

transportation and eliminating hunger and drought, green building can become a key component to solving the world's greatest challenges (Winter, 2008).

2.1.3 Concept of Green Buildings Defined and Explained

The term 'Green building' or "Sustainable Building" are used interchangeably and are defined by different authors as follows:

By 'green' it means building that have been created with explicit intent to include environmentally sustainable design (ESD) features and principles.

Leaman et al., 2007

"Green" or "Sustainable" building use key resources like energy, water, materials and land more efficiently than buildings that are just built to code. With more natural light and better air quality, green buildings typically contribute to improved employee and student health, comfort and productivity.

Mehta and Porwal, 2013

Environmental Protection Agency (EPA) of USA defines green building as follows:

"Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability and comfort. Green building is also known as a sustainable or high performance building."

"Green buildings practices are commonly defined by the areas of the environment they affect: energy, water, site, air quality and materials".

Wilson, 2006

Green building concept, in broader terms, involves a building, which is designed, built operated, maintained or reused with objectives to protect occupant's health, improve employee productivity, use wisely natural resources and reduce the environmental impacts (BEAM society, 2004). Green building is also known as a sustainable or 'high performance' building (Environmental Protection Agency).

Green Buildings are designed to meet certain objectives such as protecting occupant's health, improving employee productivity, using energy, water and other resources more efficiently, and reducing overall impact to the environment (Zigenfus, 2008; Mathew, 2015). It maximizes the use of efficient building materials and construction practices, optimizes the use of onsite sources, uses minimum energy to power itself, uses efficient equipment to meet its daily consumer consumption, maximizes the use of renewable sources of energy, uses efficient waste and water management practices, and provides comfortable and hygienic indoor working conditions (Mohanty et.al., 2010). The building may be simple compared to a lot of creative designs that is seen at the moment, but its beauty lies in its objectives, these buildings combine the creation of designer and splendour of nature and greenery which gives the design the beauty of the scene. This practice expands and complements the classical design of the building with respect to the economy, benefits, and the durability and comfort (Zaid, 2011).

2.1.4 Green Buildings in India

India's economic growth can only be sustained with corresponding to growth in infrastructure. Presently, the growing demand is being met by crumbling infrastructure, such as road networks, city transport, water and sanitation etc. A solution to the contradiction requires a massive enlargement of urban infrastructure which will further require newer green and sustainable techniques for building this infrastructure. These newer techniques encapsulate the foundation of green buildings (Ramesh and Khan, 2013).

Green building construction has taken off significantly over last decade in India. Several institutional and government bodies have come forward to build sustainable buildings (Mehta and Porwal, 2013). The green building movement in India started with the establishment of the IGBC in 2001, which was an initiative of the Confederation of Indian Industries (CII) along with the World Green Building Council and the USGBC. The first green building in India, CII-Sohrabji Godrej Green Business Centre in Hyderabad, was inaugurated on 14 July 2004. This was a great symbolic achievement. Since then, the number and volume of green buildings in India has been phenomenal (Roy and Gupta, 2008). However, capacity building for green building professionals, green building materials and technologies is needed to achieve the goals of sustainable construction in India. Emerging green building technologies and new green materials market is estimated to be around 40 billion USD and it is expected to grow (Kats, 2003). The green building concept has been gaining prominence in India with an increasing number of initiatives, primarily by Indian Green Building Confederation of Indian Industry (CII), striving to impart knowledge, offering advisory services to the industry on environmental aspects and practices for green buildings (Times of India, 2015).

2.1.5 Aspects of Green Buildings

The aspects of green building are described as below:

Sustainable Site: It refers to a site that would pose the least environmental threat during construction phase. The sites have access to basic amenities thereby, reducing pollution caused because of transportation. The landscape design should be such that it preserves all existing trees and restore natural topography, use drought resistant trees. Optimize the use of on-site storm water management treatment and provision for ground water recharge. Measures are adopted to preserve top soil through effective methods (Gupta and Shrivatava, 2015).

Water Efficiency: The main goal here is to increase water efficiency use within the building, thereby reducing the amount of water needed for

operations. Some methods which can be adopted for this include efficient landscaping techniques and use of innovative wastewater management technology (Gupta and Shrivatava, 2015). Technologies for reuse of water such as Rainwater Harvesting, Wastewater treatment plant, for conservation of water waterless urinals are installed (Elattar and Ahmed, 2014).

Energy Efficiency: It involves the installation of various methods of on-site renewable energy production can reduce the overall footprints of the building and other means of using green power. The optimization of building orientation, massing, shape, design and interior colours and finishes is done which maximizes the use of natural day lighting. This reduces the dependence on artificial lighting energy. Window frames, sashes and curtain wall system are so designed to optimize energy performance. Use of BEE rated electrical equipments is encouraged (Gupta and Shrivatava, 2015). CFC-free refrigerants are used in Air conditioners and refrigerators are installed. Renewable sources of energy such as solar, wind, geothermal etc. are used to reduce the electricity loads (Elattar and Ahmed, 2014).

Material Selection: As a result of increased use of some materials they are threatened to deplete (Elattar and Ahmed, 2014). Therefore, this aspect is mainly concerned with the reusing, reducing and recycling of the waste. Maximizes the use of recycled content materials, re-usable, renewable, sustainably managed, bio-based materials. Ways are identified to use high-recycled content materials which range from blended concrete using fly ash, slag, recycled concrete aggregate or other admixtures to structural steel, ceiling and floor tiles, carpeting, carpet padding etc. Bio-based materials and finishes such as various types of agriboard made from agricultural waste and by products including straw, wheat, barley, soy, sunflower shells, peanut shells etc. (Gupta and Shrivatava, 2015). Reuse of household waste in the form of bio gas is also a feature of this aspect. Segregation of household waste is followed.

Indoor Environment Quality: In order to enhance the well-being of the occupants, design of a building is such that materials with low emission are used. Building is designed to maximize the use of natural light for all

occupants. Bio degradable and environment friendly cleaning agents are used that do not release VOCs or other harmful agents and residue. There should be a provision for cross ventilation and enhanced ventilation system (Gupta and Shrivatava, 2015).

2.1.6 Benefits of Green Buildings

In today's scenario, Green building is accepted worldwide in the recent past but there is still a vast community that either is unaware of sustainable design concept, indifferent to its cause, or unconvinced of its benefits. To convince owners, builders, and designers (or other stakeholders) about the benefits of sustainable design, it is necessary to make them understand the numerous advantages of green building concept. To do that it is very important to understand the opinion of each group based on their selling points. To an owner, the bottom line may be financial. To an architect it might be environmental and to the engineer it might be performance (Devi and Lakshmi, 2010).

There are many reasons to build green which will provide sustainable design; architects should be equipped to provide a suitable argument relevant to the particular audience. Udechukwu and Johnson (2008) classify green building benefits into three areas viz. environmental, economic and social. Devi and Lakshmi (2010) gave environmental and economic benefits of green buildings. Sarma (2014) highlighted benefits of green building as economic, reduced energy consumption, reduced water consumption, cost efficient to run and reduced greenhouse gases. Several benefits of green buildings can be found in the literature of (Kats, 2003, 2006, 2010; Kats et.al, 2003; Turner Construction, 2005; Madew, 2006; Ries et.al, 2006; Davis Langdon, 2007; Bowman and Wills, 2008; McGraw-Hill Construction, 2008; Yudelson, 2008; Choi, 2009; Kibert, 2012). These benefits are represented in significant energy and water saving, reduced maintenance cost, increased property value, higher occupant satisfaction, improved productivity, health benefits, and reduced CO₂ and waste emissions. The benefits of adopting green building concept synthesised from the literature are discussed as follows:

- i. **Global Environmental Benefits:** Since buildings use such vast amounts of resources in their operation and since they are made of materials that need to be extricated, processed, and manufactured, it is no wonder that approaching their design in a sustainable way could have global impacts on the environment. Sustainable design offers significant advantages in the areas of energy and water use reduction, air quality improvement, and increased material efficiency.
- **Reduced Energy Consumption:** One goal of sustainable design is to reduce the amount of energy required to cool, heat, and light our buildings. By utilizing passive strategies such as day lighting, thermal mass, and shading, or by utilizing high performance systems, there is significant reduction in energy demand of the mechanical systems. This translates into a reduced need for extricating dwindling fossil fuels and power plant operation.
 - **Reduced Water Consumption:** Most of the Asian countries are water stressed and in country like India, the water table has reduced drastically over the last decade (IGBC, 2012). With water efficient design, green buildings can reduce the amount of water consumption. Efficient landscape and roof designs can also mitigate storm water runoff thereby lessening the burden on our storm and sewer systems. This will positively affect local, regional, and global waterways by reducing pollution and supporting natural watersheds.
 - **Reduced Air Pollution:** Fossil fuel is a slowly depleting resource, world over (IGBC, 2012). There are a number of indirect (relative to buildings) sources of pollution such as vehicle pollution from the transport of building products and the manufacturing of building products. There are also direct

pollutant sources such as HVAC refrigerants and the toxic emissions from our finishes. All of these have impacts on global warming, ozone depletion, and air pollution. Green Building construction and design helps to overcome the problem to some extent.

- **Increased Material Efficiency:** Due to the mining, transportation, and manufacturing processes, using local and natural materials in our buildings has a direct benefit on all three of the above strategies. In addition, utilizing recycled, reclaimed, or salvaged materials can lessen the burden on landfills by reducing the need for dumping.
 - **Handling Household Waste:** Handling of waste in residential buildings is extremely difficult as most of the waste generated is not segregated at source and has a high probability of going to land-fills. This continues to the municipalities which need to be addressed. Green buildings intends to address this by encouraging occupants of green buildings to segregate the household waste (IGBC, 2012).
- ii. **Economic Benefits:** There are some clear economic advantages to sustainable building. Reducing the consumption of energy and water would lessen the financial burden of building operations. In the case of passive heating and cooling systems, this also means a reduction in maintenance costs. And by improving the comfort for buildings' occupants, employee turnover can be reduced. The economic benefits of sustainable design can be realized in the short term, long term, and in the added value projects.
- **Short Term Benefits:** Sustainable buildings can offer immediate savings in the area of utility costs. Whether from reduced electrical energy and water usage, or from reduced cost

of storm water mitigation infrastructure, green buildings have the opportunity to lessen the cost of running utility bills. In addition, buildings with efficient layouts can reduce the cost of building materials and construction waste. Also, if a building utilizes smaller HVAC equipment and relies more on passive strategies for heating and cooling, then the first cost of equipment could be less. There could also be financial incentives from local utility companies for buildings utilizing sustainable design strategies.

- **Long Term Benefits:** Utility cost savings over the long term could pay for possible upfront cost increases. While the payback duration on items like photovoltaic panels is debatable, some other measures may realize quick pay-offs. Passive systems may need little to no ongoing maintenance; therefore a building owner could save on the building operations budget. This translates into the landscape designs as well. Natural landscapes generally require less maintenance than conventional ones. Another benefit is the churn rate. Buildings designed for flexible layouts can reduce the costs of reconfiguration.
- **Added Project Value:** Many owners are now using "Green Design" as a selling point. For leasing or re-selling property, sustainable buildings can attract new audiences and a new market. This could translate into quicker sales and higher rents. In addition, recruiting new employees (and keeping them) can be made easier by offering attractive and healthy facilities in which to work. Studies are showing that employees working in healthy environments work more productively, take less sick days, and tend to remain loyal with the firm.

iii. **Increased Productivity and Health Benefits:** Productivity is an important success factor for all organizations. Improvement in productivity has been recognized to have a major impact on economic

growth and higher standard of living. The direct measurement of increased productivity is ability to monitor things like ability to focus and think, synthesize and add value to the organization, work efficiency and output. Most common indirect measures such as absenteeism, hours worked, tardiness, safety rule violations, number of grievances filed, employee turnover (Kemppila and Lonnqvist, 2003), reduction of number of sick days (Dunckley, 2009) are used to measure productivity. Health and well-being of occupants is the most important aspect of Green buildings (IGBC, 2012). Green Building promotes healthier work environments are much lower source emissions from measures such as better siting and better building materials source controls, better lighting quality including more day lighting, use of shading devices, greater occupancy control over lights levels and less glare, improved thermal comfort and better ventilation and use of measurement and verification, and Carbon di oxide monitoring to ensure better performance of systems such as ventilation, heating and air conditioning. The presence of all these factors in a building reduces illness symptoms, reduced absenteeism and increased productivity.

2.1.7 Building Environmental Assessment Methods

Cole et. al., (2000) define building environmental assessment methods as tools for evaluating building performance with respect to a broad range of environmental considerations, organized into assessment criteria. That is, building environmental assessment methods have emerged as a means to evaluate building performance across a broad range of environmental considerations. There are many assessment systems in different countries. It is hard to say one system is better than the others because they are all designed based on a national background, which includes the limited utilization of these systems (Shi, 2008).

Ratings are largely voluntary schemes that are expected to stimulate market and consumer interest in green buildings. In fact, in most regions voluntary building rating schemes have often preceded regulatory mandates and have also helped in defining standards. The green buildings require a complex set

of sustainability criteria related to a wide range of resource and material use. The advantage of the rating system is that it helps to disseminate green building practices outside the realm of regulations that are often impeded by structural and institutional barriers. Green building rating is a practice that has the potential to become the standard. But it needs to be widely understood by building owners, architects, building managers and occupiers to make an effective impact. Ratings help the consumer to compare buildings and make the appropriate choice. This creates incentives for resource efficient buildings that are urgently needed to reduce the resource impacts. Rating is a legitimate way of changing practice and influencing change. It can also be a powerful tool in mainstreaming a large number of green measures that can collectively make the impact(Winter, 2008).

Globally, large numbers of rating tools have evolved in a number of regions that are influencing property markets towards more sustainable practices. They are based on local climates and geographical conditions(Winter, 2008; Elias and Lin, 2015). The predominant ones are:

BREEAM- Building Research Establishment Environmental Assessment Method, which is widely used in the UK.

LEED- Leadership in Energy and Environmental Design, which was developed by the US Green Building Council (USGBC) and used in the US.

Green Star- developed by the Green Building Council of Australia and used in Australia.

CASBEE- Comprehensive Assessment System for Building Environmental Efficiency, which was developed by Japan Sustainable Building Consortium and is used in Japan.

Green Mark- used in Singapore and mandated by the Building and Construction Authority for all new development and retrofit works.

NABERS- National Australian Built Environment Rating System managed by the NSW (New South Wales) Department of Environment and Climate

Change. The only rating system to measure ongoing operational performance.

Green Globes System (GGS)- This environmental assessment and rating system evolved out of BREEAM, which was brought to Canada as BREEAM Canada for Existing Buildings in 1996 and finally became Green Globes.

Hong Kong Building Environmental Assessment Method (HK-BEAM)- developed in 1996 by the BEAM Society.

Several of the prominent green regional programs in the United States are described below.

Austin Energy Green Building Program® was the first green building program and is today the most successful utility-sponsored program in the nation. Its top tier is among the most stringent of all US green home programs, though the program offers three additional tiers at more accessible levels.

Built Green® Colorado was introduced in 1995. The program was created through partnership between the Home Builders Association of Metro Denver (HBA), The Governor's Office of Energy Management and Conservation (OEMC), Xcel Energy, and E-Star Colorado. Built Green® is acclaimed within the industry for its advertising campaigns geared toward both builders and homebuyers.

Earthcraft House™ is a partnership between Southface Energy Institute and the Greater Atlanta Homebuilders Association. Southface adheres to a thorough verification process that requires a visual inspection of each certified home. The National Association of Home Builders named Earthcraft House™ "Green Building Program of the Year" in 2004. In 2005, residential green building standards entered the national stage for the first time with the following programs.

NAHB Model Green Home Building Guidelines developed by the National Association of Homebuilders (NAHB) were released early in 2005. The NAHB announced in Spring 2007 its intention to turn the Guidelines into a national rating system, implemented by local Homebuilder Association chapters. The Guidelines serve as a solid educational piece for builders less familiar with green building concepts. To ensure that builders achieve a balanced, green residence, the NAHB guidelines set Bronze, Silver, and Gold performance levels in each of the major categories (including site, water, energy, and so on). The guidelines heavily emphasize durable construction techniques based on building science research. They target the mainstream builder audience, rather than those in favor of more stringent green home standards. NAHB and the International Code Council (ICC) announced in February 2007 their intention to jointly develop an American National Standard for residential green building based on the NAHB Model Green home Building Guidelines, a major development in the US green housing scene.

LEED for Homes™, currently in pilot phase, represents the US Green Building Council's (USGBC) first Leadership in Energy and Environmental Design (LEED) product focused on residential buildings. LEED for Homes targets the top 25 percent of homes with best-practice environmental features. Usually these are built by builders who have already mastered whole-house energy performance at ENERGY STAR Labelled Home levels (a prerequisite of LEED for Homes) and are interested in raising the bar in other areas of sustainability, including water conservation, indoor environmental quality, and materials selection. In addition to meeting all mandatory requirements, builders select from a list of optional credits to earn points toward a Certified, Silver, Gold, or Platinum rating. LEED for Homes can be applied to a range of housing types, from single-family residences to mid-rise multi-family buildings. As of June 2007, 393 builders around the country had enrolled approximately 6,300 housing units in the green building program, and 220 housing units had been officially certified.

The green rating systems followed in India are:

LEED India- administered by the Indian Green Building Council (IGBC). According to IGBC, 2012, The LEED rating system, developed by the USGBC, is a recognised and popular international green rating system. It has been adopted by the IGBC to suit Indian green building requirements. This is purely a private initiative which is run by the Indian Green Building Council (IGBC) in India. The IGBC, which is part of the Confederation of Indian Industries - Sohrabji Godrej Green Business Centre (CII-GBC), has been promoting Leadership in Energy and Environmental Design (LEED) now for a decade. According to IGBC website, LEED India works on a whole-building approach to sustainability by recognizing performance in the five key areas namely sustainable site development, water savings, energy efficiency, materials selection and, indoor environmental quality. LEED-INDIA programme includes LEED India for New Construction (LEED India NC) and LEED India for Core and Shell (LEED India CS). Core and Shell buildings are those where the owners or developers do not control all aspects of the building's design and construction. These are leased or rented spaces, for example an IT park. IGBC also has its own set of ratings for homes, townships, SEZ, green factory buildings and green landscapes. The system is designed to be comprehensive in scope and simple in operation.

There are credits for each criterion under the broad categories. These criteria credits are earned by addressing the specific environmental impact in design and construction. Different levels of green building certification are awarded based on the total credits earned. A total of up to 61 credits can be earned. The credit requirement for different levels of rating is as follows:

Ratings	Credit points
LEED certified	23-27
LEED Silver	28-33
LEED Gold	34-44
LEED Platinum	45-61

The number of points needed to achieve a specific LEED certification rating is the same across rating systems, but the credit prerequisites and categories for points vary by the rating system. The number of points awarded for a specific credit is determined on the basis of the relative importance of the building related environmental impact that a specific credit addresses. For each credit, two or more options for fulfilling the credit requirements are typically given in the rating system reference guide along with potential technologies and strategies.

LEED Rating and Certification Process

A formal application review is initiated once the completed application has been received, with slightly different application review processes for each rating system and review path. In general, a preliminary review is first conducted in which all documentation are examined for completeness and forms are designated as “approved” or “not approved”. Each prerequisite and credit is also reviewed and designated as “anticipated”, “pending”, or “denied” and accompanied with technical advice from the review team. Once the preliminary review has been completed, the project team may either accept the results as final or choose to submit a response with additional documentation for an optional final review. After the final review process has been concluded, the project team can either accept or appeal the final decision within 25 days and with additional appeal fees. If certified, the LEED certified project receives a formal certification of recognition and information on how to order additional marketing material. The project team also has the option to have the project listed in the online LEED project directory and the U.S. Department of Energy’s High Performance Building Database. For the LEED for Existing Building Operations and Maintenance rating, projects can apply for recertification as frequently as every year but must be recertified at least once every five years.

TERI-GRIHA Rating System

According to GRIHA, (2015), the alternative system that soon followed LEED rating system is the Green Rating for Integrated Habitat Assessment (GRIHA) which has been conceived by the The Energy and Resources Institute (TERI) and jointly developed by Ministry of New and Renewable Energy (MNRE) as the national rating system for buildings. GRIHA was adopted as the National Rating System (NRS) under the MNRE, as of 1 November 2007. It is a green building 'design evaluation system', and is suitable for all kinds of buildings in different climatic zones of the country. TERI's green rating system GRIHA (Green Rating for Integrated Habitat Assessment) has been developed as an instrumental tool to evaluate and rate the environmental performance of a building. GRIHA attempts to quantify aspects such as energy consumption, waste generation, renewable energy adoption, etc. so as to manage, control and optimise the same to the best possible extent. It is a 100 point system with a set of 34 criteria of which some are mandatory. Minimum qualifying score is 50 and rating given in 1 – 5 stars, 1 star for every 10 points over 50. The rating can be applied to new and existing buildings of various uses. The rating system is based on national and international energy and environmental principles. The guidelines or criteria appraisal will be revised every three years to take into account the latest scientific developments during this period.

GRIHA has derived inputs from the codes and guidelines developed by the Bureau of Energy Efficiency, the Ministry of Non-Conventional Energy Sources, MoEF (Ministry of Environment and Forest), Government of India, The Bureau of Indian Standards. The rating system aims to achieve efficient resource utilization, enhanced resource efficiency, and better quality of life the buildings.

GRIHA Rating and Certification Process

According to The Energy and Resource Institute and GRIHA Council, 2015 following is the process of rating and certification process:

Master plan Rating: It includes step by step process of Registration of the project, Half day workshop for the project team, Access to online documentation tool, Receipt of completed documentation by GRIHA Council, Review of documentation by GRIHA Council and comments sent to Project team, Receipt of revised documentation by GRIHA Council, Documentation sent to External Evaluators by GRIHA Council, Comments of External Evaluators forwarded to Project team, Revised documentation from Project team shared with External Evaluators, Master plan rating awarded by GRIHA Council based on points and feedback of External Evaluators

Rating of Each Phase: The following steps followed for rating of each phase starts from Registration of the project phase (First phase would be registered with Master plan rating), Half day workshop for the project team (Workshop of First phase and Master plan Stage would be done together at Master plan Rating stage), Access to online documentation tool, GRIHA Council to conduct 3 site visits to the site during the course of the construction of the phase, Receipt of completed documentation by GRIHA Council, Review of documentation by GRIHA Council and comments sent to Project team, Receipt of revised documentation by GRIHA Council, Documentation sent to External Evaluators by GRIHA Council, Comments of External Evaluators forwarded to Project team, Revised documentation from Project team shared with External Evaluators, Master plan rating awarded by GRIHA Council based on points and feedback of External Evaluators

Both GRIHA and LEED-INDIA are operating at the national level. Both these ratings have a checklist of criteria and points that are assigned to these criteria based on their relative importance. Demand for voluntary rating is still

very small and nascent in India. Though the two rating system are around for a while – LEED since 2001 and GRIHA effectively since 2007, – the number of buildings that have come forward to get rated is a small drop in the ocean. The total number of buildings registered with GRIHA is 179 and that with LEED is 1505. The number of buildings actually rated is still much smaller – 8 for GRIHA and 223 under IGBC. It is clear that the Indian building sector has yet to warm up to the voluntary rating system.

2.1.8 Misconceptions regarding Green Buildings

Green Building is a relatively new idea, so there are quite a few misconceptions that keep people from pursuing the development of a green building or home. They are listed as below:

Green Building is a Fad: The upcoming generation of homebuyers is more concerned about their carbon footprint than any previous generation. The debate over climate change continues and industry experts expect more regulatory stipulations on building materials and methods. Consumers will always look for ways to save on energy cost, regardless of whether the fuel is nuclear energy, coal-fired plants or natural gas. Green Building strives to be healthier for human habitation while releasing fewer pollutants and using fewer fossil fuels. Focusing attention on renewable resources will help to build a strong, sustainable society that can be around for hundreds or thousands of years from now. The concept of green construction is not going away. Being informed of all available options and methods is the best approach to stay current with the every changing market. Green Building is better for the planet and better for the prosperity. It's not a fad, it's a way of responsibly maintaining our environment and a high quality of life.⁴

Green buildings are expensive: There are some additional costs during the construction phase of building green. But the operational and maintenance cost of a green-built home are significantly less. A building designed with passive solar and high-efficiency windows require less

energy to heat and cool, less workload on units also results in lower repair cost and a more years of service. Green buildings use up less materials and are built better so they have higher value and will not need constant replacement of costly materials. Factors that affect building cost are the level of green materials and technology that is incorporated in the building. Other factors may be the sustainable practices and methods that builder will adopt.⁴The additional upfront cost of green construction is typically recouped within the first five years of ownership through lower maintenance and energy cost.⁵Energy savings alone outweigh the initial cost premium in most green buildings (Good Energies, 2008).

Green building is all about landscaping: While this may not be entirely wrong, landscaping is only a part of the whole green building concept. Integrating landscaping in site development provides shading for homes and buildings to help reduce energy. Plants inside homes and offices can help reduce carbon dioxide, thus improving indoor air quality. Large open green spaces help reduce urban heat island effect caused by too much concrete surfaces. This misconception is probably common due to the constant advertisement of realtors and developers showing a lot of green space, thus giving the impression that green building is all about landscaping.⁵

To be truly green, buildings need solar energy: There are basically two ways to approach the design of green buildings. The first is through passive design which simply means making the building energy-efficient and thermally comfortable without the use of mechanical or electrical systems. The second way, after incorporating passive means, is through active design which means the addition of electrical and mechanical systems to complete the building. Many people are so captivated by the idea of getting energy from solar panels that if a building does not have this feature it is not green. Following this argument, then, the most inefficiently designed building can be made 'green' simply by installing solar panels. The right approach is passive design first, then active design next.⁵

The green concept is not for old buildings and homes: On the contrary, old buildings and homes would benefit from the green building concept. By maintaining or preserving old structures, a large amount of embodied energy can be saved. Embodied energy means the energy required for the extraction, production or manufacture, transport, construction and disposal of building materials. Old buildings, retrofitted or renovated help the environment by minimizing the need for producing new building materials that require expensive energy to produce. It also means fewer materials disposed in landfills.⁵

Green homes are less appealing: The components used in green construction are engineered to last longer and require less maintenance. Building green also involves leaving more trees on the lots and less modification to terrain. When sustainability and environmental considerations are implemented in the design of a home, the result is a more harmonious and comfortable design that blends with its surroundings.⁶

Green Building is just about “Saving the Environment”: Various green building rating tools have various approach on their definition of ‘green’, but it is not distinctively different as they all share the similar fundamentals. All the rating tools share the same principal of energy usage reduction, water usage reduction, minimizing construction materials waste, good indoor working environment, sustainable site management and also innovation segment where credits the unique strategy of different projects in achieving ‘green’.⁵

Green Building is just about the Green Design of the Building/Project: The approach of green building is definitely more than the building on its own. It is beyond merely packing in green features into a building and expecting it to work universally. What matters most of a green building isn’t what is built but how it operates, and this is easily fated by how well the design team understands the functionality of their design

feature. Various office work culture will potentially affect building design outcome.⁶ So it is certainly more than the design itself to determine the performance of the green building.

Going Green ‘dictates’ the Design of the Project: Going Green holistically improvise the design of the project instead, in respect to the problem solving skill of the design team. Instead, going ‘green’ facilitates the design of the project. Aesthetic has its limit to be played with. Architect has to be true to themselves and professional in participating the aspiration for a better built environment by holistic means, not purely aesthetic. A pyramid shape building with huge clear windows in the window (for example) may look aesthetically nice but yet it’s non-functional as it doesn’t provide thermal and visual comfort.⁵

Corbett (2012) a green educator mentioned and cleared some misconceptions small business owners might have about going green.

The only reason to go green is to save or make money: Business owners tend to overlook the benefits that going green can have beyond the bottom line especially when it comes to attracting young talent. Young people want to work in a green, healthy office, especially ones that are designed differently to allow for collaboration. “Builders and office space designers that work with businesses recognize that green and energy efficient building and layouts are important because natural light and open layouts allow for employees to be more productive, happier and healthier.”

2.1.9 Drivers to Green Building Construction

Bond and Perrett (2012) ranked the drivers that lead green real estate development, tenant satisfaction and productivity was ranked the highest followed by superior building performance, rising energy costs, competitive advantage, lower lifecycle costs, industry rating systems, government policy, building code, education and awareness and availability of green products.

Morri and Soffietti (2013) found that higher green premium in green building investment is due to factors viz. cost saving, high occupancy rate, cap rate reduction, and green labelling. Usman and Gidado (2015) pointed economic, social, technological and cultural factors as drivers for green building adoption. Some of the drivers to green building construction mentioned by various authors are presented here:

- i. **Consumer Demand:** It indicated that “doing the right thing” was the primary motivator for interest in green building, but consumer demand was the primary trigger for translating those motivations into action. Soaring gas prices, extreme weather, crippling power outages and mounting scientific evidence of the harmful effects of greenhouse gas emissions have raised public awareness and concern about the environment and the long-term effects of economic growth and development. More companies are beginning to embrace the benefits of sustainable design and construction.
- ii. **Energy Cost Increase:** Consumers cited energy cost increases as the primary driver for seeking out energy efficient green homes. The net cost of home ownership of a green home over time is lower due to savings from energy and utility bills as well as decreased maintenance costs.
- iii. **Superior Building Performance:** It results from durable, healthy green homes which was a significant driver to increased residential green building.
- iv. **Positive Publicity:** Green homebuyers feel substantially happier with their homes than other homebuyers, and green home builders receive positive publicity and perceived competitive advantages over conventional builders.
- v. **Incentives:** Consumers and builders both receive financial incentives. While incentives for high performing homes have typically been

energy-based and funded by utilities or tax credits, municipalities are starting to offer incentives for compliance with local green home standards. Some utility and technology-based organizations are providing grant money to support green building in affordable housing projects.

- vi. **Codes and Regulations:** They are another significant driver. Many of the countries have adopted sustainability through regulation with its stringent energy code. Many other municipalities are actively investigating the adoption of mandatory green home standards.
- vii. **Green Certification Programs:** In the commercial sector, green certification programs are largest trigger to green building (McGraw-Hill Construction, 2005). Regardless, the number of green home programs started by utilities, homebuilder associations, environmental organizations, and municipal groups continues to grow. Builders operating in multiple markets or those builders who are confused by competing regional green home certification brands may find that the relatively new national certification programs are better able to serve their needs.
- viii. **Lending Industry:** The lending industry has an important role to play in promoting green home building and, institutions have been slow to embrace this concept of packaged mortgages for buildings that meet specific energy use and environmental benchmarks. Some financial institutions offer creative incentive products for green building, including lower-rate mortgages. The Federal Housing Administration (FHA) now offers a program for borrowers to purchase new energy-efficient homes or to make upgrades that improve the efficiency of existing homes by including additional costs of green features into the mortgages when they can provide evidence that the improvements will lead to energy savings.

With heightened public awareness and concern about global warming and ongoing increase in energy costs, Green Buildings have gained mainstream acceptance. Smith, (2007) gave some more drivers to the development of Green Buildings. They are as follows:

- ix. **It's Easy Becoming Green:** While developing and retrofitting buildings to green standards still pose many challenges, it's getting easier and cheaper to build green. This presupposes, however, that the decision to build green is given forethought and fully incorporated into the design process.
- x. **Risk Management:** As the market share of green buildings increases and sustainable development becomes more mainstream, owners of non-green buildings could face increased risks on several fronts. The most obvious market risk could be the functional obsolescence of a non-green building in an increasingly green world. One can certainly envision a day when the green standing of a building will be one of the dimensions that distinguishes Class-A from Class-B space. Because retrofitting existing buildings to green standards is almost always more complicated and more costly than new green development, capital expenditures (and cap rates) for non-green buildings could be much higher.

2.1.10 Barriers and Challenges in implementing Green Buildings Concept

The major barrier or challenges to implement green building concept were discussed by Choi (2009); Issa, Rankin and Christian (2010); Zhang, Platten and Shen (2011). They identified high initial cost of construction and lack of communication as barriers for implementing green building concept. Hamidi (2010) pointed out lack of green expertise to initiate green design strategy from early stages of building design and planning. The slow recovery of long term cost saving hinders the progression of green building development as identified by Issa et.al. (2010). Yoke (2011) found that there is no significant

enforcement in applying green standards in green building construction as a barrier. With recent drive initiated by private and government stakeholders, green building development is expected to pick up momentum in India. But the implementation of this concept has so many hurdles in its path (Winter, 2008). Some of the barriers as stated by various authors are listed and discussed as below:

- i. **Higher perceived First Cost:** The most significant barrier to residential green building most cited by industry professionals and the public is higher perceived first cost. The added cost of incorporating green building features into residential projects depends largely on local factors such as climate, local building customs, and labor skill levels. The up-front costs may discourage investment, particularly where the benefits are long-term or are externalised beyond the individual organisation making the investment (Saunders and Schneider, 2000). Homebuyers in India, are still quite averse to pay an extra premium (Times of India, 2015).
- ii. **Lack of Knowledge:** Another barrier to residential green building is a lack of knowledge, including biases in perception, apathy, and lack of understanding about benefits of green residential building. This lack of knowledge appears pervasive at all levels of the industry, including lenders, realtors, builders, general contractors, home inspectors, buyers, suppliers, and regulatory officials (United Nation Environment program, 2010).
- iii. **Lack of Widely used Standards:** The third major challenge to green residential design and construction is the lack of widely used standards to consistently define criteria for a “green” product, service, or building. While some standards have emerged for specific product categories (such as the Carpet and Rug Institute’s Green Label Plus criteria for chemical content or the Green Seal limits for volatile organic compounds in paints), builders and consumers cite concerns over “green washing” as an obstacle to evaluating products or residences marketed as green.

With over 80 different regional green home rating systems operating in the United States, some builders imply that confusion over which standard to follow, or the difficulty in adhering to different local programs in multiple markets, is a deterrent from undertaking green building.

- iv. **Scarcity of Products and Expertise:** A fourth barrier to more widespread green housing design and construction is the scarcity of products and expertise. While environmentally preferable products and high performance residential equipment and systems are increasingly available at the national level, many markets are still underserved by manufacturers of green products and by industry professionals knowledgeable in green means and methods. Even where products or personnel are available, the lead times can be extraordinary, as demand for green outstrips the supply capacity.
- v. **Lack of Implementation of Energy Conservation Building Code (ECBC):** Implementation of Energy Conservation Building Code (ECBC) is the first and the foremost requirement. Till now, ECBC is currently voluntary, but in the future, either the central or state governments should decide to adopt it as a mandatory standard. No states have adopted it yet. Bureau of Energy Efficiency (BEE) is working closely with national and state-level government agencies to promote ECBC. Once ECBC becomes mandatory at either the central or state level, one can assume that the implementation and enforcement approach will be similar to that employed for other mandatory building codes.
- vi. **Lack of Seriousness and Leadership:** All these initiatives towards conservation measures taken by the government remained as an appendix to the long term energy policy. All the measures which taken were reactive to certain events, not proactive by nature. Moreover, even after three years of its formation, BEE remained almost non operational. Until September 2005, it did not even have a full time head. A more mobility is needed from administration side so that long term goal of India as an energy efficient, developed economic giant can be traced on realistic grounds even if in short term we have to pay for it.

- vii. **Awareness for Global Marketing Needs:** Signs of improvement in the energy intensity figures were only observed with the opening up of the economy during the last one and half decades. Increased competition both at home and abroad, has compelled the business leaders to look into alternative options to save energy cost. In this new century, when most of the industries were gearing up to boost exports, they realized that the cost of energy was robbing off their competitive edge in the international market. In India, the cost of power has escalated three fold in the last ten years. This probably can explain better why the green buildings which are estimated to reduce energy cost by 40% are likely to be the fighting front in the global markets.
- viii. **Addressing with Economics Perspective:** It was recently observed that, to minimize environmental impacts by significant orders of magnitude requires the blending of good engineering with good economics as well as changing consumer preferences. Recent experiences, provides a valuable lesson on how to avoid the common pitfall of “green buildings myopia”. While noble, the benefits of the concept appealed to only the deepest green niche of consumers. In practice, green appeals are not likely to attract mainstream consumers unless they also offer a desirable benefit, such as cost-savings or improved product performance.
- ix. **Risk and Uncertainty:** Although investments and interest in green building are growing rapidly, a number of complex and varied reasons, financial case for green building has not yet firmly taken hold in real estate and development community. There are many risks that exist in real estate community regarding green building. They are as follows:
- Uncertainty over reliability of green building technologies
 - Uncertainty over costs of developing green real estate
 - Uncertainty about the economic benefits of green real estate
 - Uncertainty about green building performance over time

- x. **Lack of Experienced Workforce:** Another main problem which is faced by India in implementing and making the customers accept the concept of green building is lack of experienced workforce. India is lacking in having many experienced consultants in the area of green building who is well explored in the literature and research in the rapid growing industry. Expansion in this industry is threatened by lack of experience workforce. It increases more risk of inexperienced and untrained service providers entering the green building market in search of a premium on their services.
- xi. **Multi Dwelling Homes:** These kinds of homes where collective decision making the necessary pose a particular challenge to green building refurbishment (Golove and Eto, 1996).
- xii. **Lack of Effective Enforcement of Policies:** It was reported in United Nations Environment program(2010) that there was lack of effective enforcement of policies by the government was found as one of the great barrier.
- xiii. **Lack of Financial Incentives:** Due to lack of financial incentives was faced as barrier as reported by United nations Environment program (2010).
- xiv. **Resistance to change:** This is a natural human tendency and not unique to the green building movement. People are reluctant to change old habits and ways of thinking. Just because green buildings seems “new” at the moment, it doesn’t mean everyone is going to jump on the bandwagon in the near future (Prouty and Glover, 2010).
- xv. **Process of certification:** Those working in green building industry think that the LEED process is very time consuming and bureaucratic. Sometimes the builders want to build green but are turned off by the LEED system (Prouty and Glover, 2010).

Development of green building can be expected to increase, if the construction cost could be reduced and the benefits be increased. The drivers influencing demand and supply of green buildings are still being developed and further research is required on the beneficial characteristics of these buildings (Lutzkendorf and Lorenz, 2007). A comprehensive efforts should be made through raising public awareness and by government agencies in providing green incentives and regulatory policies to ensure a steadily increasing demand, improved functionality and quality of green buildings (Isa et.al., 2015).

2.1.11 Retrofitting: Going Green in Existing Building

Retrofitting refers to the addition of new technology or feature to older systems to make the building green or environment friendly. The concept of retrofitting of buildings is new activity for most structural engineers. The retrofitting of a building requires an appreciation for the technical, economic and the social aspect of the issue in hand. Changes in construction technologies and innovation in retrofits technologies present added challenge to engineers in selecting a technically, economically and socially acceptable solution (Moe and Simon, 1999). This technology is often the best solution, and that means everything from more efficient appliances and lights to vegetative surfaces on the roof and even walls to renewable on-site energy generation and water systems (Carter, 2008).

In the commercial building sector everyone knows about the benefits of reducing energy usage and increasing efficiency, the number of energy efficiency retrofits is growing. Plenty of attention is paid to the construction of highly efficient green buildings, the reality is that the vast majority of buildings are already built- and many are hugely inefficient. Since buildings typically have a long lifespan, often 50-100 years, they continuously consume energy and are therefore responsible for large amounts of CO₂ emissions over their life span. Given these dynamics, it can be concluded that the market for green

retrofits will grow strongly, particularly as the concept of green building continues to move into the mainstream. Volatile energy prices, government mandates/incentives, and rising demand from building owners and tenants are the primary driving forces behind making existing building greener. As the green building retrofit market expands, energy efficient solutions (including both products and services) will represent the single largest opportunity for companies. Because energy costs represent the single largest expense for building property owners, there is usually a high degree of motivation to undertake a green retrofit. Still there are other motivations that can come into play when property owners decide to begin a green retrofit project. The other factors include expectation for increased property value, reduced time to lease retrofitted space, higher building occupancy, higher rents, and general environmental and social reasons(Prouty and Glover, 2010).Because many existing buildings will remain in use, it also requires retrofitting existing buildings with energy efficient and renewable technologies (ILO, 2011).

Kavani and Pathak (2014) have given certain points of retrofitting and some additional points have noted by the researcher. The following recommendations can be implemented to retrofit the existing Building.

Site Selection: In order to reduce heat island effect the shade should be provided on at least 30% of non-roof impervious surfaces on the site, including parking lots, walkways, plazas, etc. Open-grid pavement system for a minimum of 50% of the parking lot area should be used. Painting roof tops with white paint and plantation on roofs are some of the other ways of reducing heat island effect. The existing and mature trees should be preserved. They provide excellent shading in walkways, parking areas as well as on the walls of the house. They are also reservoir of fresh oxygen and keep the surrounding cool. Organic manure should be used for the plants. Bonsai, vertical gardens, terrariums and terrace garden are some of the techniques for growing indoor plants where there is lack of space (Times of India, 2015). Measures to reduce soil erosion should be adopted such as permanent and temporary seeding, mulching etc. The open available area should be landscaped.

Water Efficiency: The rainwater collected on the terrace is let to runoff and drain into the drainage pipeline. This water can be diverted to the garden and to the toilets through a suitable system of pipelines. Rainwater pipes from the terrace can be connected into the overhead tank above the toilet for storage of water. The overhead tanks are already designed for enough capacity. The leaking faucets and pipes in the toilets, wash areas and laboratories should be repaired immediately. Also select low flow shower, water closet, Urinals and wash basin. A sewage treatment plant should be installed and the treated water can be reused for landscaping. Efficient irrigation methods such as Drip Irrigation, Sprinklers, and Porous pipes should be installed. Water level controller should be installed in the overhead and underground water tanks. Plant those trees and plants that require less water for their growth.

Energy Efficiency: In order to reduce the energy loads, install solar water heating systems in the house. Solar panels should be installed as per the conditions and suitability of the site along with the current rates of solar panels for generating power. Replace conventional tube lights with LEDs, T5 or T8 tube lights or CFLs. Install BEE rated and CFC free equipments. Use solar reflective paints on the exterior walls which reduces the inside temperature.

Material Selection: After the building is already constructed, construction waste produced will only be that from the repair or renovation work and also alteration work if any. Such waste materials or the leftover construction materials should be reused if possible or sent to a recycling plant. These wastes are utilized in the filling of plinths in the various construction projects going on in campus. Separate the household waste which can be recycled and reused. These wastes can be used to produce bio gas also.

Indoor Environment Quality: Exhaust fans and turbo ventilators should be installed for effective ventilation. Low VOC paints should be used to on interior walls of the house.

2.2 Related Researches

The research studies were grouped under the following heads. The researchers conducted within and outside India are presented together.

2.2.1 Building Materials

Singh(2006) carried out the research on organic building materials in residential construction with the objectives to find out the extent of use of organic building materials in residential construction, to assess problems experienced in care and maintenance in the selected residential construction, to find out the health problems perceived by the residents due to use of organic building materials, to ascertain the knowledge and satisfaction level of residents regarding organic building materials and to assess level of human performance in the selected residential buildings with organic building material construction. Multistage purposive cum random sampling design was used to select 200 residential buildings in Uttaranchal. The findings revealed that wood was the mostly used organic building material in all the areas of the house in the hilly areas. Care and maintenance of the house required a lot of time, energy and money. Roofs and walls required least maintenance and floor required the utmost care, cleaning and maintenance. Deformity in walls, dampness, flaking off, dust release, termite and heating up were the problems experienced in the selected houses. Lethargy, fatigue and symptoms of humidified fever were the main health symptoms reported by the respondents. Most of them showed low level of knowledge regarding organic building materials used in their houses. Regarding satisfaction, organic building materials were ranked first on safety and care and maintenance. The poorer concentration level was shown by the respondents living in non-wooden houses than the wooden houses. The level of fatigue was reflected more by the respondents living in non-wooden houses. The percentage increase in temperature from outdoor to indoor environment was more in non-wooden houses than the wooden houses.

Elattar and Ahmed(2014)evaluated the green building material system in Egypt and proposed methodology to evaluate materials in the Egyptian environment by analysing green building material's rating systems to achieve the requirements of green buildings. It was concluded that material rating systems help the designer to choose the right materials, draft of green pyramid rating system in Egypt ignores some important elements, such as the reuse of materials, so it has to be developed. It was also found that all rating systems have points to evaluate the use of local materials, indicating its importance.

Wahi (2014)conducted a study on status of green building materials, aimed at finding out the usage, acceptability and awareness of green building materials among building professionals and promotional strategies used by the company's manufacturing these materials. The study also took into account the hindrance and catalysts faced by building professionals while using green building materials. For the study 30 building professionals (architects/builders/civil engineers/green building consultants) who were using green building materials in NCR, Delhi was interviewed. In addition, marketing heads executives of ten companies manufacturing green building materials were interviewed in order to understand the promotional strategies used by them and how useful these strategies had proven for them. It was found that fly ash based materials (fly ash bricks, blocks, AAC blocks, PPC) were most commonly used by the professionals as compared to other materials as these materials were easy to procure at competitive price. Insulation materials, FSC certified wood, salvaged wood and straw board, because of their high prices and low availability were not in much use and were found to be preferred by those professionals whose projects were going for LEED/GRIHA rating. The study showed that availability of some green building materials like FSC certified wood, straw board, insulation materials, pre-fabricated materials was less as compared to conventional building materials because of less demand, less number of manufacturers and high cost. Also, one of the reasons was difficulty in getting these materials in the required form. Delivery time was found to be more in case of green building materials due to less number of manufacturers as compared to conventional building materials and location of

the dealers and manufacturers. It was also found that the major catalyst behind using green building materials was reduced environmental impacts and gaining large number of points in LEED/GRIHA certification. As far as hindrances were concerned they were increase in project cost and limited availability of green building materials. The study also provided suggestions to overcome these hindrances which include mandatory usage of green building materials in all new construction, more incentives for building professionals and manufacturers which will encourage more number of manufacturers to manufacture these materials and bring down their cost.

Mokal et.al.(2015) studied features of all construction material which are socially and economically benefits for construction industry and human health. Green building materials such as lime, sand lime bricks, eco-friendly bricks, coloured lime plaster and reflectasol glass reduces side effect on environment by decreasing the environmental pollution content and health hazards arising with the use of conventional building materials. Lime reduces the internal temperature of a room by 4 to 5° as compared to cement as well as its manufacturing uses less energy as compared to cement production. The compressive strength of sand lime bricks was more as compared to conventional bricks. Similarly eco-friendly tile uses less energy in its manufacturing and are locally available. Coloured lime plaster requires zero maintenance as compared to cement plastering and paint work, is water proof and odourless. Reflectasol glass reduces the amount of heat transfer in the room. Hence a need was focused on the use of these eco-friendly materials for the better tomorrow and health life of coming generation.

2.2.2 Energy Efficiency in Green Buildings

Mayer(2007)carried out a study aimed to perform a payback period analysis on options to make a home more energy efficient. The study examined photovoltaic, appliances, solar hot water, geothermal heat, windows and insulation to determine which version of each was the most efficient and cost effective. For determining the heating load of the house, the energy lost due to each of the three components: the walls, the ceilings and windows were

calculated. In case of insulation payback period a derived formula was used to compute the energy lost per hour and cost benefits analysis was done for appliances and photovoltaic. For insulation low e – glass with argon should be used, other options include using 2×6 cellulose wall and cellulose insulation in the ceiling. The study concluded that photovoltaic is not feasible in the short run. However, given their entire lifespan they would pay for themselves. In case of appliances like ceiling fans, lighting fixtures, etc. the payback period is 3 years, for washing machines, etc it is 5 years, for computer, copiers etc. payback period is less than one year. In case of solar water heaters, while flat plate collectors are slightly less expensive than the evacuated tube ones, but the former have a better chance of reaching the ideal 75% efficiency. The study concluded that majority of these technologies are feasible. The exceptions to this are Icynene insulation and photovoltaic panels which require additional subsidies in order to become affordable in residential building.

A study was conducted by **Mittal(2009)** on Energy efficient buildings features in hotels of Delhi to assess the extent of energy and water conservation measures adopted in the hotels, which are the largest consumers of these resources. Audit of 5 hotels in New Delhi was carried out to gain insight into the energy efficient features installed and compare them. Seventy five employees formed a part of the sample to understand their awareness levels regarding energy efficient practices followed in their respective hotels. The findings revealed that many energy efficient features were installed in all five hotels. All the hotels had efficient HVAC systems with variable speed drive. They also had separate window and split air conditioning units for office use. However, none of the equipments used in any of the buildings was energy star rated. Well protected building envelopes through proper thermal insulation, water proofing, light coloured external walls, fixed windows and shading devices on windows ensured comfort to the guests and occupants. All the hotels used energy savers in their lighting fixtures through CFLs, T5 lamps and LEDs, lighting dimmers and lighting timers. ITC was the only buildings with occupancy sensors in all guest rooms and solar panels for external lighting. All the hotels used energy efficient equipments like washers

and dryers in their laundry units except The Maidens, which outsourced its laundry. However, Maidens was the only hotel to have installed a solar water heater to reduce power load. For water conservation, sensor based urinals, and single and dual used flush toilets with reduction in water flow were used. Rainwater Harvesting system, effluent treatment plant for treating kitchen and laundry wastewater were installed in all the hotels. ITC Maurya received the highest score on the checklist used to assess the energy efficient and water efficient features in the hotels.

O'Mara and Bates(2012)in their research study made an effort to study the reasons for investing in high performance green buildings. The reasons highlighted the need to reduce climate change, to ensure energy crises and reliability, to mitigate risk of energy price volatility and supply security and to meet energy efficiency and sustainability regulations, incentives etc. Further it revealed two facts; firstly, intelligent tools and processes at the design phase facilitate successful integrated design/ build outcomes and secondly, ongoing monitoring, analysis and improvements drive sustained performance. It was suggested that smart buildings should be connected with smart grid thus allowing two-way energy flow between the grid and load (building) thereby, distributing energy intelligently across a region to manage the load better. The research highlighted the necessity and added benefits of green buildings whether offices or homes. With the advancing need developers are coming up with new projects on Green Buildings. IGBC is formulating the required guidelines e.g. IGBC Green Homes Rating System or 'to be launched' IGBC Landscaping Rating System.

Bhutia et. al. (2014) designed Photovoltaic Module using MATLAB simulink for Green building installation. It measures the current and voltage and can be interfaced directly with any power electronics or inverter. It can be installed on roof top to generate power for residential and commercial Green buildings.

Khosla and Singh(2014) undertook a study for the newly constructed and existing buildings in order to assess its potential and capacity to save energy. Various energy saving concepts which can be incorporated at the time of

planning, designing, construction and execution stage to have energy efficiency in building keeping in mind the cost perspective are discussed in the study. For this some green buildings have been conceptualized incorporating various parameters for energy savings and modelled in the software Autodesk Revit. These buildings were analyzed in Autodesk Green building Studio to assess its energy efficiency, so that various measures could be optimized. Thus, it was concluded that appropriate knowledge and technology is available for creating energy efficient and green buildings but behavioural, organizational and financial barriers need to be overcome for achieving desired results.

Walls covered by vegetation or garden helps to reduce the penetration of heat in the house. This increases the energy efficiency in the building. Some studies concerning vertical garden/ gardening have been reported here.

Wong, 2009 carried out a research on thermal evaluation of vertical greenery systems for building walls. The 8 different vertical greenery systems (VGSs) were studied installed in Hort Park to evaluate the thermal impact on the performance of buildings and their immediate environment based on the surface and ambient temperatures. The results reflected the potential thermal benefits of vertical greenery systems in reducing the surface temperature of building facades in the tropical climate, leading to a reduction in the cooling load and energy costs. By limiting the diurnal fluctuation of wall surface temperatures, the lifespan of building facades is prolonged, slowing down wear and tear as well as savings in maintenance cost and replacement of façade parts. The effects of vertical greenery systems on ambient temperature are found to depend on specific vertical greenery systems. Given the preponderance of wall facades in the built environment, the use of vertical greenery systems to cool the ambient temperature in building canyons is promising. Furthermore, air intakes of air-conditioning at a cooler ambient temperature translate into saving in energy cooling load.

Bjerre, 2011 conducted a research on green walls with an objective to find out the need to build green walls. It was found that living walls are inspired by nature, the diverse benefits attributed to the structures, and functions of vertical gardens such as their capacity to absorb and degrade greenhouse gases, their cooling effect on buildings, their possible use as an kitchen garden. Finally it was found that possible evolutions of vertical garden in the food production in cities and their contribution towards tomorrow's architecture. This helped to understand the green wall as a useful new technology with a bright future.

Shiah, 2011 carried out a research on the application of vertical garden at the new SUB Atrium with an objective to see after assessment of social, environmental and economic impacts of vertical garden on the new SUB at the University of British Columbia. It was concluded that the vertical garden is beneficial in social, environmental and economic aspects. The vertical garden implemented at the New SUB will inspire UBC students and visitors by the green features of the vertical garden. The benefits of installing vertical garden will motivate to apply the concept. Consequently, more vertical gardens will help in achieving the goal of improving the environment.

Pavasiya, 2014 aimed at the designing of the vertical garden for the residence of Vadodara city. For the purpose 33 residences were selected purposively who had vertical garden and 30 architects and 30 interior designers were selected through convenience sampling technique. The findings revealed that the homeowners and interior designers had high extent of awareness regarding vertical garden whereas the architects had moderate extent of awareness. Majority of the homeowners experienced moderate extent of problems in using vertical garden. A Residential vertical garden was proposed as per the findings and climatic conditions of the Vadodara city.

2.2.3 Green Building rating Systems

A study conducted in **2002** by the **National Association of Home Builders (NAHB) Research Center** identified and analyzed 26 residential green

building programs throughout the country (NAHB, 2002). The NAHB wanted to focus on residential building, and so deliberately excluded commercial green building programs. The study divided each program into categories, summarizing the rating structure, certification method, level of certification, year of inception, number of builders, incentives offered, and number of homes constructed to date. Homebuilders associations administered the majority of programs, leaving only five that were city- or county run. Also, not a single one was a state wide program. While the focus of this study was mostly on local, residential programs, it can still help complement or supplement a useful framework of criteria by which analysis of state-run programs could be conducted.

Janak(2009) examined three of the most longstanding state-run green building programs in the country: CA, NY, and MN. Through a thorough literature review, in-depth case study of each state, and surveys/interviews of key people involved with the programs, the importance of the subject was established, and the structure, elements, and progress of each program is examined. A primary goal was to provide insight for other states that were looking into, or in the process of, starting their own green building program. It was found that high-level support for the program could be critical in its initial implementation, and that passing legislation was not necessarily superior to issuing an executive order. Accountability was agreed to be a crucial component in all three states. It was determined that measuring progress or success is not as simple as counting the number of completed projects, but also involves types of assistance available, level of government support, outcome potential (e.g. long-term building efficiency, performance), etc.

Elmeligy (2014)presented a comparative review to understand the differences in using different types of evaluation systems, particularly in categories of each one, and performance of their impact as applied to sustainability, both from the view point of general information, applicability, certification levels, usability, categories and present a case study as well as a sample of on-line evaluation. It was concluded, although there is a considerable degree of commonality between different rating systems which

was presented in the paper (BREEM, GBCA, GPRS, GRIHA, LEED), in terms of their aims, approach and structure, but there were significant differences in terms of scope of the environmental issues addressed, metrics and performance standards. Thus, it was suggested that it is necessary that the selection of suitable rating system is done according to its categories.

Khanna et. al. (2014) conducted a comparative study on Green building rating programs of U.S. and China. It was found that both the green building rating programs were voluntary but U.S. LEED program is administered by the USGBC, a non-governmental body whereas the China GBEL is administered entirely by central and provincial government agencies. In particular, the LEED rating systems are developed and updated in a consensus-based process through a committee of USGBC members from a diverse array of professional backgrounds, including architects, real estate agents, building owners, lawyers, environmentalists and industry representatives. LEED project registration and certification is then administered by the Green building certification Institute, a third-party organization established with the support of the USGBC to provide independent oversight of professionals credentialing and project certification. On the other hand the development of China GBEL evaluation standards as well as the label application and certification, in contrast, are all administered by government organizations within MOHURD's Building Energy Efficiency and Technology Division. In terms of the scope of the rating systems, the China GBEL program differentiates between residential and public buildings, but does not include rating systems unique to specific building types as LEED does. LEED requires a performance period of only 3 month but China's operational GBL requires 1 year of occupancy and performance for all credits. In addition to differences in the green building rating systems of US and China also faces different barriers and policy landscapes through there are some similarities. In both the countries government bodies that supervise health, fire safety, land and other public operations can be slow to revise codes to accommodate green buildings and the cost more to design and build due to greater system integration and the need for more building controls and measurement points. Lastly in both the countries, the building industry has many established practices that

discourage various stakeholders from trying new or different approaches. It was also found that the subcontractors in the construction process often view green technology as inherently risky and therefore worry about the liability of installing such technologies in project they are ultimately responsible for. The lack of green building professional accreditation process similar to the LEED Accredited Professionals process limits green building workforce capacity development in China. Secondly, financial barriers are perhaps even more pronounced in China than in US. Developers cite higher incremental cost as one of the biggest barrier to investment in green buildings.

Nduka and Sotunbo(2014) conducted a study to assess the awareness status of green building rating systems as well as the most preferred rating system for possible adoption in Nigeria. A structures questionnaire was used to collect information from various respondents who were construction professionals. Random sampling techniques were used to select 150 respondents out of which 91 were used for data analysis. Seven well known green building rating systems and 25 perceived benefits of green building factors were identified from the literature. The results indicated that most of the building industry professionals in Nigeria were familiar with green building rating systems and preferred Leadership in Energy and Environmental Design (LEED) for possible adoption in Nigerian construction projects

2.2.4 Indoor Environment Quality in Green Buildings

Singh et. al.(2010) investigated the effects of improved indoor environmental quality (IEQ) on perceived health and productivity in occupants who moved from conventional to green office buildings. Two cases were studied in which those employees (case 1, n=56; case 2, n=207) were followed who moved from conventional office buildings to LEED rated buildings in Lansing, Michigan. Pre-move and post-move surveys were conducted with web based survey. In two retrospective –prospective case studies it was found that improved IEQ contributed to reductions in perceived absenteeism and affected work hours as a result of perceived improvements in health and well being. The employees also perceived a positive effect of their new work

environment in their productivity. The findings also suggested that perceived improvements in asthma and respiratory allergies could provide 1.75 additional work hours per year to each employee with a medical history of these conditions. Similarly, employees with a medical history of depression or stress might gain 2.02 additional work hours per year because of reductions in their perceived work hours affected by these conditions. Finally, the improvements in perceived productivity were fairly substantial and could result in an additional 38.98 work hours per year for each occupants of a green building.

Kanika(2014)carried out a research on interior environmental assessment of Green Buildings in two districts i.e. Gurgaon and Panchkula for checking the satisfaction level of the occupants of green buildings. It was found that considering all the IEQ data of green and conventional buildings, green buildings were far better than that of conventional buildings in all the IEQ aspects except the humidity level. The noise level in conventional building was less than that of green building. The occupants of green buildings were highly satisfied. There was increase in knowledge of the urban and rural areas respondents after the intervention program.

Allen et. al. (2015) examined the state of evidence on green building design as it specifically relates to indoor environmental quality and human health. Seventeen research studies that specifically focused on exploring relationships between green buildings and health were searched from internet and reviewed. Overall, the initial scientific evidence published to date indicated better measured and perceived indoor environmental quality and health on green buildings versus non-green buildings. For indoor environmental quality, green buildings had lower levels of VOCs, formaldehyde, allergens, ETS, NO₂, and PM. Many of these environmental contaminants that have been linked to adverse health effects are explicitly addressed in green building design credits, so these early findings suggest that the design elements targeted at improved IEQ translated to significant reduction in actual exposure. The IEQ benefits in green buildings translate to better self-reported health outcomes across several indicators. This includes

fewer sick building syndrome symptoms, fewer respiratory symptoms reports in children, and better physical and mental health. Occupants also report benefits that indicate improved work productivity in green buildings, fewer absenteeism and fewer work hours affected by asthma and allergic in green buildings. Green buildings were associated to lower employee turnover and a decrease in the length of open staff positions.

Abbaszadeh, et.al (2006) conducted a research on occupant satisfaction with indoor environmental quality in green buildings. A total of 181 buildings of United States, Finland and Canada and 33,285 respondents were surveyed through a web based questionnaire containing self reported productivity in nine Indoor Environmental Quality categories. It was revealed from the findings that occupants in green buildings are on average more satisfied with their air quality and thermal comfort, lighting and acoustic quality in green buildings do not show a significant improvement in comparison to non-green buildings.

2.2.5 Productivity in Green Buildings

Leaman, et.al. (2007) conducted a post-occupancy evaluation, based on occupants surveyed of 22 'green design intent' buildings and 23 conventional buildings in Australia. The result showed that while the best green buildings consistently outperformed the best conventional buildings from the occupant's perspective. It was assumed that the first generation of Australian green buildings may be underperforming on some indoor environment variables. It was concluded that the green buildings that were designed properly have positive environmental outcomes and delivers positive feedback for comfort and productivity. The significant association between perceived productivity and overall comfort (lighting, ventilation, thermal comfort and noise) and between perceive productivity and thermal comfort in particular were identified.

Miller et. al. (2009) conducted a research on green buildings and productivity. The research examines green buildings in the United States from the

operations and management perspective—a perspective that has so far been lacking in the growing field of sustainable real estate research and one that is critical to commercial market participants who have expressed scepticism on the topic. With a national sample collected from a survey of office buildings managed by CBRE, the operating expenses and management of 139 green buildings were compared with 103 buildings that do not have a green label. The results showed that green buildings were more energy-efficient— with savings on electricity, gas, and water costs—when compared with their non-green counterparts. The average total operating expenses of the green building group was higher than the non-green building group. This suggests that ENERGY STAR buildings may incur additional non-energy-related expenses. Even more striking are the findings that point to the importance of the ENERGY STAR score—over the ENERGY STAR label—in judging the “greenness,” or even the energy efficiency, of a building. The results reveal that a building’s operating performance is more highly correlated with its ENERGY STAR score, and not the ENERGY STAR label. Thus, the higher a building’s score, the lower its operating expenses. Likewise, in terms of green practices—implementing green cleaning, installing restrictive plumbing devices, and motion-controlled lighting—it was found that a higher percentage of buildings that meet the ENERGY STAR standards but have no label have implemented green practices, compared with those that do carry the ENERGY STAR label. This seemed to suggest that the ENERGY STAR label is not a good indicator of the “greenness” of a property and that all green buildings are not, in fact, created equal.

In a Survey conducted by **Turner Construction Company (2008)** on green issues on a sample of 754 executives working in real estate, it was found that almost one half of the executives felt that worker productivity was greater in Green buildings than in non-Green alternatives.

2.2.6 Motivation in Adopting Green Building design and Construction

Dhingra(2010)conducted a study on adoption of Green Building concepts among two corporate houses in Noida and Gurgaon, Delhi to find out the

reasons for the adoption of green buildings by the corporate houses, factors motivated them to become green, benefits achieved so far by the companies by adopting this concept, to check the awareness level of the employees regarding green buildings, to study its impacts on employee health, safety and productivity, initiatives by government and non-government organizations. The two corporate houses involved in the study were ITC Green Centre office in Gurgaon and Spectral Services in Noida. The data were collected from 60 respondents through questionnaire, checklists, informal discussions, interview schedule. It was found that all the employees working in green building offices were well aware of the concepts of green buildings. They were well versed with green building guidelines, about platinum rated LEED certifications their company has, the benefits achieved by the company in terms of physical and operational costs. To sustain company's position at the top most level, to earn carbon credits, to become internationally recognized, for branding, reduce greenhouse effect, global warming, and the effect of environmental change were among the factors that motivated them to become green. Employees were also well aware of all the features that are installed in green buildings. The benefits achieved by these companies were saving electricity, water and cost, zero water wastage, and more productivity. It also helped in maintaining an eco-friendly environment, maintaining better occupant's health, helped in recognition, fame. Majority of the respondents also agreed that their productivity increases with better indoor environmental quality. Many of the employees were not well aware of the government initiatives.

2.2.7 Benefits of Green Buildings

A report by the **Tellus Institute and the Green CDCs Initiative (2003)** identified the range of benefits that greening affordable housing can provide, discussed the limitations of conventional project financial analysis focusing almost exclusively on "first cost" and suggested the use of life-cycle costing techniques. Through a series of case studies it was found that the incremental cost of developing green versus traditional affordable housing is very small, on the order of 1-2% and the net present value of operational

savings of green affordable housing is far greater than the additional up-front cost, often 5-10% or more of initial development costs.

Kats, 2008 in a survey of 'A landmark international study on the costs and benefits of green buildings' based on extensive financial and technical analysis of 150 green buildings across the United States and in 10 countries. The major key findings of the survey were that energy and water savings alone outweigh the initial cost premium by an average of 33% in most green buildings and that green buildings cost roughly 2% more to build than conventional non-green buildings. This stands in contrast to public perception, such as a 2007 survey by the World Business Council for Sustainable Development, which found that business leaders believe green buildings to be on average 17% more expensive than conventionally designed buildings. The study also found that productivity and health benefits are the major motivating factor for building green.

A survey conducted by **Turner Construction Company in (2008)** Green Building Market Barometer surveyed 754 executives on Green building issues through an online questionnaire. The executives surveyed represented a broad spectrum of organizations involved with facilities including developers (37%), owners of rental buildings (31%), brokers and other firms providing real estate services (27%), architectural, engineering and construction firms (22%) and corporate owner-occupants and tenants (10%). among the executives who worked for owners of rental real estate, 49% reported that they had Green buildings in their portfolios, while 59% of the corporate respondents said that they owned or leased Green buildings. Most executives saw Green buildings as having lower operating costs, while still generating more benefits to their owners and tenants. Green buildings were considered to be less expensive than non-Green buildings for several key measures of cost. The broadest consensus was on energy, where 84% of executives said that Green buildings had lower energy costs, including 29% who said they had much lower energy costs. Considering all operating costs, 68% of executives said Green buildings had lower operating costs than non-Green buildings. The benefits of Green buildings are not only financial. In fact, 76%

of the executives said that occupants of Green buildings enjoy greater health and well-being, first among the seven attributes rated. Although 87% of executives believed that Green building cost more to construct, roughly 73% said these higher costs would be paid back through lower operating costs, with a median estimated payback period of seven years.

Ries et.al. (2009) conducted a case study to measure the benefits of green building construction. The method included building performance surveys and interviews with management. A framework for evaluating the benefits of green building design and construction was developed for and used on a manufacturing facility, Castcon Stone, Inc. in Saxonburg, Pennsylvania. Castcon Stone's performance in their new green facility was compared to their performance in their previous facility. The framework compared pre-move and post-move data and included collecting and analysing company data on production in the manufacturing facility, absenteeism, construction costs, utility and maintenance costs. The results indicated that the employees generally agree that the indoor environmental quality of the new facility was superior to the old and that productivity was enhanced by the view to the outdoors, the size of the work areas, the temperature, and the relative humidity. It was found that the new facility offered advantages in daylight, air quality and thermal comfort.

Yu et. al. (2011) conducted a research on green retrofitting and benefits. The study aims to examine the costs and benefits of retrofitting existing commercial buildings in Singapore and analyses their implications for owners and occupiers. Empirical data of about 20 properties categorized into office, retail, and hotel were studied with regards to the cost of retrofitting, the savings in energy consumption after retrofits as well as other physical characteristics were provided by the Building and Construction Authority in Singapore. The main findings revealed that retrofit projects typically represent only about 3% of the current cost of construction for new commercial buildings. The savings in energy consumption and its attendant savings in utility cost are significant and represent some 10-20% of the typical operating expenses of the maintenance of the commercial properties. It was also found that the inertia to retrofit existing commercial properties has often been

attributed to the general lack of awareness of the cost and benefits amongst owners.

Kumar(2013)ascertained significance and relevance of Green affordable homes with special reference to the Indian scenario to examine and analyze the affordability, attitudinal and other aspects of green affordable homes from the perspectives of users of such homes and lastly to make suggestions for sustainable development of green affordable homes for mutual benefit of all the stakeholders. The target population of the study was from moderate and low income group residing in Ernakulam City of Central Kerela. The study has employed a descriptive analytical research approach. Both primary and secondary data were used for the research. The green homes selected for the study had taken the issue of “affordability” issue into consideration since the idea development stage of the building. It was observed that people were unaware and unprepared to make heavy investments in constructing green buildings, therefore, awareness is required. Further the study suggested that housing finance institutions and other lending agencies should insist on compliance with green standards while extending their credit facilities. Green finance should be encouraged always by all concerned. Policy makers should incorporate green compliance as one of the essential pre-conditions for regulatory clearance of all residential projects.

Matar et. al.(2015) studied the environment friendly buildings (green buildings) especially in the state of Jordan and its benefits. Descriptive qualitative method was used to gain knowledge of the green buildings and its benefits. Data were collected from primary and secondary sources. The results showed that regular buildings are characterized by three major characters, which are the drain energy and resources, polluting the environment through emissions and fumes, liquid or solid waste, and the negative impact on the health of the users of buildings as a result of the use of different chemicals and other pollutants. It was also found that the impact of constructing an ordinary building on the amount of using energy, water and building materials resources which has lead to the fear of depletion of these resources, and based on these negatives, the principles of the

environmentally friendly buildings carry ideas and theses which are able to overcome the drawbacks mentioned above.

Sass and Smallwood (2015) conducted a study to interrogate green building and construction ergonomics related issues with the objective to investigate the need for green building to address construction worker ergonomics and H&S, to find out the causes of construction workers becoming stressed, to determine the frequency at which construction workers experience ergonomic problems, and to discover why workers experience WMSDs. It was found that construction workers were exposed to many ergonomic and H&S hazards which can cause them to become ill, experience stress, experience WMSDs, experience injuries and in some cases death, and also be absent from work. Therefore, even though buildings may be rated 'green', it can be concluded that from a construction worker perspective they may not be 'green' per se. The range of ergonomic problems experienced by construction workers have their origins in design, the nature of the construction process and activities, and work organization. Therefore, it can be concluded that a range of stakeholders trigger and contribute to the existence of ergonomic hazards. The various factors that contribute to workers experiencing stress have their origins in the structure of the construction industry, design, the nature of the construction process and activities, and work organisation. The construction industry is a very hazardous industry to work in, the range of ergonomic problems experienced by construction workers and the factors that contribute to them experiencing stress have their origins in the structure of the industry, design, the nature of the construction process and activities, and work organisation, and it has yet to be realised that construction worker H&S and wellbeing is an integral aspect of sustainability and 'green' building.

2.2.8 Barriers in adopting green building design

According to **3rd Annual Allen Matkins/CTG/Green Building Insider "Green Building Survey" (2008)** with 900 respondent's who were design professionals, Contractors/Subcontractors, Construction Planning Manager, Consultants, Owner/Developers. The results suggest that the respondents

unanimously indicated that it is worth the time and effort to build green, LEED certification was perceived as attractive by just two-third of green supporters. Respondents also said that the risk of LEED/green construction were either the same or greater than the risks in traditional construction projects. The majority of the respondents felt that the cost premium for green construction over traditional construction was less than 4%. Further, given the recent increase in energy costs, 74% of the respondents said that they were more likely to incorporate sustainable elements into their future projects. When asked about the greatest risk for green construction respondents reported “design and construction defects”, “impacts to the owners” and “not recouping capital costs”.

Turner Construction Company (2008) conducted a survey of 754 executives working in real estate on green issues where executives were asked to rate the factors discouraging the construction of Green building. At the top of the list was the amount of documentation and additional cost to have a building become LEED certified, as rated by 54% of executives followed by higher construction cost and payback too long (50%) and lack of awareness of benefits of Green construction (48%).

Griffin, et. al. (2010) conducted a research to find out the barriers in implementing sustainable structural materials in green buildings. The researchers interviewed building design professionals in Oregon, United States. It also identifies the gaps in information as well as gaps in access to or availability of sustainable materials. The survey process was divided into two phases. Phase I was a series of eight exploratory interviews with individuals who assisted in refining questions and identifying potential participants in the focus group discussions of Phase II. Phase II, expert opinion about barriers to implementing sustainable structural materials was collected through interviews conducted in four focus groups. Twenty two professionals from architecture, engineering, construction and development field participated in the interview. The primary barriers to implementing sustainable structural materials were the perceived increase in cost, regulations that do not recognize new green materials and systems, and the availability of the

materials themselves. The lack of readily accessible and reliable information comparing alternative structural materials and systems also poses a significant barrier during the design and selection process. The study also reaffirmed the need for strong collaboration between stakeholders that are experienced and knowledgeable about green building strategies.

Elias and Lin (2015) studied the green building implementation from the perspective of housing developers. The data were gathered through a face to face semi structured interview, photo collections and some observation with housing developers on a sample of 22 respondents involved during the data collection period from two home and property exhibitions. The findings revealed that 77 per cent were aware of green residential concept while the other 23 per cent of the respondents realized about the green residential concept and the perceived benefits but indistinguishable. All the respondents agreed that the lack of technology transfer and the knowledge of developing nation have prevented the local housing developers to embrace green technology in their task. Secondly, housing developers have faced a limitation of finance in order to upfront the green technology costs into the initial housing development. Majority of the respondents showed no interest in making use of recycled materials for the house construction projects. Very few developers showed a potential desire to use the rainwater harvesting for housing project in near future. Many of the house developers were not able to grab 'green' opportunities due to internal organizational problems. More than three fourth of the respondents mentioned about the difficulty to achieve a standard or performance when it is driven by the context of development, the climate conditions and the location of the construction site.

2.2.9 Perception regarding Green Buildings

A survey conducted by **Turner Construction Company(2004)** on Green building perceptions and issues, solicited the views of more than 700 U.S. executives involved with buildings either as an owner of rental buildings, owners-occupants, developers, consultants, designers or builders through a self-administered questionnaire distributed over the internet. The important

findings are that three quarters of executives at organizations currently involved with Green buildings reported that these buildings had lower operating costs, Ninety one per cent of executives said that they produce greater health and well being among occupants, eight four per cent of executives believed that Green construction yielded higher building values, three quarter of the executives said that they generated a higher return on investment than non-Green buildings and nearly one half of the executives expected the number of Green Buildings in their organization's workload to increase substantially over the next three years. Sixty five per cent of the executives reported that the health and well being of the occupants of Green buildings were much higher than that in non-Green buildings. Seventy per cent of the executives rated higher construction costs, sixty per cent rated lack of awareness of its benefits as very or extremely significant factors discouraging Green building activity. Executives also believed that construction costs were fourteen per cent higher than those for other buildings. Ninety four per cent of the executives who believed Green buildings had higher construction costs said that these buildings pay back these higher construction costs through lower operating costs and other benefits. Ninety three per cent of the executives were aware of the U.S. Green Building Council's LEED Green Building Rating System, which is a voluntary set of national standards for the design and construction of sustainable buildings. The executives perceived that the costs and benefits of Green Buildings differ across the country.

The **Turner Construction Company, Green Building Market Barometer in (2005)** conducted survey to find out the views of executives working at educational facilities, both K-12 and higher educational facilities. It was found that executives at organizations involved with Green K-12 facilities (987%) and executives involved with Green College and University facilities (90%) rated community image as benefit of Green Buildings. Executives involve with K-12 and college and University facilities said that the greatest obstacles to Green construction were a perception of higher construction costs, cited by 74% and 66% of the executives respectively as a very or extremely significant obstacles and a lack of awareness of their benefits, cited by 67% and 59% of

the executives respectively. Executives who were at least somewhat familiar with the LEED system were asked about the most important benefit of LEED Certification, forty five per cent of the K-12 school executives reported that the independent confirmation of meeting recognized Green standards as most important benefit of LEED certification, compared to 33% of executives who named it as most important for college and universities.

USGBC and the Sustainable Rhythm in (2010) conducted a survey “Opening the Door to Green Building” to analyse the market transformation, engaged multiple perspectives in the building industry to examine issues of the overall market, the perception of the financial investment, the role of certifications and finally how the benefits of green building are being communicated among building design and construction professionals. The survey was distributed through an online tool to 200 participants, 90% of which were based in Ohio. The participants included owners/Facility managers/Real estate (17%), Service firms (59%), Product companies (17%) and Government advocacy (7%). It was found that 62% of the respondents indicated that there is a significant premium to build green with 46% of that group believing the premium is above 10%. Only 21% of the respondents indicated an understanding of the current certification and accreditation options in the market place. Respondents indicated that it is “highly confusing” or “rarely understandable” (42%). Standards and certifications are impacting the product market; the study indicates that over 40% of the respondents believe certifications are relevant to their product purchasing process.

Mansour and Radford(2014) proposed a framework for the mechanism of people’s perception of green building. The perception model is based on Peattie (2001) matrix, there are some intrinsic differences between green consumers and green building users. in case of a commercial or office building, the user will not buy this building, so that when discussing laypeople’s behaviour as green consumers, economic factor is not on the same scale of importance in a green purchasing situation. These two factors affect the perception of building users in a positive sense because they do not

have to pay a premium, so that they are willing to give higher degree of compromise and they might have higher level of confidence based on their belief in sustainability. The four factors that affect the perception of green buildings are degree of belief in sustainability, degree of green certification, the congruity of design with the existing schema of similar conventional buildings, and users' personal experience of green building. Occupant's belief in sustainability and a building's degree of green certification are the major drivers of laypeople's judgement on a green building. More deeper or final judgement depends on one's evaluation of building's design schema and its congruity with the existing schema in conventional buildings, and one's experience of building systems over period of time. Occupants' experience can be categorized in to five categories of experience; task performance, social territories, way finding, cultural expression and visual and non-visual aesthetics (Doxtater, 2005). The environmental and experimental factors constitutes certain judgement, which influence the level of confidence one has in green building, this degree of confidence is similar to the confidence one has for a green product.

2.2.10 Awareness regarding green buildings

Green building awareness survey(2007) aimed to find out the consumer interest and awareness of green building in Washington State on a sample of 268 respondents (Northwest-16%, Southwest-40%, Central-10% and Eastern-35%). Data indicated that Energy Star was the most recognized of all of the residential green home certification programs. Interviewee consistently said that green building was more environmentally friendly and used less waste. Respondents indicated the education on what is meant by green building is still needed. Additional resources are needed for real estate agents and sales offices on green home options. Respondents felt that green buildings are more environmentally friendly than conventional buildings. Majority of the respondents understand that green buildings are at least somewhat more energy efficient than non-green certified buildings (74%). Only 53% of respondents indicated that they believed green homes to conserve water than conventional buildings. Additionally 31% respondents indicated that they

didn't know whether green homes had water conservation benefits. Majority of the respondents appeared to understand that utility costs of green certified buildings were less than those of non-green buildings. One half of the respondents indicated that they thought green buildings were more energy efficient, yet only 36% indicated that utility costs were much less. Respondents indicated that buildings built to green standards were environmentally friendly than were energy efficient (78%). Respondents also indicated that they didn't know whether or not green buildings were constructed with higher quality materials than non-green buildings (31%). Forty per cent of the respondents reported that green buildings were either much or somewhat better built than non-green buildings. Only 66% of respondents thought that green buildings had a much or somewhat higher resale value than buildings not built to a green standards.

Teig(2007) conducted a survey on “Why Green Buildings has Staying Power? The survey drew responses from 218 corporate users and 166 developers of commercial real estate. The findings revealed that 52% of corporate respondents and 39% of developer's respondents currently own, manage or lease at least some “green” properties. Respondents are most likely to be involved in office and retail. Among developers, 55% own or manage retail, followed by office (48%) and mixed-use and hospitality (35%). On the corporate side, 51% of the respondents own or lease office space, followed by industrial (42%) and retail (25%). Corporate users and developers anticipated that the amount of green facilities they own or lease will more than double from 9% to 21% in the next five years. About one half of the corporate users (46%) and developers (51%) considered green design either important or extremely important. Only 17% of corporate users say green design is not at all important in the site selection process, while just 10% of developers said that it is not at all important to their company for current or future development.

Shenzhen Fountain Corporation in (2008) conducted a survey on Green Building Awareness and Sustainability, Changsha, Hunan Province. Survey was conducted on a sample of 374 respondents of city of Changsha, China.

With a large percentage of respondents (18.38%) in the real estate industry, a fairly high level of awareness of Green buildings could be witnessed within the sample. Majority of the respondents were familiar with the China Green label Program (58.29%). Majority of the respondents associated environmental friendliness with Green buildings. The vast majority of the respondents perceived Green buildings to be much more energy efficient than non-green buildings (67.3%). Over 77% of the respondents perceive Green buildings to be more environmentally friendly than non-green buildings. More than one half of the respondents feel that Green buildings are built with much higher quality materials. Utilities and maintenance cost in Green buildings was perceived to be much lower by 35.77% of the respondents. The vast majority of respondents (68.33%) perceive a green building to be built to much higher quality standards than a non-green building. Over 45% of the respondents think that Green building has a much higher resale value compared to non-green building. More than one half of the respondents think that a green building can conserve much more water than a non-green building. Majority of the respondents think that their next home should be “green” as it is extremely important. Nearly 30% of the respondents would not be willing to pay any additional premiums for Green homes.

Fleming(2009) in a survey National real Estate Investor on Doubling down on Green comprising developers, corporate real estate executives and city and country government officials. The findings showed an overwhelming majority of developers (88%) and corporate executives (86%) indicated that they consider green design to be as important or more important. A majority of developers said that they have previously retrofitted properties for greater energy efficiency, are in the process of retrofitting, or are considering retrofitting properties to make them more energy efficient. Government officials also jumped on the bandwagon to lower utility bills with 78% indicating that they are upgrading or planning to upgrade one or more products in the coming years including HVAC, lighting or water controls in public buildings. Survey findings also showed that more state and local governments (56%) would consider using performance contracts to improve energy efficiency in their facilities. Only 34% of the respondents said that the

federal stimulus influenced their decisions. Respondents differ on how long it takes to recoup the costs for energy retrofits. Corporate executives and developers indicated that it takes between three to four years to recover costs, while government respondents reported that it takes five or longer to recoup costs. A majority of the developers believed that green requirements will eventually become part of required building codes. Developers and corporate respondents indicated that they have taken advantage of few government incentives. Nearly 23% of the developers reported that they have taken advantage of tax incentives, 16% said they have taken advantage of rebates and discounts on environmental products and 9% have taken advantage of grants, tax incentives (16%), rebates and discounts (11%), and permit zone fee reduction (5%). Almost 85% of corporate executives and 76% of developers said that they are at least familiar with the U.S. Green Building Council's LEED program. A slightly lower percentage of government officials (59%) are familiar with LEED. A majority of both corporate and developer respondents report that they believe LEED to be an effective system for energy savings and environmentally friendly buildings.

Conte and Yepes (2012) had conducted a study on Green Buildings: Analysis of State of Knowledge. The purpose of this study was to analyse the state of knowledge up-to-date. The study was conducted through a literature research and a subsequent process and analysis of the papers found. A total of 124 articles were selected for review. It was found that there was lot of information available on Green Buildings. It was also concluded that everyday, more people, groups, associations, governments, countries are interested in joining the “Green Movement”, mainly aware of the importance it has on the environment and also helped by the economic benefits that are available and the prestige and recognition that this brings. United States was the country with more papers published and this could be attributed to the fact that LEED Rating Systems is the most internationally recognized certification rating system, developed by US Green Building Council. To implement the energy savings measures is necessary to use materials, devices, green technology and other aspects. The initial cost increment in green building is the most common barriers. The energy efficiency is the most interest topic to

researchers, because involve in a directly or indirectly way others green building aspects (design, materials, water saving, cost).

Rashid, et. al. (2012) conducted a study to investigate the mechanism for the effects of environmental design features of a green building on occupants' environmental awareness and organizational image. The data were collected from 175 occupants of the Leadership in Energy and Environmental Design (LEED)-certified green building using a questionnaire instrument. There were two sets of questionnaire, one questionnaire investigated workspace related questions such as background, workplace design, and individual and organizational outcomes. The other questionnaire was related to departmental space including questions on some environmental features of individual workspaces, and other on departmental spaces or common amenities. The finding of the study suggested that the occupants certainly appreciated the environmental design features of the buildings. These environmental design features also made the occupants more environment conscious, even though these features did not help improve their assessment of organizational image. In other words, even in a case where the "green" building and the organization that occupies it are treated as an integrated system with the occupants being aware of the environmental friendliness of the building, the building may not help improve the occupants' awareness of organizational image. The study found no evidence for direct relationships between the occupant's assessments of individual workspace and departmental space features and their assessments of environmental awareness and organizational image. The study, however, found some evidence for indirect relationships showing that the occupant's assessments of individual workspace and departmental space features had affected their satisfaction with individual workspaces and the building, which affected the occupants' assessment of environmental awareness and organizational image.

Campwala(2013)conducted a descriptive research on NET Zero buildings with a sample of 20 architects and 20 civil engineers of Vadodara city selected through purposive sampling technique through a questionnaire. The findings revealed that a little more than one-half of civil engineers had

moderate extent of awareness whereas majority of the architects had moderate extent of awareness regarding net zero buildings. It was found that out of the two categories civil engineers were more aware about net zero building. For the present research study the investigator had mainly focused on the design of the net zero building with the solar panels and the materials. The designing was done using AutoCAD software.

2.2.11 Incentives related to Green buildings

The NAIOP Research Foundation retained **Yudelson Associates in (2007)** to investigate local government incentive programs, specifically for green buildings. Through an extensive literature review, Yudelson Associates identified and characterized local and state incentives for green building construction by the private sector. Three separate online surveys of developers, architects and local government officials, with email and telephone interviews used to supplement survey results. Of the total number of survey respondents, 48 per cent had experienced five or more green building projects, 95 per cent were members of the USGBC, 75 per cent were LEED Accredited Professionals and 78 per cent had personally participated in a LEED registered project. In terms of geographic location of projects, 60 per cent were in the West or Southwest and only five per cent represented Canadian projects. Finally, 45 per cent had developed or worked in a location that offered green building incentives. In terms of green building achievements, 69 per cent of respondents had secured a LEED Gold or Platinum designation for at least one project. However, 28 per cent thought that green buildings carried a four per cent or more cost premium. Additionally, 48 per cent thought that perceived cost increases were the biggest barriers to building more green buildings. The most significant barrier to the rapid growth of green buildings is perceived cost increase (41%). The most successful green building incentives are in Chicago (13%) and Portland, Oregon (9%). Respondents believe that the most significant incentive or trigger that has been effective in promoting green building is an internal philosophy to build green (44%). Density bonuses

(83%) was considered as incentives that developers indicated would be the most significant for them and that they would like to see implemented.

The American Institute of Architects (AIA, 2007) undertook a study of municipal green building programs in 2007. Their goal was to analyze the growth and effectiveness of green building policies in cities of 50,000 people or more. They identified a notable lack of current, comprehensive data on green building programs as the impetus for their study, and hoped that their report would provide invaluable information for other municipalities to follow. Their main methodology was to survey representatives from each community. Among their questions were the number of years that the green building program existed; the extent of the program; whether it applied to just public buildings or all buildings; types of incentives offered by communities; and what the regional strengths and weaknesses were. They created a “Quick Reference Matrix” organized by state and municipality. The case study reflects a diversity of long standing policy. Many have been established for several years, therefore offering an opportunity to see what has worked well and which adjustments were needed. It was also found that incentives and far reaching programs were largely concentrated in California and D.C – to – Boston. These studies are going beyond standard concepts of green design by incorporating green requirements into all buildings. Many of the policies are either just now getting off the ground or being phase in over the next few years. It was also concluded that the current state of green building law is not consistent.

2.2.12 Comparative Studies between Conventional and Green Buildings

According to a survey conducted by **U.S. Green Building Council 2009** on Regional Green Building case study project analysed the post occupancy performance of green buildings conducted for 12 consecutive months. The element that were measured were energy efficiency, greenhouse gas emission, water efficiency, commute transportation, construction and operating cost, green premiums, health and productivity and occupants comfort. It was found energy performance was better than conventional

buildings. The median calculated greenhouse gas emission in pounds of carbon di oxide was less in green building rather than conventional buildings. The water usage in green building was 7.7 gallons/ square foot/year and 5.9 gallons/occupants/day. This is less than the water usage in conventional buildings. People residing in green buildings participated in optional transportation commute and median vehicle miles travelled (9.2 miles) via passenger's vehicle was less as compared to people residing in conventional buildings (12.1 miles). The study noted reduced asthma, less absenteeism, less sick time. Occupant satisfaction is high, especially related to indoor air quality and lighting. The lowest ratings given by occupants were related to temperature and acoustics, but still generally positive.

Bhardwaj, 2014 carried out a study on IGBC Green Homes and Mughal Heritage Buildings to gain an insight about IGBC Green Homes and Mughal Heritage buildings in terms of energy efficiency, water efficiency, site selection, material efficiency and indoor environmental quality and to compare both kind of buildings and evaluate whether these parameters are appropriate for Mughal Heritage Buildings or not. The research was carried out in Delhi/NCR as it is in houses large number of LEED certified buildings and Mughal Heritage buildings out of which 5 both type of buildings were selected. It was found that Gurgaon (TATA), Gaur city (Gaursons) and Cape Town (Supertech) had pre certified gold rating whereas Lotus Boulevard (3C Company) was just registered and was aiming at silver rating and lastly, Ecociti (Supertech) received pre certified platinum rating. Thus, it is evident that these projects since their inception have always strived to protect the environment and have taken enormous efforts to implement various sustainability and green measures within their interior as well as exterior spaces. The roofs and walls, energy and water features, vegetation and choices of materials are all intended to create a micro-climate of a moderated and comfortable environment. The Mughal buildings show a uniform pattern both in structure and character. The main characteristics features of Mughal architecture are the bulbous domes, the slender minarets with cupolas at the four corners, large halls, massive vaulted gateways, a recessed archway inside a rectangular fronton, and park like surroundings and delicate

ornamentation. Features like water storage, irrigation management, heat island effect control, building orientation, daylighting, cross ventilation etc. were present in these Mughal buildings. In spite of being sustainable sites, having good indoor environment quality, orientation and planning, these buildings falls short in fulfilling IGBC parameters.

2.2.13 Water Efficiency in Green Buildings

Chanan et.al. (2003) reviewed two studies on sustainable water management in commercial buildings undertaken by Institute of Sustainable Future, for Sydney Water Consumption to determine the potential water savings from various water management options in a typical commercial high rise building. Both the study showed the reduction of up to approximately 80% of water demand and 90% of sewage discharge achieved through the integration in innovation water efficiency measures, rainfall capture and use, treated effluent reuse and evapotranspiration through roof gardens.

Ahn and Pearce (2013) adopted a case study approach to identify and analyze green design and construction practices that create a green and luxurious environment without damaging the hotel's financial position. Two LEED Platinum rated hotels were selected and data collected on their green design and construction practices. It was found that to enhance the water efficiency, both hotels installed high efficiency fixtures and fittings, including water closets, dual flush toilets, waterless urinals, and low-flow showers that reduce water consumption in the hotel. Since those fixtures are known to be closely related to guest satisfaction and a vital part of luxurious bathroom environment, the design team considered not only the need to reduce water consumption but also quality and design of fixtures in the two hotels. By implementing these water saving strategies, a reduction of about 34% of portable water was achieved compared to conventional hotels. In addition, major strategies adopted for landscaping the hotels' surroundings were to plant native and adapted plants, to install drip irrigation systems, and to avoid using turf grass anywhere on either site. They use a non-portable water source for plant irrigation and also installed refrigerators in the hotel kitchen

that used geothermal energy instead of water cooled systems, providing significant water saving.

Khan, 2015 conducted a case study to evaluate the extent of satisfaction among users of rainwater harvesting systems in Vadodara city. For this 9 cases were selected from various types of building from different area of Vadodara city. The findings revealed that all the users who had installed the Rainwater Harvesting System since minimum past 3-4 years and maximum 7-8 years and were still using it were highly satisfied by the specific features of Rainwater Harvesting System, its installation, its initial cost and its utilization for future use. The users faced the problems to a high extent at the time of cleaning and maintenance of the Rainwater Harvesting System chambers, changing the sand, gravels and pebbles as there was difficulty in getting the labour for getting this work done. The researcher proposed the design of Rainwater Harvesting System as to provide ease to the users in cleaning and maintaining the Rainwater Harvesting System by providing an outer covering of the chambers which will keep it clean and will consume less time in cleaning before the arrival of monsoon.

Conclusion

The review of literature revealed that much efforts has been made to research area of “Benefits of Green Buildings”, “Green Building materials”, “Green Building and Productivity”, “Vertical gardens”, “Net Zero buildings”, Indoor Environment Quality in Green Building”, “Green Building rating Systems”, “Barriers and Challenges in adopting Green Building concept” in India as well as outside India. An overview of the researches highlighted that majority of the studies focused on buildings already constructed on the principles of Green Building Rating Systems and awareness of people residing or working in green buildings. The researcher did not find any study focusing on awareness of homeowners of existing (non-green buildings) regarding green buildings and also the assessment of it for the extent of its greenness. Opinion of the builders also needs to be assessed in Indian context.