IMPLEMENTATION OF GREEN CONSTRUCTION (SUSTAINABLE) ON EXISTING STRUCTURES AND IMPACT ASSESSMENT OF RATING SYSTEM

A

THESIS

Submitted in partial fulfilment of the requirements for the award of the degree

Of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

CONSTRUCTION MANAGEMENT

Under the supervision of

Mr. Abhilash Shukla

(Assistant Professor)

by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

MAY- 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"IMPLEMENTATION OF GREEN CONSTRUCTION (SUSTAINABLE) ON EXISTING STRUCTURES AND IMPACT ASSESSMENT OF RATING SYSTEM"** submitted for partial fulfilment of the requirements for the degree of Master of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Mr. Abhilash Shukla** (Assistant Professor). This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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May, 2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"IMPLEMENTATION OF GREEN CONSTRUCTION (SUSTAINABLE) ON EXISTING STRUCTURES AND IMPACT ASSESSMENT OF RATING SYSTEM"** in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Tarun Bhardwaj (172608)** during a period from July, 2018 to May, 2019 and on under the supervision of **Mr. Abhilash Shukla (Assistant Professor)** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: 11/05/2019

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ACKNOWLEDGEMENT

I take this opportunity to acknowledge all who has been great sense of support and inspiration throughout the project work. There are lots of people who inspired me and helped, worked for me in every possible way to provide the detail about various related topics, thus, making of report work success. My first gratitude goes to our Professor & Head of department **Dr. Ashok Kumar Gupta** for his guidance, encouragement and support. Without his guidance it would have been real tough job for me to compile my thesis and degree.

I am very grateful to **Mr. Abhilash Shukla (**Asst. Professor), for all his diligence, guidance, and encouragement and helped throughout the project work. I also thank him for the time that he spared for me, from his extreme busy schedule. His insight and creative ideas are always the inspiration for me during the dissertation work. Without his help it would have been a very difficult task for me to compile the project and also on time. He step by step guided me. Thanks, sir, for your concern.

It is **My Parent's** support that walked alongside me as I progressed my work day by day. And I also want to thank my dear one's and officials who throughout my degree helped me out especially **Mr. Kapil Sharma, Sh. Ganesh Lal sir (TCP), Sh. Rajesh Kaundal sir (ATP), Ms. Malvika Sharma and Ms. Seema Chauhan**. They helped me out whenever I needed one.

Tarun Bhardwaj

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LIST OF ACRONYMS AND ABBREVIATIONS

GB..... Green buildings

LEED.....Leadership in Energy and Environmental Design

IGBC.....Indian Green Building Council

EDGE.....Excellence in Design for Greater Efficiencies

GBI.....Green Building Index

BEE.....Bureau of Energy Efficiencies

ECBC.....The Energy Conservation and Building Code

MNRE.....Ministry of New and Renewable Energy

TERI.....The Energy and Research Institute

H.P. .....Himachal Pradesh

LCC.....Life Cycle Cost

LCCA.....Life Cycle Cost Analysis

CBA.....Cost Benefit Analysis

NPV.....Net Present Value

ROI.....Return on Investment

ABSTRACT

With the growing urbanisation and colonisation of our society by humans have affected the natural cycles and have introduced global warming as a very big problem in almost every field of life we come across, in one way or the other. Living beings are striving for their survival after when they exploited the eco-system and created an imbalance by deforestation and various development projects (non-green recommended implements). The construction industry alone is responsible for majority of its destruction of the habitat etc if not done in the unplanned manner. Due to its maximum impact on environment, there comes the need of the hour for shifting from uncontrolled growth of the construction sector to much researched green initiative developed technology and reducing carbon foot print where ever possible. The existing buildings have the potential of maximum energy saving if the retrofit introduced is planned and greener for improved quality of living. Renovation cost or demolition cost will rise but if green retrofitting and repair is done of existing building then it might be higher in cost before but cost savings will be a great factor to analyse upon as it progresses further in its life time.

Keywords: global warming, construction, repair, green construction, green building

CHAPTER-1
INTRODUCTION

1.1. General

Green structure is the one which has structure and the sources used environment reliable and resource capable throughout life-cycle i.e. from planning stage to finish of its life cycle stage. During the planning design of the structure all of the professionals collectively, with the customer, have to work for the desired result. The scenario of green construction grows day by day as we compare it to the traditional construction as of its benefits.

As per Kibert (2012, p. 1), "the result of applying sustainable development advances to create an accountable environment which is referred high performing green builds". Sangster, stressed on the primary targets of GB to be lowering disturbances created by nature and waste production; lowering energy and different resource demand; sustainable power source use; improve human wellbeing and comfort.

LEED is a rating technique for the design, development, maintenance and operation of green builds, establishment done by IGBC. An exploration was led by the WGBC for assessing the impacts of green builds on the wellbeing and gainfulness of the customers and collaboratively with the World Bank they are promoting green builds with certifying them with the program of EDGE certifications. Different tools are being used in various parts of the globe i.e. Green Star of Australia and GBI for Malaysia. Objective goal of green revolution (green construction) is to lower the impacts of construction to health of users or affected population and to the natural surroundings by: -

- Efficiently utilizing energy, water, and different resources
- Protecting occupant wellbeing and improving worker efficiency
- Reducing waste, contamination and degradation of environment.

The approach of natural buildings is based on usage of natural raw materials including terms such as green, practical and sustainable designs. **Sustainability is a method of utilizing available resources without compromising the future requirements.**

Some of the green building plans do not mention retrofitting's but are mentioned in open plans. The principles of green buildings can be easily applied to retrofits and new

constructions. A study reported 12 sustainably designed buildings with less operating cost and good energy performance (U.S> General Services Administration, 2009). The residents of these eco-friendly buildings were completely satisfied [1].

1.2. Concept of Green Building in India

A Building or a structure that uses less water, is energy efficient, conserves natural resources, has reduced waste generation and provides healthier living environment is known as green building/structure. IGBC which was framed by the CII (**Confederation of Indian Industry)** and is the country's first certified firm for green buildings and allied services. Being a Green Business Centre, CII situated in Hyderabad is India's 1st rated Platinum green structure. IGBC has a vision to develop a sustainable environment for everyone.

It has achieved a milestone of 4.72 billion sq. ft. of area covered in 4,400+ developed or developing projects that include industrial, residential, commercial, healthcare centres that are covered in 22 IGBC G.B. ratings. 2,100+ IGBC Member Organizations involving engineers, corporates, draftsmen, experts, establishments, government, and so on, 2,800+ Professional experts and also partners of almost 30,000.

IGBC certification is given to the projects performing well in all phases of the process mentioned in their criterions and up till now almost 1,250 projects rated as green builds by its certification program. There were enormous savings when investigated and are listed below:

- Energy- 15,000 MWh
- Water- 45000 KL
- Certified projects of IGBC have 30 MW renewable sources installed
- 12,000 tons for every million sq. ft. per year
- Construction waste diversion of almost 500 tons.

IGBC ratings comes under one of the following:

1. Certified
2. Silver
3. Gold
4. Platinum.

1.2.1. IGBC Mumbai formed IGBC Green league (IGL)

The main objective of IGBC is Learning and growing together.

1.2.2. EDGE

The Confederation of Real Estate Developers' Associations of India (CREDAI) and the IFC (World Bank group member) have collaborated to promote the concept of Green Buildings in India through EDGE (Excellence in Design for Greater Efficiencies) certification. Prakash Javedkar signed an MoU on November 25, 2014 (Minister for Environment and Forests).

1.2.3. BEE

The ECBC sets code for energy potential standards for the design and construction of buildings with minimum adapted area of 1,000 m^2 & power of demand to be 500 KW. The energy performance index of the code range is from 90 kW·h/sqm/yr to 200 kW h/sqm/yr. Building coming under the index is termed as **"ECBC Compliant Building".**

A star rating scheme was launched by BEE for official buildings only in the day time in three climatic zones, composite, hot & dry, warm & humid on 25 February 2009. IGBC rated green buildings are also able to meet or exceed the ECBC compliance. [2]

1.2.4. ECBC

Energy Conservation and Building code was the one of the first steps taken by the govt. for building construction sector. They promoted the energy efficiency in the civil work sector. It has variety of design criterions i.e. Building envelope, ventilation systems, heating & pumping systems, etc. [3].

1.2.5. GRIHA (Green Rating for Integrated Habitat Assessment)

MNRE & TERI both collaboratively developed countries first self-rating system for Green builds which was termed as GRIHA (Green Habitat for Integrated Habitat Assessment). The evaluation has 3-stages to be addressed: -

1) Documents submitted online (criteria as prescribed)
2) The GRIHA secretariat appoints team of experts for visiting site and evaluating the concerned property applying for rating.

GRIHA has 34 criterions in four sections as following:

(1) Site selection and site planning,

(2) Conservation and efficient utilization of resources,

(3) Building operation and maintenance, and

(4) Innovation.

1.2.6. Repair

The Repair process involves bringing back a particular structure to its previous conditions as its performance level remains the same.

Some main types of repairs are:

1. Filling the errors such as cracks and falling plaster.

2. Repair of doors & windows and also replacing the glass panes.

3. The concerned electric wiring check and repair.

4. Re-plastering of walls as required.

5. Constructing again the non-structural walls, boundary walls etc.

6. Checking and repairing gas pipes, water pipes and plumbing services.

7. Relaying cracked flooring at ground level.

8. Rearranging disturbed roofing tiles.

9. Redecoration — whitewashing, painting, etc. [4]

1.2.7. Retrofitting

Retrofitting is an addition of new technology or features to older systems. This can be achieved by following methods:

- Installation of energy efficient technologies during the retrofitting of aged homes.
- Seismic retrofit is used for making old structures earthquake opposing.
- new technologies are mainly incorporated by Naval vessels as retrofitting by changing their operational designs compensating their weak points.

1.2.7.1. Benefits of a retrofit

- Replacing the older versions from new ones is an asset.
- Maintenance costs lessens and reliability also has an appropriate increment.
- New or shifted products are also settled easily in a retrofit.
- Benefits of the new versions of technologies used saves the capital cost.

1.2.7.2. Problems faced

Challenges: -

- Financial,
- Technical,
- Construction & legal processes;
- Cultural,
- Material and labour related problems (Bahacan Aktas1 and Beliz Ozorhon2,2015) [6]

1.3. Project specific

There are many parameters that can help in evaluation of green buildings:

- Expertise in creating site planning designs
- Protection of Top soil and its conservation during construction.
- Optimization of building design and structure to reduce demand of conventional energy.
- Reduce the use of Conventional energy by incorporation of renewable sources of energy-based system such as solar water heaters.
- Efficient water and waste management that leads to a decrease in water usage and contamination.
- Improvement of indoor environment quality like indoor air and thermal quality.
- Selection of more efficient sustainable construction raw materials.
- Optimization of operation and maintenance.

Himachal Pradesh, a state lying in the foothills of Himalayas that covers an area of 55,673 sq. km. It has an elevation of 350 meters to 6000 m above mean sea level. With an average annual rainfall of 1600 mm, the climatic variations are also present i.e.

hot and sub-humid tropical, warm and temperate, cold alpine, cool and temperate and glacial. The state has a warmer climate down in the valleys whereas remain snow covered on the highest of its peaks lined with glaciers.

1.4. Civil work sector (building work) in Himachal Pradesh

From the perspective of building sector, the visualization is following: -

- To achieve a net zero green built for the energy consumption, water and managing water. With surplus renewable sources of energy more emphasis shall be laid on sustainable development.
- The land sources should be utilized in such a manner that the consistency of the slopes is not disturbed.
- Design measures should be used in somewhat perfect way so as to confirm thermal comfort.
- Supply of low cost, durable substituted materials as compared to raw materials such as steel, cement, bricks used in conventional buildings.
- Acceptance and regulation of new substitutive techniques with using regionally available materials.
- Above all, sustainable regional development should be the prime aim.

The Himachal Pradesh Government has identified the challenges faced due to tough terrains and their vulnerability. A detailed vulnerability assessment has been noted by the Environment Master Plan by Himachal Pradesh State in 2013, that highlights different sectors geographically.

There was a growth in consumption of electricity at an average rate of 13.2 % from 1981 to 2010. By 2021-22, if the growth rate is assumed to stay constant, 9000 Million kWh to 24000 Million kWh (from 2013). Due a rise in industrialization with the growing population, there is large increase in energy consumption demand. The state has a large number of hydroelectric plants but still faces shortage of electricity in winters. The state was facing electricity shortage of about 2.3 % and maximum demand was round about 10.8 % (2013-14).

The major consumers of electricity are buildings, being the second largest consumers in the industry. Domestic section is the main user and has been expanding consistently within the building sector. The residential sector has been estimated to account for about 24 % of the

total electricity consumption in 2012-13. Using energy efficient options would save around 25% electricity in residential structures and 30% energy saves for new commercial buildings. 15 commercial buildings in Shimla are assessed to show an annual energy savings potential of 2.22 MU (BEE, 2009).

Cold and composite areas of H.P. have a mix response as cold achieves net zero easily as when we compare it to composite ones. The possible approaches are increment in the share of clean energy, energy efficiency matching in all structures, making use of every possible open space which leads to solar PV generation. As we are growing towards a sustainable era, we should be giving level importance to urban planning.

CHAPTER 2: LITREATURE REVIEW

All the studies in the research papers so evaluated were based on the following topics:

- Green construction
- Renovation of existing buildings
- Crafting of Conventional v/s Green Buildings
- Life cycle cost assessment
- Cost analysis of constructing
- Use of sustainable techniques in structure.

CII (Confederation of Indian Industry) reviews on Green Building Movement in India which states that, “With the developing awareness on green buildings, the Green Building Movement certain to soar above leading heights. The introduction of the concept of green buildings and its productive nature is challenging though carrying new opportunities. The stakeholders of the constructing enterprise need to be well equipped to meet these opportunities. There is an impending need for the stakeholders to actively participate in the green building movement via the IGBC and local chapters. As initiations of many green structures are coming up powering the Green Movement, the country will stand out as one of the leaders in green creations”.

2.1. Suttell noted that, “Despite the growing reputation of sustainable practices and excessive-overall performance technology in drafting designs with construction, situation in the facilities enterprise maintains because of loss of correct, thorough, and quantifiable statistics concerning the monetary and monetary influences of excessive-performance homes”.

2.2. Bahacan Aktas and Beliz Ozorhon [8] states in his work that sustainability has come to be a primary concern for the development enterprise. Renovation enhances the energy savings and now a days it is growing on a multiplicative way. Examination of components i.e. drivers, vitality, green beginnings of construction, limitations, benefits & affects. This work highlights the greening and legalization of the present structures. Investigation on six cases out 10 available projects was done. Out of which five projects were taken by private firms. An overall of five of these initiatives have been undertaken via personal organizations.

As this research involves LEED certified public project, the gaps and similarities between the view point and methodologies of both private and public clients was determined to a large extent.

2.2.1. Research Gaps (R.G.) –Though the above research work was updated but it showed emphasis only on Turkey point of view which might vary in countries with different climatic conditions and regulations. The author himself has suggested for similar analysis.

2.3. Marco Filippi [9] states that the high energy efficiency of the green structures play a pivotal role in framing a sustainable prospective. In this text, interference on buildings built before 1945 (referred as "historical buildings") mean a higher profit/value ratio, because, in many instances, green retrofitting can be connected to obligatory refurbishment works and renovated buildings can take on a thrilling market value. The remarks mentioned on this piece of work stimulates a dialogue on operational processes, barriers and demanding situations that traders, professional figures and supervisory government can come upon whilst they are involved in the green retrofitting of ancient buildings reflecting Italian cultural history.

2.3.1. R.G.-This study was based only on the existing historic buildings situated in Italy (economically stable and developed nation) and only a few effects of green fittings in real estate market has been discussed. But more advanced methodologies are required for the developing nations like India.

2.4. Inappropriate design of buildings in Malaysia led to poor environmental effect and reduces the monetary cost of building. This study is investigating and providing capability retrofitting of present building (UTHM). The strategies that may be carried out within the antique buildings had been investigated with a purpose to enhance the performance. Reports confirmed that there is a real requirement of converting present buildings into green retrofitting. The set-up of solar technology is the most precedence step amongst others within the operation green building retrofitting. [1]

2.4.1. R.G.-Only classic approaches for conversion of buildings into green structures were used. Prime emphasis was laid on major areas of green building conversion.

2.5. The finest advantages of UGI gets executed in climatic condition of hot-dry summers, there may be relatively little statistics available for land managers to decide the right approach in UGI implementation. This is a layout for priority defining and selecting cooling

temperatures. The four main cooling benefits of UGI were expressed by the author those were green open areas, shading of trees, greener roofing systems and green partitions and facades) and reflect the results of a case study framed in Melbourne, Australia. This work focuses mainly on temperature moderation. As such, in a state that has a negative impact on other ecosystem, the UGI provides benefits that will aid in temperature mitigation on a large scale. [2]

2.5.1. R.G. -The case study highlights steps that can be taken by the concerned authorities to take positive and precautionary actions start moderating high temperatures of urban lands using UGI. But it still lacks in determining proper arrangement of UGI in wide open landscapes or street canyons.

2.6. This research is done on the survey basis of 100 firms where Haris et al. found the factors determining energy efficient investment. "The main aim of this study is to provide new opportunities to builders and researchers with good knowledge of creating retro fittings incorporated with sustainable energy conservation. But the main challenges faced during these measures include changes in human behaviour, climatic changes and changes in government policies; etc. which have a direct impact on selection and implantation of retro fittings. The key challenging factors are limited financial sources, long time result processes and barriers in operations. Up gradation of the present buildings is at a very low rate. Energy efficient, financially sensitive with risk management are the basic points that will help in curing retrofit problems.[3]

2.6.1 R.G. - More studies with sensible case studies are required to promote advances in retrofitting's. Methods that are productive and economically stable should be used to provide economically sound and environment sensitive buildings. More flexible methods including human adaptiveness should be steps of major concern for advancement in retrofitting's.

2.7. A Study was conducted by the help of survey on 3 stages of obstacles - individual, organization related and institution related, concluding it with seven solutions to overcome them. It states that the main reason behind the failure of green building designs is that they do not underline the communal and subjective barriers. Buildings it has supplied best a quick evaluation of the subject and creator himself indicates and encourages similarly research on the briefed topic of his dialogue can be transformed into green structures by changing organizational formulas in association with growing requirement and psychology of the society (Giddens, 1979).[4]

2.7.1 R.G. - This study is an excellent explanation of the obstacles faced by the society however; it provides only a small overview of the topic. Further studies related to these articles are suggested by the author himself.

2.8. Amos Darko, Albert P.C. Chan (2016) [10] analysed 10 selected research papers from 10 different journals of CM from1990 to 2015 (August end) and constructed a trend that reveals that research on GB concept has increased with time. The study was supported by researchers from various nations namely Egypt, Singapore, US etc. Developing countries like Egypt, China and Columbia played a role crucial role in promotion of GB, and are expected to grow more in this field by urbanization.

2.8.1. R.G.- though the selection of the referred papers reports the trend of research on GB, but still lacks in more compatible studies. The paper might be reviewed in future to broaden working area and also focus on GB in other sectors as well as support the given findings.

2.9. C.M. Tam, Vivian W.Y. Tam 1, W.S. Tsui [11] proposed "green construction assessment" (GCA) system with the help of a tool, known as Environmental Assessment (EA) for monitoring, checking and reviewing the environment in accord with the construction management. Two types of environmental signs have been gathered: operational performance indicators (OPIs) and management performance indicators (MPIs). This provides thorough information for the contractors to lay down standards for evaluating performance. GCA gives a reliable, scientific and broad estimation of the environment. It comprises of thirteen such performance indicators in consultancy with the construction firms.

2.9.1 R.G. - this research is the beginning of green construction era, which demands more research work and the problems that arise vary in different fields.

2.10. R. N. Swamy [12] states that there has been an extraordinary advancement in the field of construction during the past years. The main achievements include the refreshing images of newly constructed dams, monuments, offshore structures, bridges and other buildings. But the transformation that has occurred globally is due to factors such as population growth, urbanization, excessive pollution and waste generation and also natural factors such as changes in weather and climatic conditions.

They have a great impact on the construction industry as constructions depends on available resources, energy and environment sustainability. The pillars that help in sustainable

development are sustainable designs for durability, substitutes for cement materials. Construction should be quoted as an integrated approach with in-situ performance structurally, which assures structural integrity and material stability.

2.11. Recycled powder can be used in place of SF or cement in RPC to make an RPC mixture. This mix is eco-friendly and also cost responsible. The ratio of the RPC mix is based on maximum packaging theory. After this analysis the water-cementious material ratio (w/cm) the selection of the recycled powder was done. This further affected the durability, strength and flowability with standard curing in the RPC mix.

The influence of GGBFS powder was observed which resulted in decrease in compressive and flexural strengths due to standard curing where crushed quartz was replaced with natural sand. This change brought decrease in chloride penetration to some extent, but a decrease in flowability and strength of the RPC mixture was largely observed. Thus, only a 10 % replacement was suggested.[5]

2.12. Kneifel, J. [13] states that identification of new energy efficient construction methodologies has become the prime factor to reduce energy consumption. An integrated approach was used to estimate effect of cost on energy-based carbon emissions. The objective of this study was to analyse decrease in emissions from the carbon sources with sustainable energy efficiency in buildings. About 576 energy efficient programs were run for 12 buildings in 16 different cities, with 3 building designs according to their locations respectively. Energy consumption and life-cycle costing of carbon emissions in each design was determined.

The research reports energy utility in new commercial builds to be reduced by 25-30% on an average and up to 40% (max.) can be done efficiently depending on their location. This is an initiation of cost effectiveness energy saving methods though having many implications. This work can be extended by linking more types of buildings design alternatives and locations. This kind of data is being incorporated by NIST in database sand framework designed by BEES. A great advancement can be achieved through these methods with changing time while factors such as project financing, government aid, alternative pricing; etc.

2.13. Sieglinde Fuller [14] states that application of LCCA (Life Cycle Cost Analysis) can be done to monetary investments which involve large scale investment to reduce future costs. This is a good estimation method of investment and monetary profits in future, but it would vary for structures with different designs, with different operating and maintenance costs. LCCA is an approach to analyse total buying, owning and dismantling expenditure of a building. This concept helps in determining incorporation of costly methods but have very low maintenance costing, thus proving to be a cost-efficient method. The commonly used measures are Lowest –LCC, Net Inflows, Internal rate of return, Savings to investment ratio (or Savings Benefit to cost Ratio), and Payback period.

2.14. Marszal, A. J., & Heiselberg, P. [15] stated that introduction and usage of more energy efficient technologies has become the major requirement in a developing land creating an eco-friendly and cost-effective environment. ZEB has questioned the point of usage of energy efficient methods and renewable technology. This technology known as Net ZEB gives an overview of private economy analysis as per owner's perspective by application of the LCC methodology.

Net ZEB mainly aims at minimizing energy usage to such an extent that the left-over energy can be generated as renewable energy.

The authors have also suggested some limitations of the LCC methodology as follows

(1) data usage in the local context

(2) the only renewable technology used is PV

(3) The BOLIG project is on a large scale makes the level prices lower.

(4) Unique modular builds

The authors also concluded that the energy consumed in constructing the building was far more than the renewable energy.

2.15. Wen, Y. K., & Kang, Y. J. [16] noted that buildings need to be constructed in a way to remain safe in times of natural disasters such as earthquakes and hurricanes and reduce the damage loss. Factors such as design load, duration of occurrence and intensity affects the certainty of the buildings. Overall cost of construction, maintenance, and failure resultants, including injuries and deaths, as well as lessening some amount at times were considered. They also researched on optimal designs for single and multiple loads and estimated its expenditures that should be built to prevent natural hazards.

In the past decade there has been a large-scale loss due to occurrence of large intensity natural disasters such as earthquakes and hurricanes that has made increasingly important to design the structures that have long-term benefit as compared to cost. The cost limit states need to be checked for uncertainties from time to time. A method including initial cost, costs due to different limit states under any number of hazards, and costing from time to time are properly considered.

2.16. Leckner, M., & Zmeureanu, R. [17] presented efficient use of solar energy to generate at least primary energy required by a house in a whole year, thus creating energy efficient homes through NZEH program. But this theory is not much supported graphically as in colder climatic regions such as Montreal. The energy payback time is 8.4 to 8.7 years, its concluded when compared with conventional build. The combi- system is 3.5 -3.8 has PBR (Power Back Ratio) compared with the heating system of conventional house. Solar collectors &photovoltaic modules from a wider range should be used in future for better results.

2.17. This study evaluated all kind of building structures (construction systems, construction products, civil construction sectors; etc.) and summarized literature synthesis of LCA &LCCA and LCEA. Study shows that LCEA and LCA were used to evaluate "exemplary buildings" which energy efficient buildings as compared to "traditional buildings". The main drawbacks are that the studies are carried only in urban files and not in rural areas, these studies are not distributed well all over the world. This proves that most of the studies are carried only in developed nations. [6]

2.18. Wang, B., Xia, X., & Zhang, J. stated that construction section is the major consuming department of the world's total energy. Therefore, use of energy efficient methods are given prime importance. Currently, the concept of retrofitting's the most productive and cost-effective method to bring growth in conservation of energy. An optimization model for retrofitting's and life cycle cost analysis was performed at present stage through Net Present Value (NPV). The best solution was calculated by considering alternative measures for each retrofitting intervention. The main aim of this model is gaining energy efficiency and cost effectiveness in limited time period. This problem can be solved through Differential Evolution algorithm (DE). This case study resulted in evaluation of cost effective, energy efficient methods applied incorporated with retrofitting's and their planning. The current

model is associated with analysis on building investment linked with total cost analysis obtaining cost benefits [12].

2.19. Goh, B. H., & Sun, Y. [19] researched LCC advantages and its development so far till date, but it is still not clear. Hi work focuses on use of LCC technology with life cycle methods on sustainable structures. It also estimates the total expense of "green buildings" compared to "conventional buildings". The findings show evaluation parameters of investment costing and energy productivity of green buildings, concluding that at social, economic and environmental levels optimization shall be done to produce more sustainable buildings.

2.20. Motuzienė, V., Rogoža, A., Lapinskienė, V., & Vilutienė, T.[20] worked on advancement is energy efficient designs of buildings to promote conservation of environment and demolition phases to keep a check on the impact of construction on environment. In this case study, environmental effects of 3substitutive types of envelopes are known as masonry, log and timber frame. The results of LCA and analysis of cost were determined by hierarchy procedure.

2.21. Tsai, W.-H., Yang, C.-H., Chang, J.-C., & Lee, H.-L. [21] Reported that the most important consideration in sustainable environment development is emission of carbon. Estimation of the building cost is based on managing of CO2 emissions (CSR Policy). The Study contributed (1) to help construction managers of organizations to more-precisely recognize the various allocation techniques of sources and investment for electricity saving practices to each green constructing through fine cost variables; (2) this presents a tool for bidding on eco-friendly projects; and (3) this shows contribution to the innovation operation research (OR) literature, specifically in regard to incorporating the life cycle assessment size into creation cost control by means of utilising a mixed selection version for green building projects".

2.22. Morrissey, J., & Horne, R. E. [22] showed the significance of built environment and its environmental impact. The key method in designing &constructing of structure is high thermal efficiency of the constructions. In Australia, there is a lack of national energy performance due to poor thermal capacity. The report presentation shows an integrated presentation, LCC way of going on to a large number of used house designs to investigate LC

expenses in cool climates. It has been concluded that more cost-effective buildings are more energy efficient. A life cycle assessment provides complete information on all environment parameters including emission of greenhouse gases and cement manufacture.
Theoretical issues associated with analysis of life cycle energy has been reported in this research paper and further analysed on thermal modelling life cycle cost at cool temperature conditions. Findings play a major role in cost effective method with energy conservation.

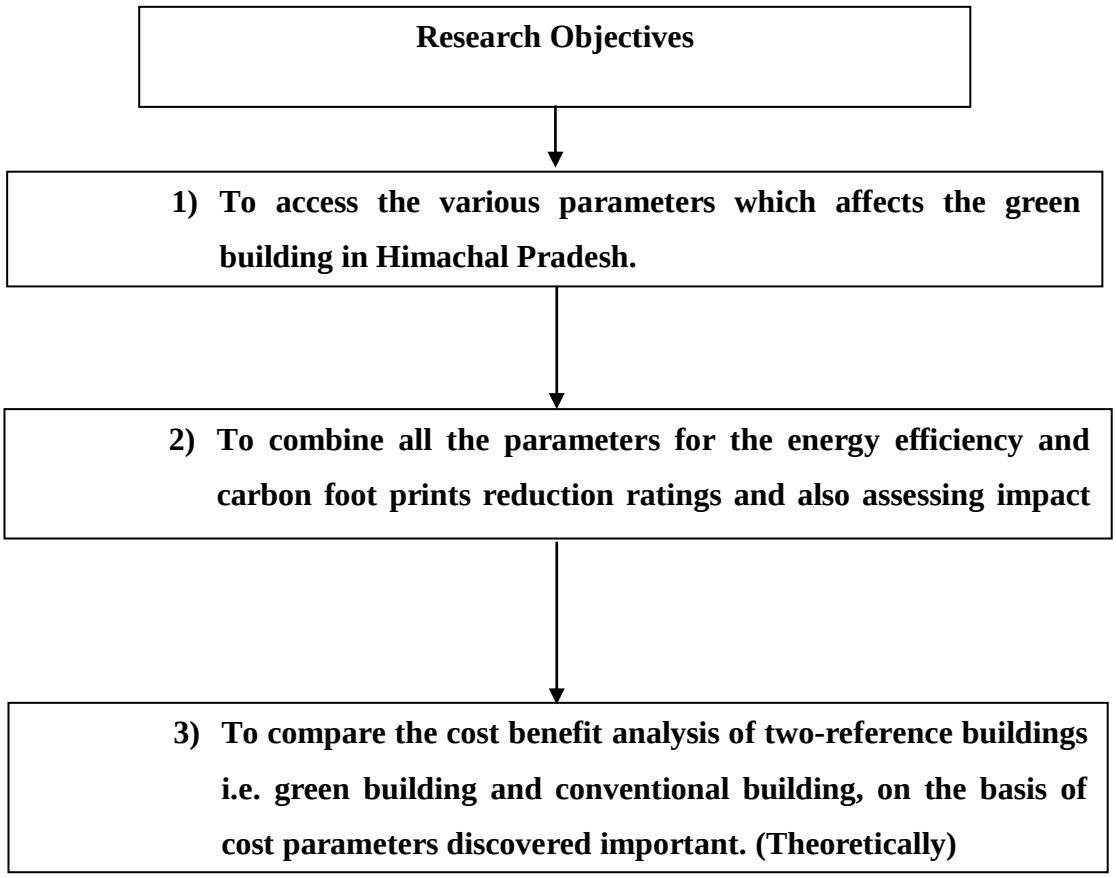
2.23. The study reveals that use of energy is a result of wide range of buildings. As the Kyoto targets on quantification of greenhouse gases, at the national level these approaches are necessary. Such analysis proves to be of great help as they reflect emission of greenhouse gases.

The paper reads theoretical based problems linked with LCA & utilizes designs based on Australian residential buildings. However, the results are productive enough in saving 6 % of total embodied energy. There are more ways of simulation that can be drawn by additional insulation.[7]

2.24. Zabalza Bribián, I., Valero Capilla, A., & Aranda Usón, A. [23] states that the building enterprise uses good quantities of raw materials that also involve high strength consumption. Choosing materials with excessive content material in embodied electricity entails an initial excessive level of energy intake within the constructing production stage however additionally determines future power intake so that it will fulfil heating, air flow and air conditioning demands. This paper provides the outcomes of an LCA, evaluating the most typically used constructing materials with a few eco-substances the usage of 3 exclusive impact categories.

2.25. Gluch, P., & Baumann, H. [24] wanted to state that the environmental considering equips, which is LLC oriented, recommended beneficial in ecological determination- creating been identified. The implementation level inside structure seems to be limited, conceptual discussion occurs. Theoretical assumptions were discussed and the proper use of LCC technique makes ecological responsible funding selections.

2.26. Research objective: -



CHAPTER 3: RESEARCH METHODOLOGY

3.1. General

3.2. Case studies

There were two buildings taken as reference for our study and experience.

Reference building 1- Data centre building (I.T.), Mehli, Shimla, H.P.-Conventional building of Himachal Pradesh (Office building)

Reference building 2- Himurja Building Complex, Kasumpti, Shimla- One of the first retrofitted buildings Green building of Himachal Pradesh.

It is the part of the SDA complex in kasumpti, Shimla, H.P.

3.2.1. Common for both types of buildings: - (Location of both buildings are almost similar)

3.2.2. Characteristics of site: -

1. Located on steeply sloping edge (Long axis is having the southern exposure)
2. No forest cover (due to presence of the steep slope)
3. Maximum sun facing (South-facing)
4. High velocity winds

3.2.3. Climatic characteristics: - (comes in the cold and cloudy zone)

1. Monthly temperature (mean)- <25°(degree Celsius)
2. RH - < 55%
3. Precipitation - > 5 mm
4. Total of clear days - < 20

Location: - Shimla

Longitude: - 77°10' E

Latitude: - 31° 06' N

Altitude: - 2202m AMSL

3.2.4. Features of Himurja Building: -

1. Double glazed windows – 12mm vacuum
2. Wooden flooring
3. South facing
4. Brick masonry (exterior cladding of walls)
5. Trombe wall
6. Windows and walls are north facing with wooden lining
7. Glass wall at back side of building wall for insulation
8. CGI Sheet roofing (triple layer: - sheet-glass-sheet)
9. Glass Solarium present in top of building (now due to cracks replaced with transparent sheet)
10. Top floor has glass wool insulations (new construction rest is old)
11. Double door at entrance to make the Indoor air quality and temperature normal as per the climatic set up. (rubber sealings in doors and windows)

Figure 1: Himurja Building (retrofitted green building)

Figure 2: Double Door system for proper ventilation and temperature maintenance

Figure 3: Vents provided for cross ventilation across rooms.

Figure 4: Solarium installed inside the himurja complex & internal office space

Figure 5: IT Bhawan, Mehli (conventional type of build)

3.3. Methodology

The research study focused on parameters assessment & also impact assessment of rating systems for region of Himachal Pradesh and on the basis of the parameters assessed we would compare the two-reference building on the cost basis. Following is the steps followed for the research work: -

1. Literature synthesis was conducted for assessing the parameters for green buildings.
2. Various rating system in India and their related documents were studied for assessing the impact of rating system.
3. Questionnaire survey was prepared for assessing impact of parameters and for studying the impact of rating systems.
4. Survey was conducted with the professionals for getting the desired results.
5. Top 50 parameters were evaluated on the survey basis and 27 impacts assessing questions of rating system were also elaborated.
6. Survey consisted of 147 questions of total, 5- point Likert scale used, with covering the majority of areas majorly listed for green buildings.
7. Survey analysis was done and comparison of the two-reference buildings on the basis of the cost parameters was elaborated theoretically by cost benefit analysis of the two. (discovered in study considered to be important)
8. Results were compiled and listed for study.

3.4. Data collection

3.4.1. Literature Synthesis: -

This was the most crucial part of the study as we discovered parameters and questions for the impact assessing of the rating bodies. This also opened the eyes of the research and gave a direction to the research for what has been done and what has to be considered for the future as important.

3.4.2. Questionnaire: -

The details for the assessing of parameters and impact study were generated by the questionnaire developed for the professionals of the state of Himachal Pradesh. On the basis of the importance of the parameter the further study was directed and the professionals consulted for the survey were the working professionals of the state of H.P. in various departments of different climatic areas.

3.4.3. Interviews: -

The details were also collected by personnel interviews with different professionals as per there availability. This helped the research in knowing the real problems or practical ones which existed presently in different terrains of the state of H.P.

3.4.4. Site look up: -

This was the important part for the research purposes as the data accumulation and interviews with the concerned authorities were conducted. The site details, pictures of various site features etc. were also assembled.

3.5. Data analysis: -

Parameter discovery for the state of Himachal Pradesh and short listing 50 top parameters for study analysis: -

1) Climate change
2) Pollution all types
3) Better Indoor environmental quality
4) Protection of habitat
5) Healthier & comfortable environment
6) Illumination levels
7) Indoor chemical & pollutant source control
8) Acoustic quality
9) Views
10) Better connectivity to all basic and day to day amenities
11) Accessibility (Public and private transportation & also to the person with disabilities)
12) Pedestrian pathways
13) Sewer and waterway contamination
14) Cost basis (Initial construction & renovation cost)
15) Cost basis (O & M cost, life cycle cost)
16) Deconstruction cost
17) Medical cost
18) Rental returns
19) Green features when installed in planning phase
20) Renewable energy usage
21) Electrical and plumbing systems

22) Plug loads i.e. refrigerators & coolers, etc.
23) Utilization of land, water, fly ash, existing site features etc.
24) Waste management
25) Water management
26) Aesthetic quality
27) Attractiveness
28) Building envelope
29) Orientation of structure
30) Low off-gassing materials &energy saving ones
31) Ventilation (natural)
32) Ventilation (mechanical)
33) Use of technology during construction
34) High rise construction
35) Energy efficient technology & renewable energy technology
36) Responsible sources of materials
37) Material reuse onsite offsite
38) Design for disassembly
39) Saving heritage and cultural identity
40) Intelligent building control systems
41) Waste segregations
42) Soil saving up to post construction
43) Occupiers (comfort, usability & productivity)
44) Use of plants
45) Erosion and sedimentation control
46) Brownfield redevelopment
47) Heat island effect (roof & non-roof)
48) Use of locally available materials
49) Certified wood usage
50) Innovation in design

3.5.1. Analysis of the 50 parameters listed, as per there numbering, is mentioned in the following table: -

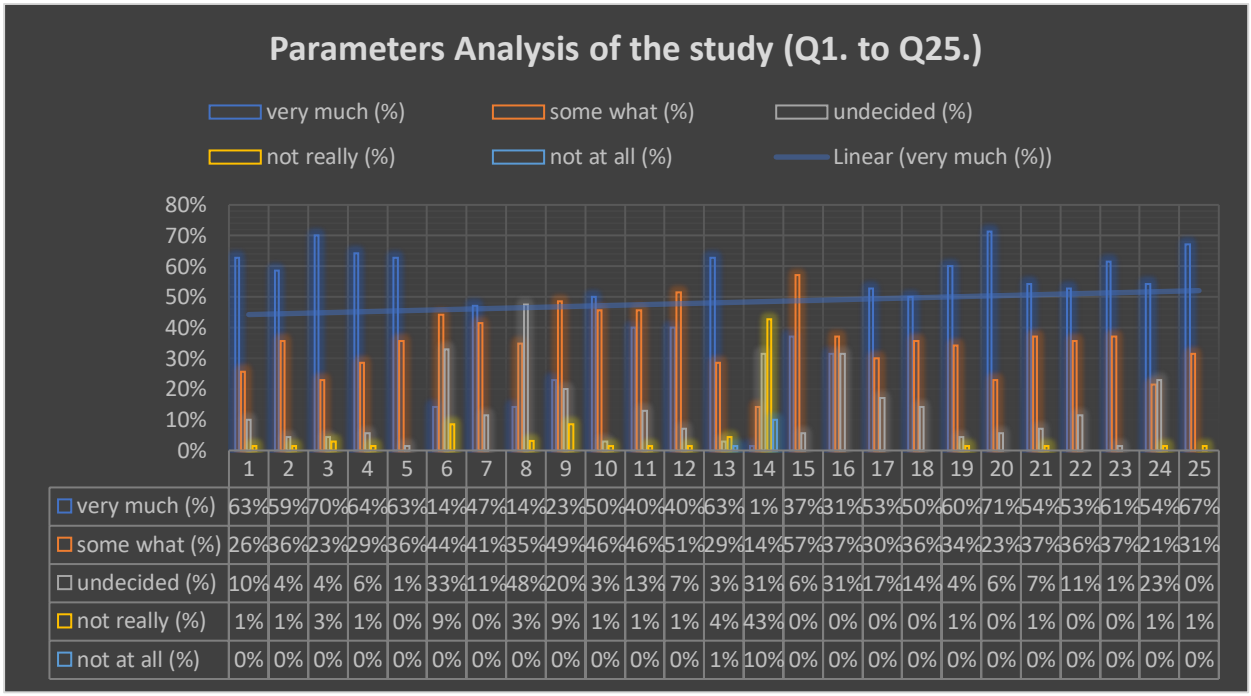
Table 1: Analysis of 50 parameters discovered

Questions	TOTAL	Very much (%)	Some What (%)	Undecided (%)	Not really (%)	Not at all (%)	Total (%)
Question(Q) 1	**70**	63%	26%	10%	1%	0%	**100%**
Q 2	**70**	59%	36%	4%	1%	0%	**100%**
Q3	**70**	70%	23%	4%	3%	0%	**100%**
Q4	**70**	64%	29%	6%	1%	0%	**100%**
Q5	**70**	63%	36%	1%	0%	0%	**100%**
Q6	**70**	14%	44%	33%	9%	0%	**100%**
Q7	**70**	47%	41%	11%	0%	0%	**100%**
Q8	**63**	14%	35%	48%	3%	0%	**100%**
Q9	**70**	23%	49%	20%	9%	0%	**100%**
Q10	**70**	50%	46%	3%	1%	0%	**100%**
Q11	**70**	40%	46%	13%	1%	0%	**100%**
Q12	**70**	40%	51%	7%	1%	0%	**100%**
Q13	**70**	63%	29%	3%	4%	1%	**100%**
Q14	**70**	1%	14%	31%	43%	10%	**100%**
Q15	**70**	37%	57%	6%	0%	0%	**100%**
Q16	**70**	31%	37%	31%	0%	0%	**100%**
Q17	**70**	53%	30%	17%	0%	0%	**100%**

Q18	**70**	50%	36%	14%	0%	0%	**100%**
Q19	**70**	60%	34%	4%	1%	0%	**100%**
Q20	**70**	71%	23%	6%	0%	0%	**100%**
Q21	**70**	54%	37%	7%	1%	0%	**100%**
Q22	**70**	53%	36%	11%	0%	0%	**100%**
Q23	**70**	61%	37%	1%	0%	0%	**100%**
Q24	**70**	54%	21%	23%	1%	0%	**100%**
Q25	**70**	67%	31%	0%	1%	0%	**100%**
Q26	**63**	40%	60%	0%	0%	0%	**100%**
Q27	**70**	20%	73%	6%	1%	0%	**100%**
Q28	**70**	60%	33%	7%	0%	0%	**100%**
Q29	**70**	67%	27%	6%	0%	0%	**100%**
Q30	**70**	53%	34%	10%	3%	0%	**100%**
Q31	**70**	54%	23%	17%	6%	0%	**100%**
Q32	**70**	21%	26%	33%	13%	7%	**100%**
Q33	**70**	34%	34%	30%	1%	0%	**100%**
Q34	**69**	25%	62%	12%	0%	1%	**100%**
Q35	**70**	19%	74%	6%	1%	0%	**100%**
Q36	**70**	43%	46%	10%	1%	0%	**100%**
Q37	**70**	34%	53%	9%	4%	0%	**100%**

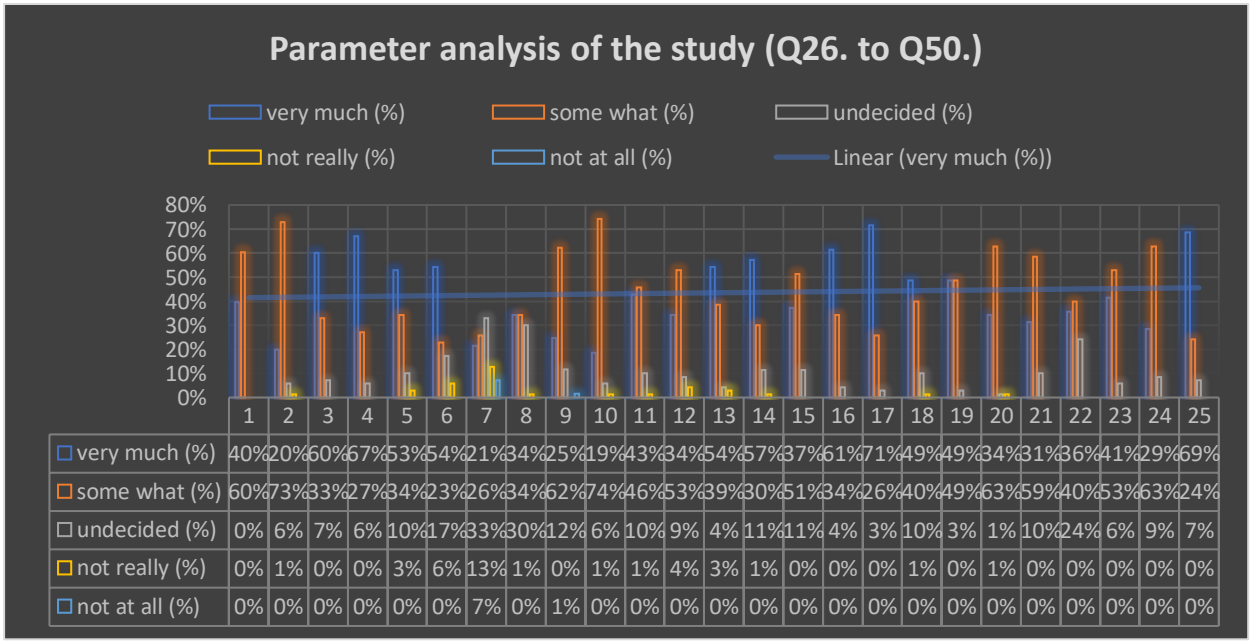
Q38	**70**	54%	39%	4%	3%	0%	**100%**
Q39	**70**	57%	30%	11%	1%	0%	**100%**
Q40	**70**	37%	51%	11%	0%	0%	**100%**
Q41	**70**	61%	34%	4%	0%	0%	**100%**
Q42	**70**	71%	26%	3%	0%	0%	**100%**
Q43	**70**	49%	40%	10%	1%	0%	**100%**
Q44	**70**	49%	49%	3%	0%	0%	**100%**
Q45	**70**	34%	63%	1%	1%	0%	**100%**
Q46	**70**	31%	59%	10%	0%	0%	**100%**
Q47	**70**	36%	40%	24%	0%	0%	**100%**
Q48	**70**	41%	53%	6%	0%	0%	**100%**
Q49	**70**	29%	63%	9%	0%	0%	**100%**
Q50	**70**	69%	24%	7%	0%	0%	**100%**

3.5.2. Graphical analysis of the 50 parameters data: -



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
very much (%)	63%	59%	70%	64%	63%	14%	47%	14%	23%	50%	40%	40%	63%	1%	37%	31%	53%	50%	60%	71%	54%	53%	61%	54%	67%
some what (%)	26%	36%	23%	29%	36%	44%	41%	35%	49%	46%	46%	51%	29%	14%	57%	37%	30%	36%	34%	23%	37%	36%	37%	21%	31%
undecided (%)	10%	4%	4%	6%	1%	33%	11%	48%	20%	3%	13%	7%	3%	31%	6%	31%	17%	14%	4%	6%	7%	11%	1%	23%	0%
not really (%)	1%	1%	3%	1%	0%	9%	0%	3%	9%	1%	1%	1%	4%	43%	0%	0%	0%	0%	1%	0%	1%	0%	0%	1%	1%
not at all (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure 6: -Parameters Analysis of the study (Q1. to Q25.)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
very much (%)	40%	20%	60%	67%	53%	54%	21%	34%	25%	19%	43%	34%	54%	57%	37%	61%	71%	49%	49%	34%	31%	36%	41%	29%	69%
some what (%)	60%	73%	33%	27%	34%	23%	26%	34%	62%	74%	46%	53%	39%	30%	51%	34%	26%	40%	49%	63%	59%	40%	53%	63%	24%
undecided (%)	0%	6%	7%	6%	10%	17%	33%	30%	12%	6%	10%	9%	4%	11%	11%	4%	3%	10%	3%	1%	10%	24%	6%	9%	7%
not really (%)	0%	1%	0%	0%	3%	6%	13%	1%	0%	1%	1%	4%	3%	1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%
not at all (%)	0%	0%	0%	0%	0%	0%	7%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure 7: -Parameter analysis of the study (Q26. to Q50.)

3.6. Impact assessment of the rating system in the state of Himachal Pradesh: -

(Appendices-A)

Table 2: Impact assessment analysis of the green rating bodies of India: -

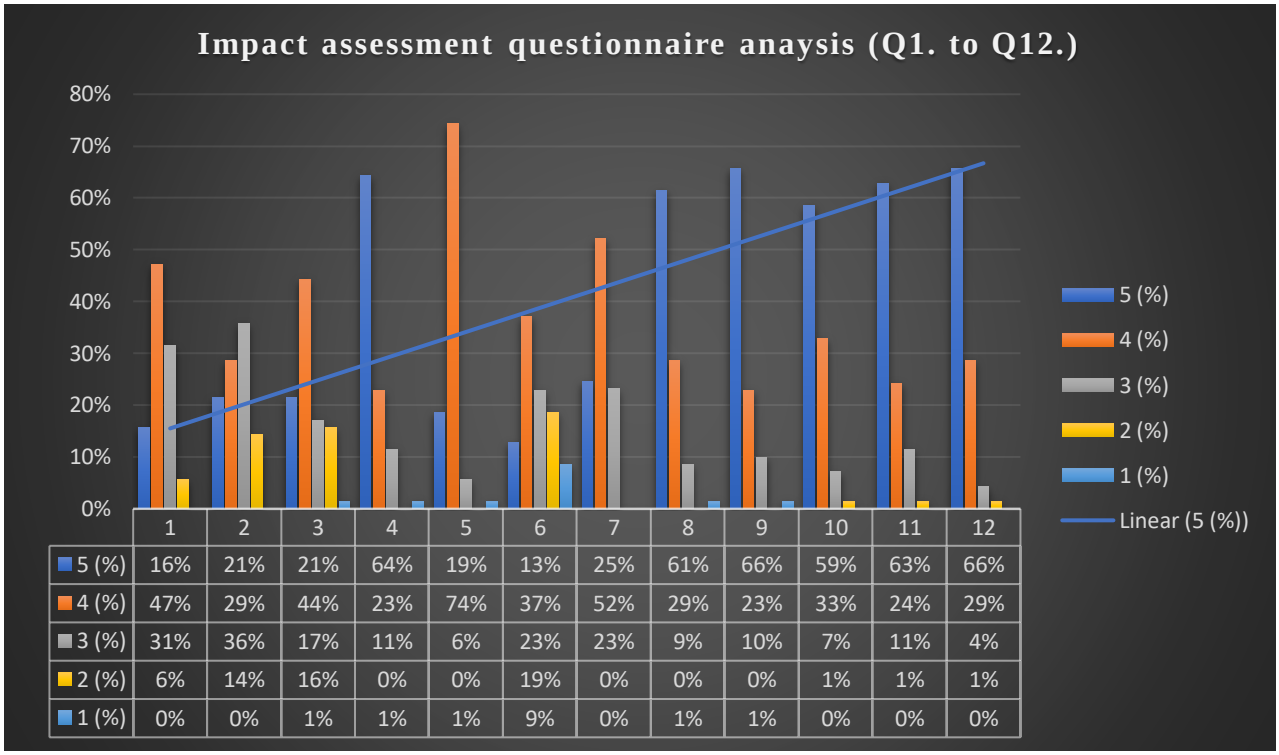
Questions	TOTAL	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	TOTAL (%)
Q1	**70**	16%	47%	31%	6%	0%	**100%**
Q2	**70**	21%	29%	36%	14%	0%	**100%**
Q3	**70**	21%	44%	17%	16%	1%	**100%**
Q4	**70**	64%	23%	11%	0%	1%	**100%**
Q5	**70**	19%	74%	6%	0%	1%	**100%**
Q6	**70**	13%	37%	23%	19%	9%	**100%**
Q7	**69**	25%	52%	23%	0%	0%	**100%**
Q8	**70**	61%	29%	9%	0%	1%	**100%**
Q9	**70**	66%	23%	10%	0%	1%	**100%**
Q10	**70**	59%	33%	7%	1%	0%	**100%**
Q11	**70**	63%	24%	11%	1%	0%	**100%**
Q12	**70**	66%	29%	4%	1%	0%	**100%**
Q13	**70**	36%	53%	11%	0%	0%	**100%**
Q14	**70**	39%	46%	14%	1%	0%	**100%**
Q15	**70**	30%	40%	24%	6%	0%	**100%**
Q16	**70**	27%	50%	20%	3%	0%	**100%**
Q17	**70**	34%	44%	14%	6%	1%	**100%**

Q18	**70**	34%	51%	11%	3%	0%	**100%**
Q19	**70**	30%	56%	11%	3%	0%	**100%**
Q20	**70**	44%	44%	9%	3%	0%	**100%**
Q21	**70**	40%	51%	7%	1%	0%	**100%**
Q22	**70**	29%	66%	4%	1%	0%	**100%**
Q23	**70**	33%	54%	10%	3%	0%	**100%**
Q24	**70**	53%	39%	7%	1%	0%	**100%**
Q25	**70**	21%	66%	11%	0%	1%	**100%**
Q26	**70**	39%	47%	11%	3%	0%	**100%**
Q27	**70**	50%	40%	9%	1%	0%	**100%**

This data shows that how much important role does the rating system plays for the promotion and upliftment of the green and sustainable construction in the country and especially Himachal Pradesh as this survey was intended and conducted in the state of H.P., India.

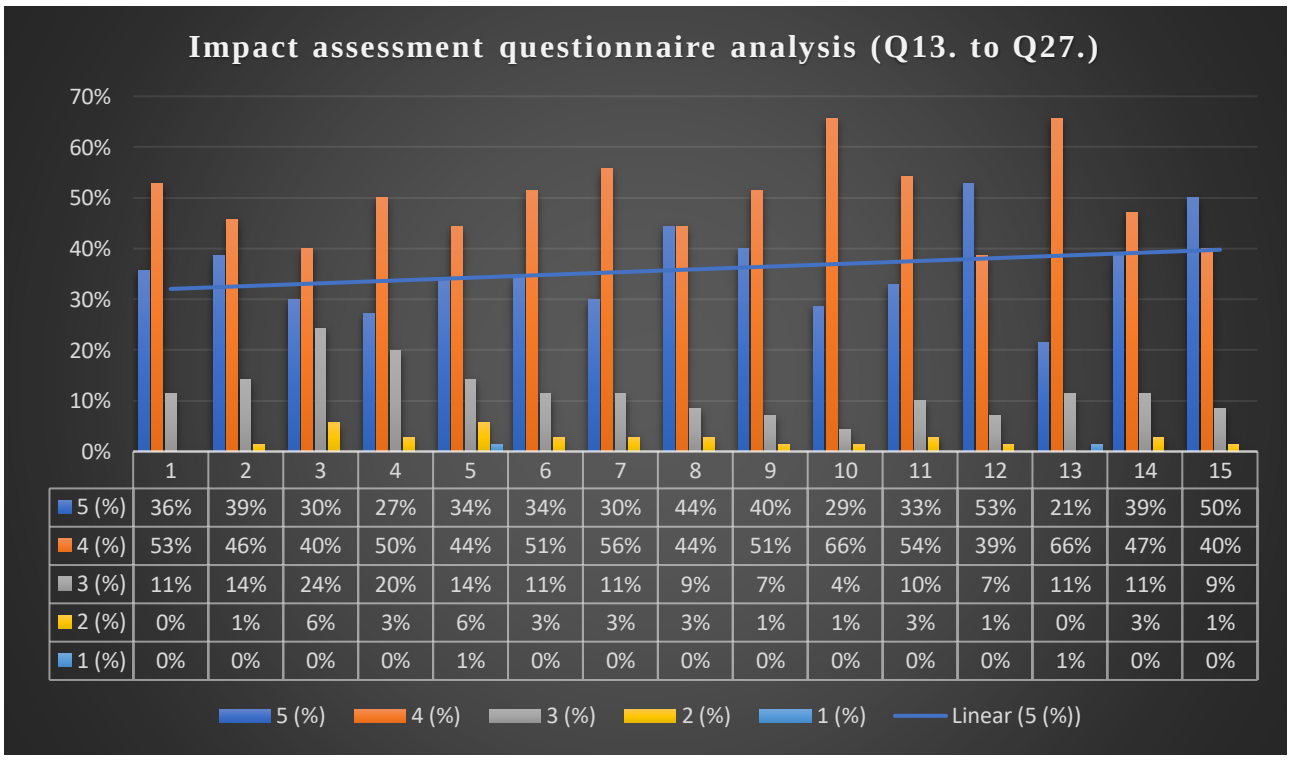
Major districts covered were Shimla, Solan, Kangra, etc. Shimla being the colder one and Baddi & Nalagarh, of district- Solan being the hotter ones. The personnel were asked to answer the questions according to the climatic conditions of their concerned area and the importance level they felt for the parameters for the region of Himachal Pradesh.

3.6.1. Graphical presentation of the impact analysis of the rating systems in India: -



	1	2	3	4	5	6	7	8	9	10	11	12
5 (%)	16%	21%	21%	64%	19%	13%	25%	61%	66%	59%	63%	66%
4 (%)	47%	29%	44%	23%	74%	37%	52%	29%	23%	33%	24%	29%
3 (%)	31%	36%	17%	11%	6%	23%	23%	9%	10%	7%	11%	4%
2 (%)	6%	14%	16%	0%	0%	19%	0%	0%	0%	1%	1%	1%
1 (%)	0%	0%	1%	1%	1%	9%	0%	1%	1%	0%	0%	0%

Figure 8: Impact assessment questionnaire analysis (Q1. to Q12.)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5 (%)	36%	39%	30%	27%	34%	34%	30%	44%	40%	29%	33%	53%	21%	39%	50%
4 (%)	53%	46%	40%	50%	44%	51%	56%	44%	51%	66%	54%	39%	66%	47%	40%
3 (%)	11%	14%	24%	20%	14%	11%	11%	9%	7%	4%	10%	7%	11%	11%	9%
2 (%)	0%	1%	6%	3%	6%	3%	3%	3%	1%	1%	3%	1%	0%	3%	1%
1 (%)	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%

Figure 9: Impact assessment questionnaire analysis (Q13. to Q27.)

3.7. Knowing maintenance, operation & investment costs: -

3.7.1. Maintenance cost: - The maintenance cost of the Himurja complex was about 25 lacs till date which comes out to be 2 lacs (approx.) or less per annum and the data centre building was about 2,22,210 Rs. The maintenance costs were exceeding for conventional builds through 15% or more.

3.7.2. Operation costs: -The operation costs for the green build was about 25-30% less than that of the conventional builds. The operation costs were affected by the type of usage in the office building i.e. electricity department would utilize more energy than compared to a normal other department like civil engineering or even IT department.

3.7.3. Total cost of investment: - Estimated cost of green building were 40-45% higher than for the same built up area of 823 sq. m of conventional built which was made comparable by reducing the cost to cost per sq. meter than converting it into cost of 823 sq. m. 59 Lacs (approx.) was the initial construction cost of the green build and for conventional build it was 33 Lacs (approx.)

3.7.4. Analysis of cost benefit (CBA): -

The cost and benefit of the two reference buildings were analysed on the basis of cash inflows (benefits) and outflows. These data accumulated from site visits and interviews with personnel's and by comparing the two buildings cost as even to each other by converting cost per sq. m for both builds. The cost of the buildings was made comparable by converting the cost each into per sq. m and then by placing it as initial ones for the concerned entities. This analysis was made for the major parameters of cost found out to be most important and if it directly or indirectly might become the reason for the variation of cost. The indirect parameters which were discovered important and cannot be estimated directly were interpreted theoretically in the result section. NPV of the project calculated for both buildings with the details as available on the time of the site visits, interviews, etc. Due to limitation of data sources the study could manage to calculate the NPV and ROI on the basis of some major parameters of cost only. The data was interpreted for getting the desired results.

The calculation had operation cost, maintenance cost and initial cost of investment as the basis for cost benefit analysis of the two structures as they serve as the major factor for choosing the best choice available.

CHAPTER: 4

RESULTS AND DISCUSSIONS

1. Results of the climate change, better IEQ, protection of Habitat, healthier and comfortable environment, sewer and water way contamination, green features when installed in planning phase, renewable energy usage, utilization (of land, water, fly ash, existing site features etc.), water management, building envelope, orientation of structure, waste segregation, soil conservation till post construction, innovation in design all bragged that they are the very basis for any of the green construction activity concerned for the state of Himachal Pradesh.
2. Indoor chemical & pollutant source control, Better connectivity to all basic and day to day amenities, Accessibility (Public and private transportation & also to the person with disabilities), Pedestrian pathways, Cost basis (O & M cost, life cycle cost), Medical cost, Rental returns, etc were considered somewhat important or undecided as per their needs and planning.
3. The cost basis (initial construction cost & renovation cost) was found more in favour to conventional builds.
4. The mechanical ventilation in the conventional builds are more to be utilized as compared to green ones but are not side-lined due to different climatic condition. This was a mixed poll which interpreted this conclusion.
5. As from the literature review Natural Ventilation was a major parameter and poll results also interprets the same saying.
6. Aesthetic quality, Plug loads, High rise construction performance, responsible sources of materials, material re-use onsite and offsite, Design for disassembly, saving heritage and cultural identity, occupiers (comfort, usability, productivity), use plants, erosion and sedimentation control, use of locally available resources, certified wood usage are some of the unique parameters which were discovered during the study and were considered somewhat important as for their implementation may enhance to an era of responsible construction with sustainability as its prime goal.
7. Materials with low off gassing & energy saving materials, use of technology during construction, Brownfield redevelopment, Heat island effect (roof & non-roof), illumination levels, acoustic quality, views are all parameters which got a mixed back

of review and most of the review being towards the positive quantum of my project. This can be concluded by saying that these mentioned parameters are also a very important one to be considered but for mostly commercial projects and for certifying them a good rating points stand.

8. NPV value for G.B. = 43981865

NPV value for convention build = 82771598

ROI for the G.B. = 70%

ROI for conventional build = 97%

The calculation was done for a span of 25 years at rate of 12%.

The cost appreciation was taken to be 27% annually.

9. The calculation had operation cost, maintenance cost and initial cost of investment as the basis for cost benefit analysis of the two structures as they serve as the major factor for choosing the best choice available.
10. Due to the operation and maintenance cost of the green build to be less than that of the conventional one it is clear from the result of NPV and ROI that the appreciation of the project over the years will result in significant large amount of cost savings.
11. The conventional builds only have the initial investment cost 30-40% less than that of the green builds. But this amount gets recovered with the duration and appreciation of the property build with the utmost quality.
12. The impact of rating system on the state of Himachal Pradesh was also assessed which concluded that market demand, split incentives, need of more stringent standards for rating, need for revision and adaption of latest updates in the field, current policies and system effect on rating system, accessibility to information were all now becoming somewhat important.
13. Role government, rules and regulations, role of promotional activities, monitoring the performance of the rated building time to time, disclosure and obtaining energy performance certificates on lease/sales, categorizing the building projects, need for online directory of all projects were the top most things which should be taken care of if proper impact of rating system is to be flourished.
14. Awareness among people was found to be just satisfactory.

15. Awareness among professionals was also mixed one. The lack of skilled personnel's is the major problem encountered during construction project in making it green.
16. Rules and regulations are also not laid properly nor clearly which makes the misuse of the rating agencies as prominent.
17. Green rating system was also found out to be easy to mind.
18. The need for study for green builds for various climatic conditions and impact assessment of rating system are the hottest area to be researched as per the survey.
19. These discovered parameters could be a very good use for adopting it in the criteria used for evaluation by TERI-GRIHA, for rating a green project.
20. Existing buildings can be renovated to green builds with a significant amount of energy and water savings resulting in a 40% and 30% savings respectively.
21. The initial cost of construction was almost about 45% higher than conventional builds but in the long run other than the initial investment all things result in greater savings, land appreciation, maintenance cost reduction by almost 30%.

CHAPTER: 5

CONCLUSIONS

1. The study did manage to pile up the 50 top parameters and the level of their importance for the state of Himachal Pradesh.
2. Medical costs and rental returns are also found to a plus point from the study.
3. The parameters assessed can be used for more precise judgment of green built building and also it can be adopted by TERI-GRIHA for point assessment of the rating criteria.
4. Some of the parameters could be made as a criterion and would not be compulsory to fulfil but can help a green project in getting extra rating. (mainly high commercial projects)
5. The benchmarking, disclosure & reporting should be made compulsory for the construction project which implies with the rating in papers.
6. The follow up after the completion of a green rated project should be done at regular intervals as for checking its status being matching which was expected both in design and performance. (performance monitoring)
7. The CBA analysis also tells the same thing as expected by a green built construction with an initial investment recovery in life cycle.
8. The study also bragged out that there is a very urgent need for having study researches in the field of impact assessment of rating system in the present scenario for better results for the future as the rate of green building development is doubling every 3 years. There is also a need for study for different climatic zones in India as India is having the most versatile type of climatic zones.
9. This study is also important as India is a developing country and process of development comes with the aggressive processes of construction and for Himachal Pradesh a unplanned example of development is the region of Baddi, District- Solan.
10. All kinds of pollution and unplanned design of most of the constructions are present in a single place. The region is inhabited by people basically working in various firms as Baddi is the Himachal's best progressive area as compared to other in terms of capital generation. The reason for the uneven design is to generate more capital as rental costs will increase by putting the free space to use as rented one.

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APPENDIX-A

Questionnaire for the professionals to access the parameters of green building for the state of Himachal Pradesh and the impact assessment of rating system:

PERSONAL DETAILS **DATE:**

Name:

Gender:

Age:

Educational Qualification:

Profession:

Years of experience:

Annual income:

Members in family:

Years of experience in green construction:

GREEN BUILDING PARAMETER ASSESSMENT QUESTIONNAIRE

Answer the following by indicating the answer as 1, 2, 3, 4 or 5. (The effect increases as the number increases, 1 means no influence, 5 means quite important)

Indicate how far Green Buildings are better than Conventional Buildings- 1 2 3 4 5

ENVIRONMENTAL ISSUSES	
1. Climate change	1 2 3 4 5
2. Depletion of ozone	1 2 3 4 5
3. Land pollution	1 2 3 4 5
4. Water pollution	1 2 3 4 5
5. Air pollution	1 2 3 4 5
6. Light pollution	1 2 3 4 5

7. Noise pollution	1 2 3 4 5
8. Better indoor environment quality	1 2 3 4 5
9. Protection of habitat	1 2 3 4 5
10. Healthier environment	1 2 3 4 5
11. Comfortable environment	1 2 3 4 5
12. Indoor chemical and pollutant source control	1 2 3 4 5
13. Views	1 2 3 4 5
14. Glare control	1 2 3 4 5
15. Illumination levels	1 2 3 4 5
16. Acoustic quality	1 2 3 4 5
ACCESSIBILITY	
17. Better urban connectivity	1 2 3 4 5
18. Load on local traffic conditions	1 2 3 4 5
19. Pedestrian pathways	1 2 3 4 5
20. Proximity to amenities	1 2 3 4 5
21. Public transportation	1 2 3 4 5
22. Private transportation	1 2 3 4 5
23. Sewer & waterway contamination	1 2 3 4 5
24. Level of accessibility for persons with disabilities	1 2 3 4 5
COST BASIS FOR GREEN BUILDS TO CONVENTIONAL BUILDS	
25. Initial construction cost	1 2 3 4 5
26. Operation cost	1 2 3 4 5
27. Maintenance cost	1 2 3 4 5
28. End of life cycle cost	1 2 3 4 5
29. Renovation cost	1 2 3 4 5
30. Deconstruction cost	1 2 3 4 5
31. Total cost of construction	1 2 3 4 5
32. Life cycle cost of construction	1 2 3 4 5
33. Green features when installed in planning phase	1 2 3 4 5
34. Medical costs	1 2 3 4 5
35. Rental returns	1 2 3 4 5
INDICATE IN TERMS OF ENERGY EFFECIENCY FOR GREEN HOMES TO	

BE BETTER THAN CONVENTIONAL ONES	
36. Solar energy	1 2 3 4 5
37. Wind energy	1 2 3 4 5
38. Geothermal energy	1 2 3 4 5
39. Hydropower	1 2 3 4 5
40. Electrical and plumbing system	1 2 3 4 5
41. Plug loads i.e. refrigerators & coolers, etc.	1 2 3 4 5
INDICATE FOR GREEN HOMES:	
42. Utilization of land	1 2 3 4 5
43. Water utilization	1 2 3 4 5
44. Visual or lighting comfort	1 2 3 4 5
45. Waste management	1 2 3 4 5
46. Worker productivity	1 2 3 4 5
47. Attractiveness	1 2 3 4 5
48. Aesthetic quality	1 2 3 4 5
49. Building envelope	1 2 3 4 5
50. Orientation of structure	1 2 3 4 5
51. Market demand	1 2 3 4 5
52. Enhancement of market image for real estate	1 2 3 4 5
53. Materials with low off gassing	1 2 3 4 5
54. Natural ventilation	1 2 3 4 5
55. Mechanical ventilation	1 2 3 4 5
56. Energy saving materials	1 2 3 4 5
57. Use of technology during construction	1 2 3 4 5
58. Difficulty in construction	1 2 3 4 5
59. High rise construction performance	1 2 3 4 5
60. Difficulty in retrofitting	1 2 3 4 5
61. Energy efficient technology	1 2 3 4 5
62. Renewable energy technology	1 2 3 4 5
63. Awareness among common people	1 2 3 4 5
64. Awareness among professionals	1 2 3 4 5
65. Responsible sources of materials	1 2 3 4 5

66. Material re-use onsite	1 2 3 4 5
67. Material re-use offsite	1 2 3 4 5
68. Design for disassembly	1 2 3 4 5
69. Role of government	1 2 3 4 5
70. Govt. incentives	1 2 3 4 5
71. Rules and regulations	1 2 3 4 5
72. Heritage and cultural identity	1 2 3 4 5
73. Support of national economy	1 2 3 4 5
74. Energy use submetering	1 2 3 4 5
75. Leak detection	1 2 3 4 5
76. Organic waste management	1 2 3 4 5
77. Intelligent building control system	1 2 3 4 5
78. Protection of landscape	1 2 3 4 5
79. Landscape water demand	1 2 3 4 5
80. Utilization of fly ash	1 2 3 4 5
81. Waste water treatment	1 2 3 4 5
82. Waste segregation	1 2 3 4 5
83. Operations & maintenance	1 2 3 4 5
84. Soil conservation till post construction	1 2 3 4 5
85. Utilization of existing site features	1 2 3 4 5
86. Onsite utilities and circulation efficiency	1 2 3 4 5
87. Split incentives	1 2 3 4 5
88. Assurance of premium for developers when the go green	1 2 3 4 5
89. Unclear savings for investing or buying	1 2 3 4 5
90. Annual rewarding to local governing bodies for their best performance	1 2 3 4 5
91. Role of promotional activities	1 2 3 4 5
92. Importance of performance monitoring	1 2 3 4 5
93. Importance of regulatory and institutional performance monitoring	1 2 3 4 5
94. Underperformance	1 2 3 4 5
95. Occupiers comfort	1 2 3 4 5

96. Occupiers usability	1 2 3 4 5
97. Occupiers productivity	1 2 3 4 5
98. Need of more transparent data for performance monitoring	1 2 3 4 5
99. Disclosure and obtaining energy performance certificates on sales/lease	1 2 3 4 5
100. Use of plants etc	1 2 3 4 5
101. Erosion & Sedimentation Control	1 2 3 4 5
102. Brownfield Redevelopment	1 2 3 4 5
103. Alternative Transportation: Low emission & alternative fuel refuelling Stations	1 2 3 4 5
104. Alternative Transportation: Parking capacity	1 2 3 4 5
105. Reduced site disturbance: Development footprint	1 2 3 4 5
106. Heat Island Effect, Non- roof	1 2 3 4 5
107. Heat Island Effect, roof	1 2 3 4 5
108. Water efficiency in AC systems	1 2 3 4 5
109. Innovative wastewater technologies	1 2 3 4 5
110. CFC reduction in HVAC & R equipment	1 2 3 4 5
111. Use of regional materials	1 2 3 4 5
112. Certified wood usage	1 2 3 4 5
113. Outdoor air delivery monitoring	1 2 3 4 5
114. Low emitting materials usage	1 2 3 4 5
115. Thermal Comfort: Verification	1 2 3 4 5
116. Thermal Comfort: Design	1 2 3 4 5
117. Innovation in Design	1 2 3 4 5
118. Online questionnaire for improvement of work onsite and off	1 2 3 4 5
119. Feedback to users	1 2 3 4 5
120. Need of more stringent standards for rating	1 2 3 4 5
121. Need for revision and adaption of latest updates in the field	1 2 3 4 5
122. Effect of current policies and system in place for performance of rating system	1 2 3 4 5
123. Accessibility of information	1 2 3 4 5

124. Quality of information	1 2 3 4 5
125. Importance of division into different categories i.e. residential, commercial, etc.	1 2 3 4 5
126. Importance level of checklist of points awarded to projects to be disclosed	1 2 3 4 5
127. Need for online directory of all projects and pre-certified buildings	1 2 3 4 5
128. Generating and disseminating information	1 2 3 4 5
129. Indicate for use of extensive glass	1 2 3 4 5
130. Importance of benchmarking, disclosure & reporting	1 2 3 4 5
131. Green rating systems to be intelligible	1 2 3 4 5
132. Strengthen technical preparedness for bridging the gap between modelled and actual performance of buildings	1 2 3 4 5
133. Role of rating agencies for awareness campaign	1 2 3 4 5
134. Role of biophilia i.e. "the urge to affiliate with other forms of life"	1 2 3 4 5
135. Seasonal design of the built green structure	1 2 3 4 5
136. Need for study of impacts of rating system	1 2 3 4 5
137. Need for study for different climatic zones in India	1 2 3 4 5
138. Green building to be sustainable not fully green i.e. alternatives if required	1 2 3 4 5
139. Indicate for green building to be purely green	1 2 3 4 5
140. Did the questionnaire provide appropriate information needed to answer the desired questions	1 2 3 4 5
141. Did the questionnaire fulfil the job which it was intended for, indicate?	1 2 3 4 5
142. Indicate for the language of the questionnaire to be easy/others.	1 2 3 4 5
143. Will this questionnaire be any help for future studies or design, indicate?	1 2 3 4 5

144. Do you think the topic of the questionnaire is relevant for study_____?
145. Mention a prime problem from your experience which affects the green build's in state of Himachal Pradesh _____
146. Mention an area of concern in the concept of green buildings which needs to be researched for the region of Himachal Pradesh_____
147. Major parameter you find is the most important _____

THANK YOU FOR TAKING THIS SURVEY!