T.C.
İSTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

ARCHITECTURAL MANAGEMENT FOR SUSTAINABLE BUILDINGS

MASTER THESIS

Ali Sattar Farhood ABULIBAN

Engineering Management Department

Engineering Management Master in English Program

AUGUST 2022

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Thesis Advisor: Assist. Prof. Dr. Bülent İMAMOĞLU

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LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

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DECLARATION

I declare that this M.Sc. thesis titled "Architectural Management of Sustainable Buildings" was written without any help that would contradict scientific morals and traditions in all processes from the project phase to the conclusion of the thesis, and the works I benefited from were those shown in the Bibliography, and I honorably benefited from them. (03/08/2022)

Ali Sattar Farhood ABULİBAN

PREFACE

Are we on the right track in terms of scientific progress? And what did the industrial revolution bring to nature on the one hand, and the future of the earth on the other? Apparently, we are in a situation of natural resource depletion, and what is happening now, from climate change to high CO_2 levels in the atmosphere, resulting in global warming, is the strongest evidence for this. Unless we (the scientific community) begin to work together to conquer this enormous challenge by not only warning and grieving about our dying planet, but also taking significant moves toward our saviors, which are sustainability and optimization in all parts of our lives.

The construction industry accounts for a significant portion of global energy, electricity, water, and material consumption. According to the United Nations' Intergovernmental Panel on Climate Change (IPCC), this industry accounts for over 20% of worldwide CO_2 emissions. It is critical to develop innovative, more effective building systems and technologies that have a lower environmental impact.

The building designers have a significant amount of responsibility. They must consider sustainability from an early age, and so engage in the process of conserving natural resources, conserving energy, and setting the path for the development of a new sustainable strategy and way of life.

Finally, I'd like to thank my advisor, Dr. Öğr. Üyesi Bülent İMAMOĞLU, for his invaluable assistance and support throughout the composition of my thesis. My family, of course, who gently pushed and stimulated me while providing unending support. My parents, I believe, deserve credit for this thesis because without their love and encouragement, I would not have gotten to where I am now.

August 2022 Ali Sattar Farhood ABULIBAN

Architectural Engineer

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ABBREVIATIONS

AIA :American Institute of Architects
TU/e :Eindhoven University of Technology
MHP :Method Holistic Participation
SPS :Straw Panel System
HVAC :Heating ventilation air-conditioning
RMIT :Royal Melbourne Institute of Technology
LCA :Life Cycle Assessment
PM :Prime Minister
WCED :World Commission on Environment and Development
UNCED :United Nations "Conference on Environment and Development"
UNFCCC :United Nations Framework Convention on Climate Change
LEED :Leadership in Energy and Environmental Design
IAQ :Indoor Air-Quality
USGBC :U.S Green Building Council
BREEAM :Building Research Establishment Environmental Assessment Method
EPA :Environmental Protection Agency
CSRE :Cement Stabilized Rammed Earth
WCED :World Commission on Environment and Development
GHG :Geeen House Gas
VOC :Volatile Organic Compounds
DOE :Department Of Energy
PV :Photo-Voltaic

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ARCHITECTURAL MANAGEMENT OF SUSTAINABLE BUILDINGS

ABSTRACT

The central theme of this thesis is the importance of individual and collective responsibility for the future of humanity and the future of this planet (where there is no other place to go). Because of climate change, we are on the verge of reaching a point of no return unless we begin to properly consider the environment in everything we produce, including the design of buildings, which we are doing right now in our industry. Because of global warming and climate change, there is an increasing demand for the integration of environmental practices into the building and architectural industries. This thesis investigates this need.

The ability to be energy efficient is the most important feature of sustainability, and architects are constantly adapting new technologies in an attempt to integrate both the outside and the constructed environment in an energy efficient manner.

The suggested outline for this thesis was developed after reviewing the most recent research in the topic. Followed by an extensive review of the literature, each principle is discussed in detail, including the strategies and procedures that should be taken into consideration throughout the life cycle of a building project. Case studies from around the world are also included to ensure a better understanding of this field. In order to achieve a suitable balance between economic, social, and environmental considerations during design, the construction outlines should be redefined by the professionals considering the data they use when appraising building projects, thereby contributing to the long-term viability of the construction sector. More eco-friendly consciousness has emerged as a result of the integration of environmental practices, which has sparked significant public changes that have altered the area of architecture significantly. The movement toward environmentally friendly architecture has attempted to revitalize the relationships between the built and natural surroundings to a significant degree. The most important means has been to continually pushing for greater energy efficiency while also investigating new sustainable technologies and always keeping the repercussions of any decision in mind, most notably in the first phases of designing. It is possible to define the concept of continuous consideration of energy efficient design with the word sustainability, which refers to a general notion that satisfies its current needs without interfering with the demands of the future.

According to the AIA, architects should consider using energy simulation in their designs. Improved energy efficiency systems in construction projects are made possible in large part by the efforts of building designers. The decisions that have the greatest impact on energy optimization are taken during the early stages of the design process. Typically, designers do not use those assessments until it is too late.

Keywords: *Sustainability, sustainable buildings, climate change, environmental friendly, sustainable design*

SÜRDÜRÜLEBİLİR BİNALARIN MİMARİ YÖNETİMİ

ÖZET

Bu tezin ana teması, insanlığın geleceği ve bu gezegenin (gidecek başka bir yerin olmadığı) geleceği için bireysel ve kolektif sorumluluğun önemidir. İklim değişikliği nedeniyle, şu anda sektörümüzde yaptığımız bina tasarımı da dahil olmak üzere ürettiğimiz her şeyde çevreyi doğru bir şekilde düşünmeye başlamazsak, geri dönüşü olmayan bir noktaya ulaşmanın eşiğindeyiz. Küresel ısınma ve iklim değişikliği nedeniyle, çevresel uygulamaların yapı ve mimari endüstrilere entegrasyonu için artan bir talep var. Bu tez bu ihtiyacı araştırmaktadır.

Enerji verimli olma yeteneği, sürdürülebilirliğin en önemli özelliğidir ve mimarlar, hem dış hem de inşa edilmiş çevreyi enerji verimli bir şekilde entegre etme girişiminde sürekli olarak yeni teknolojileri uyarlamaktadır.

Bu tez için önerilen taslak, konuyla ilgili en son araştırmaları gözden geçirdikten sonra geliştirilmiştir. Kapsamlı bir literatür taramasının ardından, bir bina projesinin yaşam döngüsü boyunca dikkate alınması gereken stratejiler ve prosedürler dahil olmak üzere her bir ilke ayrıntılı olarak tartışılmaktadır. Bu alanın daha iyi anlaşılmasını sağlamak için dünyanın dört bir yanından vaka çalışmaları da dahil edilmiştir. Tasarım sırasında ekonomik, sosyal ve çevresel hususlar arasında uygun bir denge sağlamak için, inşaat ana hatları, inşaat projelerini değerlendirirken kullandıkları veriler göz önünde bulundurularak profesyoneller tarafından yeniden tanımlanmalı ve böylece inşaat sektörünün uzun vadeli uygulanabilirliğine katkıda bulunmalıdır. Çevresel uygulamaların entegrasyonunun bir sonucu olarak, mimarlık alanını önemli ölçüde değiştiren önemli kamusal değişimlere yol açan daha çevre dostu bilinç ortaya çıktı. Çevre dostu mimariye doğru hareket, yapılı ve doğal çevre arasındaki ilişkileri önemli ölçüde canlandırmaya çalıştı. En önemli yol, sürekli olarak daha fazla enerji verimliliği için zorlamak ve aynı zamanda yeni sürdürülebilir teknolojileri araştırmak ve özellikle tasarımın ilk aşamalarında herhangi bir kararın yansımalarını daima akılda tutmak olmuştur. Enerji verimli tasarımın sürekli göz önünde bulundurulması kavramını, geleceğin taleplerine müdahale etmeden mevcut ihtiyaçlarını karşılayan genel bir kavramı ifade eden sürdürülebilirlik kelimesi ile tanımlamak mümkündür.

AIA'ya göre, mimarlar tasarımlarında enerji simülasyonu kullanmayı düşünmelidir. İnşaat projelerinde iyileştirilmiş enerji verimliliği sistemleri, büyük ölçüde bina tasarımcılarının çabalarıyla mümkün olmaktadır. Enerji optimizasyonu üzerinde en büyük etkiye sahip kararlar, tasarım sürecinin ilk aşamalarında alınır. Tipik olarak, tasarımcılar çok geç olana kadar bu değerlendirmeleri kullanmazlar.

Anahtar Kelimeler: *Sürdürülebilirlik, sürdürülebilir binalar, iklim değişikliği, çevre dostu, sürdürülebilir tasarım*

1. INTRUDUCTION

1.1 Study Topic

One of the modern architecture drawbacks is that it doesn’t keep in consideration the relationship between building and its surrounding (nature) leading to a kind of disconnection between many related factors that should be took seriously in the design of a building.

All buildings analogy suitable for all countries with different weather, this was the dream of Le Corbusier in which the building is independent of its location. If we take a building from a certain city in the east, you would find few differences from a building in the west, a mass of closed steel and glass boxes without fresh air or natural sun light. These cause loss of identity of the buildings around the globe (Gissen, 2003).

Sustainability on the other hand, is a measure of the relationship between building and its surrounding making use of renewable resources and utilize it within the design of the building (Yilmaz, 2006).

In recent years, several sectors have shifted their focus to environmental sustainability and the implementation of green practices in response to growing worldwide awareness of the harmful effects of human activity on the environment. In order to reduce the environmental effect of their construction projects, building construction firms from across the globe have included the green idea into their strategies.

Due to the rising fear from the harmful effects of human actions on the environment, there is a rapid movement towards sustainable industry applying green procedures Hwang and Ng (2013).

There are different problems for project managers as the sector evolves, which necessitates them taking on additional responsibilities that were previously outside their scope. Ceran and Dorman (1995) claimed that construction project managers need to enhance their conventional tasks with non-engineering knowledge and abilities in order to fulfill today's professional expectations in the industry. Today's project manager should not only perform the conventional tasks of project management, but must also conduct the work in the most optimal and practical way with regard to sustainability.

1.2 Purpose of Study

How to employ sustainability values in the building industry is the goal of this thesis, also how to link two disciplines represented by architectural management and sustainability, precise definitions are needed to understand and join them together.

1.3 Literature Review

In the past, the main concerns of shareholders and business owners in any building process was lower cost, in use efficiency, quality and productivity of the produced building. Recently, shareholders and business owners began gradually more interested in the impact of building on the nature Ortiz et al. (2009). Architectural design based on nature preservation (sustainable building) is the only option for humanity to ensure a better life quality for the next generations by preventing environment destruction, decreasing pollution, waste minimization and the optimum use of energy, all this could only be accomplished by practicing eco-friendly architectural designs. A new discipline of architecture should be adopted which can produce buildings that can treat its own waste, minimize the using of natural resources and hence resulting in a better, cleaner environment (Yılmaz, 2006).

Plessis (2003) enquired a simple question, “are our responses really preparing us for the changes (environmental and socio-economic threats) ahead?” Suggesting that for the building industry to produce better, ecofriendly and healthy nature, it should have to alter or even discard most of the current usual practices and hence facing three main tasks:

- Taking the following technology jump;
- Implementing new construction methods; and
- Implementing new building products.

On the other hand, we have the green construction materials that should be included at the early stages of design. These materials should have similar or even higher properties than the often used materials. Thus, selecting materials with the minimum impact on nature is necessary for any green building design kshatri (2021). Also, the use of steel as a construction material in the structure of a building is considered beneficial through the life cycle of the building as steel could meet the sustainability criteria due to its durability and can be recycled and reused. As a result reducing the influence on nature Aksel and Eren (2015).

Besides choosing sustainable materials, there are several sustainable design strategies which can be employed in buildings design for example, the use of renewable energy, building alignment, and even the use of colors to reflect or absorb heat which reduce the direct energy consumption. All these factors can be added in the early phase of building design Antolin et al. (2019).

To stand on the challenges which face the green construction particularly the design team Rekola et al. (2014) analyzed the practices in the management of sustainable buildings to recognize the role of the design team. The study found that the definition of such new discipline and all its boundaries is still not understood yet. But, it does not mean more tasks rather than modifying existed tasks to be applicable on this new system in a way that goes in harmony with nature.

Many researchers conducted interviews and questionnaires to more understand green construction and its challenges from project managers and owners point of view. The study by Hwang and Ng (2013) revealed the challenges and tackles of executing a green project by interviewing project managers. The results showed essential key points should be taken to overcome such challenges which are: (1) more time needed for preparations; (2) choosing subcontractors who works and understand sustainability could be more difficult; (3) choosing green materials and tools also could be more ambiguous; (4) more prices should be took into considerations; (5) more time spent in consulting, paper works, design modification, thinking in different construction strategies, etc.; and (6) unexpected situations. While the study of Shi et al. (2013) which is a survey with owners of green projects exposed that there are more costs, more time and the lack of green providers and information.

Use of simulation and computer-aided assessment could be a powerful tool for evaluating sustainable architecture. Suryawinata (2021) used immersive technology as a tool for studying sustainable buildings. This tool proved to be useful in improving building sustainability making the road for more eco-friendly architecture.

Inorder to design a sustainable building, sustainable architect should put in his mind what comes after his product expiry. Deconstruction, the sustainable face of demolition, should not look at as a waste or abandoned product, it is a material that can be used in other buildings with low costs and low impact on natural resources. Putting deconstruction in the plans of a building which could make it easy to be deconstructed or reused in the future is becoming more interesting for building designers and considered as a critical factor in any new design Chini and Bruening (2003). Also there is another critical factor to be considered in practicing sustainability which is maintenance of buildings. Asmone and Chew (2016) suggested the idea of green maintainability of buildings. A facility of optimum performance with low cost and lower natural resources used is the core of green maintainability. This concept is very useful in sustainability which means that we can lengthen the life of a building with minimum use of resources.

Research developments over the past two decades in the field of sustainable construction have been reviewed by Udomsap (2020). Waste reduction, social sustainability, sustainable management, recycling of materials and alternative materials were the core for this study. He found that that social sustainability is the poorest aspect while the alternative materials are the most favorable in the field of sustainability.

Peter Schmid, Professor at TU/e, discusses contemporary topics and concerns related to green architecture. He begins with the basics of surviving, which are always an issue in many areas of the globe, and works his way up to the present day. Progressing to the realization that we doesn't have other alternatives in our hands—there is simply no other place for us to go. As a result, we should start a task of long planning and explore considerable limitations in consumption if we are to continue. The present commercial system is the most significant impediment to change, followed by political policy and finally technological concerns. He believes that our duty is to request excellence, not in the logic of 'further' things but in the logic of 'fewer' destructive living selections. He proposes a method he calls (MHP) for interdisciplinary interaction and collaboration along with achieving an understanding that may result in acceptable solutions. He also highlights the significance of depending on green power and commodities supplies, mentioning the Framework (SPS) as an illustration of a components strategy that is environmental friendly, low-tech, and can be produced by local industry (Kibert, 2003).

2. EARLY STAGES, BASICS AND RELATED ORGANIZATIONS

2.1 Introduction

To start with such subject, we need to define the reasons behind choosing it and this is the core of any scientific research. The most important reason is the growing number of research papers which appeared in the recent years (2000 and upward) compared to the previous years (before 2000). The other reason is the building sector statistics which proves that this sector is one of the most energy, natural resources and water consuming industry and this contributes directly or indirectly in the most critical life threating problems the modern world suffer from which are the global warming, ozone depletion and climate change. These statistics are important for us as building designers to keep in our minds the catastrophic consequences of the product we made if it is made with unconscious hands without taking in to considerations the effects on nature.

Also it is important before starting with this chapter to have a look at the organizations working in this field which established a system and regulations to follow inorder to make a sustainable buildings and hence getting certified.

Choosing sustainable materials has its share in this chapter due to its essential role in the construction of a sustainable building. The input in every construction process is (labor, equipment and materials) as shown in figure (2.1) and it is very important for the designer to have a strong idea about sustainable materials available in the market and the local companies deals with sustainable materials so as to incorporate it in the design of the sustainable building and also taking recycling and reusing of material (inside and outside construction site) in to consideration (Glavinich, 2008).

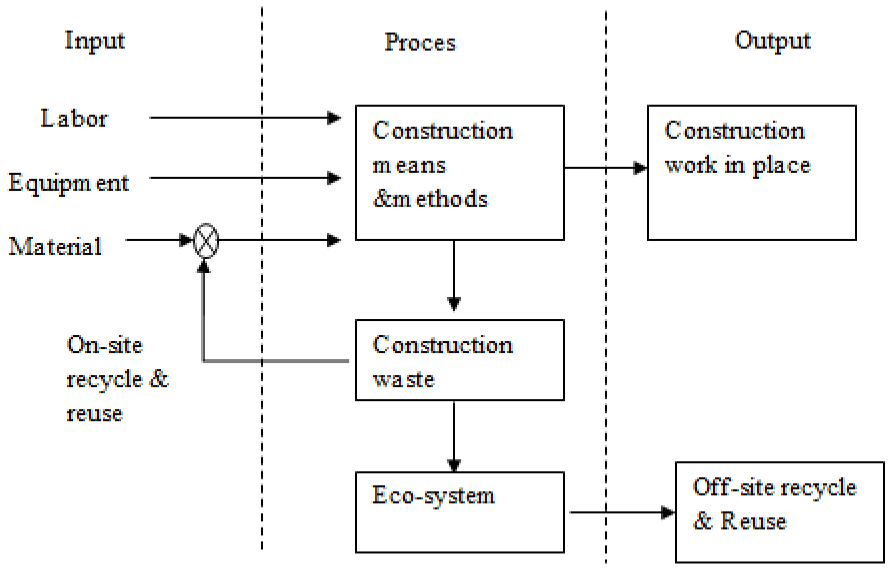

Figure 2.1: Green construction process

Source: Glavinich, (2008)

Finally in this chapter, examples of sustainable buildings from around the world have been explained to clear up the idea of sustainable buildings and to closely study such experience where these buildings are the seeds for such new direction in building industry which could alter the future of mankind toward more optimized use of natural resources and guarantee the future of next generations (Glavinich, 2008).

2.2 Statistics

Possibly, the construction industry is the most natural materials demanding of all industries all around the world. In relation to other industries, construction industry increased the world energy consumption and the usage of limited oil derived energy sources has elevated worries about finding other sources due to the exhaustion of this source and the consequences of using this energy source like CO_2 emissions which cause ozone layer deterioration, global warming and changing of weather. All phases of construction sector consume a huge amount of energy from the construction materials production to construction itself ending with operation of the buildings Akadiri et al. (2012).

2.2.1 Energy

Buildings consumed 38.9% of total energy consumption in the United States in 2005. Residential structures made up 53.7 percent of the total, while commercial structures made up the remaining 46.3 percent. Buildings consumed 72 percent of total electricity usage in the United States in 2006, and this figure is expected to climb to 75 percent by 2025. Residential building use accounted for 51 percent of the total, while commercial building use accounted for 49 percent. The ordinary domestic uses minimum $2,000 per year on energy expenditures, with heating and cooling accounting for more than half of that. A typical household's overall energy usage is split 50 percent for space heating, 27 percent for running appliances, 19 percent for heating water, and 4% for air conditioning. HVAC systems in buildings account for nearly 10% of greenhouse gas emissions and 25% of electricity consumption in the United States (McQuade, 2009).

Buildings are responsible for over 30% of global energy use and CO_2 gas emissions. This part is expected to rise due to the increase in time spent in buildings. HVAC systems, which are responsible for ensuring thermal comfort and acceptable air quality, are the greatest contributors to energy consumption in buildings (approximately 50% of consumption in developed nations). Buildings account for 4.4 percent of total global energy consumption for heating and cooling. Due to a combination of global warming and the introduction of air conditioning into the market, it is anticipated to rise to 35 percent in 2050 and 61 percent in 2100. The Mediterranean region's cooling requirement accounts for ten percent of overall energy demand. Between 2005 and 2009, cooling demand in Spain and Italy climbed by 30%. Because of this occurrence, it is vital to incorporate energy efficiency measures that counterbalance the impacts of deficient architectural design. The residential sector is responsible for 25.4 percent of the ultimate energy consumption in the Eurostat Statistics. However, it accounts for 63% of the total building energy savings that might be realized by 2050. In Europe, fewer than 20% of residential structures choose to overheat rather than assume cooling costs. As a result, under ideal conditions of thermal inertia and sun protection, only a few cities in Spain would need to use electricity for air conditioning (Ghahramani, 2017).

2.2.2 Atmosphere and air

Buildings account for 38.9% of total carbon dioxide emissions in the United States, with 20.8 percent coming from the residential sector and 18.0 percent from the commercial sector (2008) (U.S Department of Energy, 2007).

A city with a population of 1 million or more people can have an annual mean air temperature that is 1.8–5.4°F (1–3°C) warmer than its surrounds. The temperature difference in the evening might be as high as 22°F (12°C). Midsummer highest energy demand, air conditioning costs, air pollution, and the greenhouse gas island effect are all factors that contribute to 5–10% of peak electricity demand for cooling buildings in cities (Akbari, 2005)

2.2.3 Use of water

Building residents use 13 percent of the overall water expended in the United States every day. Commercial building occupants use 25.6 percent of the total, while homeowners use 74.4 percent (1995) (U.S. Geological Survey, 1995).

The population of the United States approximately doubled between 1950 and 2000. During the same time period, however, public water demand more than tripled! Americans now use an average of 100 gallons of water each day—enough to fill 1,600 drinking glasses (U.S EPA Water sense program).

Faucets account for more than 15% of total indoor residential water use, amounting to more than 1 trillion gallons of water per year in the United States. Showering accounts for approximately 17 percent of home indoor water use in the United States—more than 1.2 trillion gallons of water utilized each year. In a short amount of time, a leaking faucet loses gallons of water. A leaking toilet can waste up to 200 gallons of water each day. Of the 26 billion gallons of water consumed daily in the United States, approximately 7.8 billion gallons, or 30 percent, is committed to outdoor purposes. The majority of this is put to good use as landscaping. Water heating consumes 19% of home energy and accounts for 13% of the average electricity bill. In the United States, $4 billion is spent on energy to run drinking water and wastewater systems each year. If this could be cut by 10% through improved efficiency, it would save $400 million each year (US EPA, Office of Water).

2.2.4 Use of the land

The United States has a total land area of 2.3 billion acres. Between 1945 and 2002, the urban land area doubled, growing at about double the population growth.

Between 1997 and 2002, the expected size of farmland used for domestic purposes rose by 21 million acres or 29 percent (U.S. Department of Agriculture, 2002).

It is predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized (Urban life: Open-air computers, 2012)

So, if this urbanization continued to grow, more economic, environmental, water, health, food and crime problems.

2.3 Rating Systems

Many questions have been bursting out to the surface in the recent years. What makes a building sustainable? What proves its sustainability? So, the need for a procedure from a specialized authority in which, by following it, the building will get a recognized license for being sustainable.

Building regulations and assessment methods are different from one country to another considering the environmental criteria, but it lead to the same goals, which are reducing CO_2 emissions, reducing the use of natural resources, increasing the reuse recycling of materials. So, many organizations have been established all around the world that deals with sustainable buildings, such as LEED and BAREEM, briefly explained in this section.

The American Institute of Architects has recently pushed designers to consider computer modeling of energy as an important part of achieving higher efficiency systems in the produced designs. Significant assessments are made at the primary phases of the design procedure, while in the traditional way; designers add those assessments after the event Antolin et al. (2019).

2.4 Systems for Assessing the Quality of Buildings

In the field of building evaluation, Professor Ray Cole of the University of British Columbia widely regarded as one of the world's leading experts, reports that a variety of objectives can be served by performing an on-site building evaluation in the manner currently used. As a first step, it may be used to show how well a building complies with established standards for sustainable construction. For one thing, it may be used to compare the performance of one building to another in the same category. By providing performance data that indicate what high performance entails over a broad range of resource, ecological, and public health factors, an efficient construction evaluation approach or methodology may be employed to educate and influence the design of buildings. Building evaluation systems, such as LEED and BREEAM in the UK and the US, were originally designed to measure the environmental impact of structures. Currently, there is a lot of discussion on how building assessments may be used to help achieve sustainability in the built environment. As he points out, even with seemingly simple instruments like building evaluation systems, it is difficult to handle complicated concerns like sustainability. In order to maintain their potency and vigor, he recommends that these evaluation tools will need to be reimagined. He also notes that the question of how to build assessment systems, which have been highly effective as industry transformation tools, can indeed react to different aspects of sustainable development, must still be resolved (Cole, 2003).

There is a growing need in Australia to hold building owners and operators accountable for their properties' environmental performance. Tools that may be used to assess a building's environmental performance are discussed. (LCA) tools, energy simulation tools, and building grading schemes are all examples of these types of technologies. These methods, he demonstrates, may be used not just to assess the effect of a building but also to direct the design process in order to meet performance goals. Although some of these techniques have their own subjective features, such as the weighing methods used to signal the relative significance of various topics that might hinder their utility. It's still a long way to go, but great progress has been made in the development of new and enhanced tools for the design of high-performance buildings (Graham, 2003).

Lützkendorf, (2019) goes into great length on the German scenario for sustainable construction covering regulation, structure rating, and environmental rating of building products, design and rating methods, and the significance of building certifications. He also discusses the importance of building certificates. If you want the construction industry to be more environmentally friendly, you need new and innovative products as well as a coordinated effort from everyone involved to make sure that the positive environmental characteristics of buildings are turned into money.

2.4.1 Green building society of the United States of America

The US (USGBC) is an industrial group that includes owners, designers, and builders. The USGBC supports green building through its support of the LEED green building rating systems. These rating systems are intended to establish an objective criterion for verifying a building's environmental friendliness. As governmental and non - governmental building owners become more environmentally aware, they are increasingly seeking LEED certification. Although the design purpose for LEED certification is established during the design phase, it must be realized throughout construction. The contractor should be aware of LEED guidelines since they might affect material and equipment selection as well as construction standards and costs. Understanding LEED criteria will also help the contractor assess the project for the owner (Glavinich, 2008).

2.4.1.1 LEED rating systems

In 1999, the USGBC launched the LEED grading system in the case of new construction and major modifications (LEED-NC). Ever since, the USGBC has created or is currently developing rating systems. to accommodate the unique demands and features of many building types and projects. LEED rating systems currently include those listed in the table 2.1 Fowler and Rauch (2006).

Table 2.1: LEED rating systems

		Version	
LEED Designer	Rating system purpose	No.	Date
LEED-NC	New construction and major renovations	2.2	2005
LEED-CS	Core and shell	2.0	2006
LEED-CI	Commercial interiors	2.0	2005
LEED-EB	Existing buildings: Upgrades, Operations, and maintenance	2.0	2005
	Homes (Pilot)	1.11a	2007
	Neighborhood Development (Pilot)	2.0	2007
	Retail: New Construction and Major Renovation (Pilot)		2007
	Multiple Buildings and on-campus Building Projects (Pilot)		2007

LEED-NC was the original LEED rating system developed by the USGBC, and it is presently the most widely used assessment system in the United States. LEED's core and shell (LEED-CS), commercial interiors (LEED-CI), and existing buildings (LEED-EB) grading systems are all based on LEED-NC.

2.4.1.2 LEED-NC certification process

A building project's LEED-NC certification begins with the owner's choice to make the facility sustainable. The owner applies with the USGBC early in the design process to have the construction project certified. Since the choice to get a facility LEED-NC certified will govern many key factors all across the design process, including land choice if the project site has not previously been decided, the owner's choice and enrollment must occur early in the design phase.

As part of the application procedure, the owner, in collaboration with the contractor and/or designer, defines project objectives in the six areas depicted in Figure 2-1

- Sustainable site (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (EQ)
- Innovation and Design Process (ID)

The ability of the owner to show that the building project achieves the LEED evaluation system's standards is required for LEED-NC certification. Figure 2-1 summarizes the LEED-NC evaluation method, which covers the six areas indicated as well as precise subcategories identified as requirements or points below each area. Prerequisites do not have any scores connected with them, but they must be met in order for the facility to gain any scores in that area, as shown in Figure 2-1. One prerequisite, for example, is related with the Material and Resources (MR) area. The standards connected with precondition P1, which handles the storage and collection of recyclables, must be satisfied in order for the project team to gain any scores in LEED-NC certification in the Material and Resources area.

When the conditions for an area have been completed, scores for LEED-NC certification can be earned by completing the standards of the different credits shown in the area. Many credits are divided down, as shown in Figure 2-1, so that more scores can be provided dependent on the degree of accomplishment. Credit 8 in the

Indoor Environmental Quality (EQ) area, for instance, is concerned with daylight and vistas. No scores toward LEED-NC certification will be given for Credit 8 if the facility does not satisfy the criterion of Credit 8.1, which is daylighting in 75 % of the building spaces. The facility will get one score for LEED-NC certification if the standards for Credit 8.1 are fulfilled and 75 to 89 % of the spaces are daylit. Likewise, two scores will be awarded for LEED-NC certification if more than 90% of the facility spaces satisfy the natural lighting standards outlined in Credit 8.2 (Department of Energy, 2006).

As illustrated in Table 2-2, the project team reports how they are fulfilling both category requirements and credits for scores toward certification during design and construction. Aside from meeting category qualifications, the owner has entire authority over which areas and points inside those areas will be pursued in order to acquire certification. The LEED grading process does not require that every point be handled in the facility design and construction. The degree of LEED certification will, however, be determined by the number of points gained by the project. The following points are necessary to accomplish different degrees of LEED certification:

Several submittals, including some early design submittals, are required as part of the LEED submission procedure. The person who filled out the enrollment paper (the owner, contractor, or architect) would also be responsible for delivering the LEED certification proposal to the USGBC. This would include the appropriate project paperwork to back up each prerequisite and credit request, as well as other supplementary material Fowler and Rauch (2006).

Table 2.2: Classification level and credits in LEED system

Certification Level	Points Required
Certified	26–32
Silver	33–38
Gold	39–51
Platinum	52–69

A project biography with at minimum three features, as well as the service charges. The USGBC releases initial conclusions after receiving and reviewing the application, together with a demand for any further evidence it requires completing its final examination. The project team submits its final submittal to the USGBC within 1 month, after which the USGBC conducts a last assessment and awards LEED certification to the project.

2.4.1.3 Information on the LEED rating system

As part of its LEED-NC rating system resources, the USGBC offers a LEED Reference Guide and LEED Letter Forms for project teams. With the LEED-Reference Guide, you may learn about each requirement and credit's purpose, the submissions that must be made for each one, and more. By presenting online forms for verifying that qualification and point achievement standards have been fulfilled, LEED Letter Documents assist the construction team in preparing the LEED certification proposal. The USGBC offers the LEED grading system, letter forms, and a reference guide for sale on its website (Japan Sustainable Building Consortium (JSBC), 2007).

2.4.2 Green globes certification

The Building Research Establishment Environmental Assessment Method (BREEAM) In the U.K was created as a free green building grading standard. According to BREEAM, current commercial buildings can be evaluated for their energy and environmental efficiency on four different dimensions:

- Energy Efficiency
- Energy Efficiency
- Management and Operation

Newly constructed buildings were incorporated into the Canadian Standards Association's (CSA's) BREEAM Canada for Existing Buildings publication in 1996. The BREEAM Green Leaf program was developed in tandem with the Federation of Canadian Municipalities' Green Leaf for Municipal Buildings. In the year 2000, BREEAM Green Leaf for the Design of New Buildings was born out of these initiatives. An evaluation method for building owners was a primary goal of Green Leaf, which was developed by the BREEAM organization. A web-based version of Green Leaf called Green Globes was developed in 2004 (National Resources Canada, 2007).

Each area is divided down into seven subcategories and each subcategory receives a specific score, as indicated in Table (2.3):

Table 2.3: Points and scores in green globes rating system

	Green Globes Rating Category	Points	Percent
A	Project Management	50	5.0
B	Site	115	11.5
C	Energy	360	36.0
D	Water	100	10.0
E	Resources, Building Materials & Solid waste	100	10.0
F	Emissions and other impacts	75	7.5
G	Indoor Environment	200	20.0
TOTAL		1000	100.0

Table 2.4: Green Globe Rating system certification levels

Certification Level	Percentage of Points Required
1 Globe	35-54
2 Globes	55-69
3 Globes	70-84
4 Globes	85-100

2.4.3 Turkish green building council

The Turkish Green Building Council (ÇEDBİK) was founded in 2007 to promote environmentalism in the construction sector.

ÇEDBİK believes that ecologically sound structures and cities enable us to live and work in cleaner environments and achieve better lifestyles. Aside from educating the community on the importance of sustainable construction, ÇEDBİK also encourages the construction sector to grow in accordance with sustainable concepts.

The Turkish Green Building Council (ÇEDBİK) is a non-governmental association with over 100 important participants from the construction, property investment, financial services, building products, building administration and allied sectors.

Ecological impact assessment techniques can help the building sector go sustainable. The ÇEDBİK is currently customizing an ecological certification process for buildings to the Turkish geographical, climatic, political, social, and technological setting.

ÇEDBİK was given Full Council accreditation by the World Green Building Council (WGBC) in June 2012 and continues to grow in collaboration with other global Green Building Councils and the domestic building market. Interaction with foreign policy initiatives and access to cutting-edge technology on green building problems help ÇEDBİK adapt and interact with the Turkish building field.

ÇEDBİK is a project partner in the major European building energy refurbishment scheme BUILD UPON, sponsored by the EU Horizon 2020 Project (Turkish Green Building Council (ÇEDBİK), 2017).

2.5 Materials Choosing Principles

A construction material's embodied energy is a factor in determining how sustainable it is. It is the quantity of energy required to extract a specific substance from the earth until its demise. Transporting materials is also a concern that has to be considered. The more sustainable the building process is, the fewer materials will have to be shipped and transported. For this reason, local materials are preferred. In addition, fewer natural resources would be depleted because of the reduced labor and expense of replacing materials with higher-quality alternatives Garg and Jain (2014).

Principles for selecting materials and products:

- Supply Effectiveness: Properties such as recycled content, natural or renewable origins, source-effective industrial practice, locally available substances, recovered, restored, or reprocessed, and can be reused at the end of use are fundamentally considered by supply effectiveness.
- Indoor Air Quality (IAQ): Materials that are low or non-toxic, emit little chemical emissions, are moisture resistant, and are well-maintained improve IAQ.

This term mostly refers to the amount of energy needed in the concrete-making process. At the time of concrete building, those materials that demand as little energy as possible should be used.

The parts of buildings that help us save water during construction or even cut down on water use in the manufacturing process are used in landscaped areas.

It's important to think about affordability when the costs of a product over its life-cycle are similar to the costs of traditional materials, or if the total cost of the project is within the project's budget Garg and Jain (2014).

2.6 Examples of Sustainable Materials

2.6.1 Alkaline cement

In order to produce Portland cement, a substantial quantity of energy resources and fuels must be used, which has an environmental impact. In order to reduce these emissions, it is vital to investigate new green or alternative cements. Green alkaline or geopolymeric concrete is the most promising because of its features and low environmental footprint. Consequently, it's dubbed "future cement" because of this. Natural or synthetic silicoaluminates of natural source (such as clays) or industrial by-products (such as waste materials) are chemically combined with alkaline solutions in order to produce it Eliche-Quesada et al. (2020).

2.6.2 Bamboo

The abundance of bamboo in tropical rain forests explains its widespread usage in traditional dwellings across the world. However, the usage of bamboo as a construction material has become outdated since the beginning of the industrial period. As far as building materials go, bamboo is a good option because it's both inexpensive and temporary. Also, many modern builders refer to it as "the poor man's lumber" because of its low quality. For modern construction, brick, concrete, and steel are the most popular structural and construction materials. However, as global climate change and sustainability concerns have developed, bamboo as a construction material has become a hot topic.

A growing number of architects and builders are turning to bamboo as a construction material. Deforestation has made it difficult to find high-quality timber for building purposes. Construction materials such as wood take a long time to re-grow and are ready to be used. Bamboo, on the other hand, may be harvested in just 3-5 years. When bamboo is planted, it also emits oxygen as a byproduct, a property it shares with industrial materials such as steel, plastic, and concrete. Bamboo has long been regarded as an environmentally friendly construction material. The fibers of bamboo, when used in building, are incredibly strong. Two times as strong as concrete, bamboo's tensile strength is comparable to that of steel. The shear stress of bamboo fiber is greater than that of wood. The sway of bamboo is greater than that of wood. It's possible to bend bamboo without it breaking. Bamboo is counted as a 32-year-old. In contrast to steel, which has tensile strength of 23,000 N per square inch, wood is one of the strongest building materials, with a tensile strength of more than 28,000 N per square inch Anagal et al. (2010).

The preservation of bamboo as a building material is an absolute necessity. Because bamboo is susceptible to termite and fungal assault, this is why it's so popular. There are a number of ways in which the borax boric acid solution is used to preserve bamboo, including immersion, gravity or vertical dip diffusion, and the use of a compressor machine to inject the solution. Sodium borohydride and boric acid have been proved to enhance the life of bamboo (Purwito, 2015).

Chemicals used in preservation raise a number of issues and controversies concerning the environmental impact of waste water. Because of this, various investigations on the preservation of bamboo using organic substances have been undertaken (Nurdiah, 2016).

2.6.3 Green concrete

Eco-friendly components may be used into concrete to make it more environmentally friendly. In addition to being more environmentally friendly, green concrete is also more cost-effective to make, as waste materials may be utilized as a partial cement replacement, charges for waste disposal are eliminated, energy consumption in the manufacturing is reduced, and durability is better. The color of this concrete is not indicative of its composition. In order to conserve natural resources and make better use of them, trash can be recycled into new goods or utilized as an admixture in other products to prevent waste from being dumped in landfills. When it comes to ecological aggregates, nothing beats stone dust, smashed concrete, and marble trash. Cement may be made more environmentally friendly by substituting it with fly ash or micro silica in bigger volumes to generate new ecological cements and binding materials that require less energy to produce. In addition to cost-effectiveness, pozzolanic wastes were used to improve the qualities of concrete, particularly its durability (Orsos, 1992).

2.6.4 Cork

An oak known as the cork oak has a suberous coating called cork. It has five layers of cell walls and has 42 million cells per cubic centimeter. Natural cork is among the most adaptable raw materials ever discovered. Lightweight and flexible, cork is impermeable to gases and liquids, impermeable to heat and sound as well as dielectric. It is also impermeable to moisture. The closed cell structure of cellular material is what gives it its distinctive features. If compressive stresses are present, cork is an ideal thermal insulation material because of its low conductivity paired with adequate compression strength. Flooring and handles can also benefit from its anti-sliding capabilities because of its high level of friction. Seals and joints in wind instruments and combustion engines are among the many uses for today's cork goods. It is also utilized as a heat-absorbing medium for flooring, shoe laces, food packaging, and stoppers, to name just a few. Natural cork stopper manufacture may only use up to 25% of its raw material, thus other uses for the substance were explored. The development of cork composites is among the most potential areas for cork technological progress Gil and Moiteiro (2003).

2.6.5 Wood

Wood is one of the few building materials with as many environmental advantages as bricks and concrete. With its vast range of applications, it is the most extensively used construction material in the U.s, as well as the most versatile. Products made from trees that are efficient, durable, and helpful might range from a simple to an engineered wood composite that is created in a huge manufacturing facility Perez-Garcia (2005). The production and utilization of raw materials is critical to the long-term viability of any resource. Being a renewable resource, is one of wood major advantages. When forests are managed and harvested sustainably, the wood supply will be available in perpetuity Murray et al. (2006).

2.6.6 Rammed earth

Load-bearing walls are built with rammed earth. Rammed earth walls are constructed by layering compacted dirt in a strong formwork and compacting it over time. Stabilized rammed earth and un-stabilized rammed earth are the two main types of rammed earth building. Stabilizers (cement, lime, etc.) are used in addition to soil, sand, and gravel in the production of stabilized rammed earth, whereas unstabilized rammed earth employs only soil, sand, and gravel. Unstable rammed-earth structures are vulnerable to deterioration owing to rainfall. Cement stabilized rammed earth can successfully handle these issues. Since the last 5–6 decades, Portland cement has been utilized to build rammed earth walls. There are several examples of CSRE buildings across the world. Rammed earth construction has a number of important advantages, including low embodied carbon, a continuous wall surface, the ability to customize the texture and color of the surface and a wide range of wall thickness and plan form options. The usage of CSRE walls for structural purposes, particularly for load-bearing walls, is becoming more popular among construction professionals. In Australia and across the world, a number of "green" buildings have been built. Awards have been bestowed on a number of these structures. The Charles Sturt University (CSU) Campus in Thurgoona in New South Wales, Australia, has a two-story rammed earth "Academic Offices Building." Academic Office Building has garnered several honors, including a special "jury prize" from the Royal Australian Institute of Architects for an environmentally sound design Hall (2002), Walker (2005), Venkatarama Reddy (2009).

2.6.7 Hempcrete

In order to make hempcrete, hemp shaves, lime binder, and water are mixed together. One-eighth the weight of concrete, it is a lightweight substance. Hempcrete may be used to build walls, floors, and roofs; it can also be precast, sprayed, or molded (monolithic) (e.g. hemp bricks or panels). Hempcrete is an environmentally friendly product. This product is sourced from sustainable sources in adequate volume. The process of manufacturing consumes less energy. Greenhouse gas emissions are reduced with this product. It provides a sturdy and long-lasting structure, as well as a safe and healthy living environment. This product's packaging may be recycled Bedlivá and Isaacs (2014).

2.6.8 Slate

The embodied energy of traditional construction materials including wood, stone, brick, lime, sand, and soil is already low. This may be shown in a graphic that compares the long-term durability of slate with that of contemporary fiberglass roofing. In the time it takes a standard slate roof to function, four or more high-quality fiberglass shingle roofs would have to be built (Sedovic, 2003).

Table 2.5: Life cycle costs of slate v. fiberglass roofing material

	Slate	Fiberglass
Year 1	$299,400	$94,500
Year 40	23,400	207,900
Year 80	31,200	321,300
Year 120	39,000	434,700
TOTAL	$393,000	$1,058,400

Life cycle roofing cost comparison between S1 quality slate and high quality (40) years fiberglass shingles, calculated with a constant 3% inflationary factor. When shown over its expected performance lifetime, slate is economically superior.

Source: (Sedovic W., 2003)

2.7 Examples on Sustainable Buildings

2.7.1 Vertical greenery systems (Green walls)

Rooftop gardens (GR) and vertical greening systems (VGS) for constructions are two of the most inventive and intriguing alternatives. VGS operate primarily through four mechanisms: the shade cast by the plant, the insulation supplied by the vegetation and substrate, evaporative cooling via evapotranspiration, and finally, the wind barrier effect. It is shown that these systems are capable of improving the thermal performance of the buildings, in particular by intercepting solar irradiation and achieving shadow factors comparable to those given by artificial barriers commonly employed in buildings, such as panels, awnings, and so on. Green walls in London, United Kingdom, as seen in Figure (2.2), are a clear illustration of this technique Dunnet and Kingsbury (2008), (Dover , 2015).

Figure 2.2: Double-skin Green Façade (green wall) made with wire mesh and Boston Ivy**.**

Source: Coma, (2017).

2.7.2 Vertical forests

This implies that when cantilevered balconies are used to create space for trees to grow around the exterior of a structure, vertical forests are generated figure (2.3). Vertical forest engineering is an interdisciplinary new field for architects, botanists, and structural engineers to investigate further in terms of plant and tree species, nutrition, and growing conditions (e.g. root system development), as well as engineering aspects such as wind loads, earthquakes, and tree stability, as well as their development over time. As an illustration, take Milan, Italy-Vertical Forests (2) (Giacomello, 2015).

Figure 2.3: Milan, Italy- vertical forests

2.7.3 Forest cities

Cities may "naturalize"—that is, promote a diverse range of natural elements—by taking precise, grounded measures. These "naturation" programs, which attempt to attract wild biodiversity (particularly beneficial species), involve the establishment of feeding, breeding, and sheltering places across the city, whether in green, gray, or blue zones. While establishing urban infrastructure such as parks and gardens is a typical strategy for nature conservation, other activities include the installation of rooftop gardens, walls, façades, and balconies. As a result, the number or area of ecosystems within a metropolis that can run autonomously, without human intervention, increases. Jardi Tarradellas of Barcelona illustrates a "green wall" construction in the city's neighborhood that is home to a diverse bird population figure 2.4 Juncà et al. (2016).

Figure 2.4: Barcelona’s Jardi Tarradellas

Source: Jardí Tarradellas - Green side wall (2011)

2.7.4 Singapore- super trees

A new and landmark garden is the "Gardens by the Bay" development around Marina Bay Sands. This area has some outstanding natural systems that were created with a $1 billion investment to rehabilitate a reclaimed coastline. All of the "Super Trees" and exhibit spaces are intended to serve as teaching features, demonstrating how biological ecosystems and cycles operate. They are a good example of how nature can be used in a city Figure (2.5) (Newman, 2014).

Figure 2.5: Singapore super trees

Source: (Newman, 2014)

2.7.5 Hamburg Germany- green algae building

The BIQ House was completed in 2013 in Hamburg, a city with a temperate Northern European climate. The building consists of 15 apartments spread across four stories and a rooftop level, ranging in size from 50 to 120 square meters and with a gross floor area of roughly 1600m2. In a low-energy residential structure, 200m2 of integrated photo-bioreactors in 120 panels installed on the façade create algal biomass and heat as renewable energy resources. The algal façade panel system creates a thermally regulated microclimate within the structure, as well as noise reduction and dynamic shading. The building cost was estimated to be around five million euros. Figure (2.6) illustrates the BIQ (Buildiup, 2015), (Arup, 2013).

Figure 2.6: Hamburg Germany- Green Algae Building.

Source: Colt International

2.8 Our common future

The Brundtland Report was released by the UN in October 1987 via Oxford University Press. H. Brundtland, former PM of Norway, was honored as Chair of the (WCED). Achieving sustainable development requires regional integration and cooperation of states. Derived from the Stockholm Conference, the report tried to reproduce the spirit of the event. Our Common Future put environmental concerns front and center on the political agenda, combining them with growth (The world commission on environment and development, 1987).

Our Common Future, published in 1987, might be regarded the birth of modern global sustainable development. It not only provided the first globally acknowledged concept of sustainable development, but also claimed that sustainable living required worldwide recognition to be effective. It eventually made people realize the desperate need for new, healthier ways of coexisting with one another and the Earth. Long-standing voices resulted in a worldwide call to arms. Many others had built the framework for sustainable research and production, but there had not been a coherent gathering of brains. After Our Common Future, the Earth Summit produced Agenda

21 in 1992. The Earth Summit was concerned about human-induced climate change. In Rio de Janeiro, the Outline Agreement on Climate Change was presented for signatures, pledging to stabilize greenhouse emissions to protect the climate system. The signatories pledged to develop initiatives and national strategies to reduce carbon emissions to 1990 levels. Five years later, the Kyoto Protocol set emission objectives for participating industrialized nations, based on 1990 pollution levels, to be achieved between 2008 and 2012. Eighty-four governments signed the protocol, committing to restrict or reduce their GHG output. The US has not signed. Protocol in place since February 16, 2005 (The world commission on environment and development, 1987).

2.9 Earth summit

There was a short paper issued at the 1992 United Nations (UNCED), generally known as the Earth Summit. The Rio Declaration set out 27 principles for future sustainable development. Over 175 nations signed it.

The Declaration was adopted during the Rio Conference on June 3-14, 1992.

Following that, the world community convened twice to examine progress in implementing the document's principles, first in New York City in 1997, then again in Johannesburg in 2002. However, data from 2007 suggests that the document's environmental aims had not been met (United Nations Conference on Environment and Development, 1992).

2.10 Kyoto protocol

On the basis of scientific consensus that global warming is occurring and that human-made CO_2 emissions are driving it, the Kyoto Protocol extended the 1992 (UNFCCC). The Kyoto Protocol was signed on December 11, 1997, and came into force on February 16, 2005. In 2020, the Protocol has 192 parties (Canada had withdrawn in December 2012).

Based on the principle of shared but differentiated responsibilities, the Protocol required developed countries to reduce current emissions because they were blame for the recent amounts of greenhouse gases in the atmosphere.

The first Protocol commitment period was from 2008 to 2012. The Protocol was completely implemented by all 36 nations in the first phase of the program. Because their individual emissions were slightly somewhat higher than their objectives, nine nations had to use flexibility mechanisms to support other countries' carbon reductions. The 2007–08 financial crisis reduced emissions. The breakup of the Soviet Union lowered emissions in the early 1990s.

The Doha agreement, signed in 2012, extended the pact to 2020, with 37 nations having enforceable targets. It came into force on December 31, 2020, after being accepted by the required 144 states, although the second commitment period expired on that day. 34 of the 37 parties had confirmed.

During the annual UNFCCC Climate Change Conferences, steps to be done after the second commitment period expired in 2020 were discussed. This led to the 2015 Paris Agreement, which is a distinct UNFCCC document rather than a Kyoto Protocol modification (Kyoto Protocol to the United Nations Framework Convention on Climate Change).

2.11 Paris agreement

The Paris Agreement is a 2015 international pact on climate change. 196 parties negotiated the Agreement in 2015 near Paris, France.

The Agreement was officially opened for signature on April 22, 2016 in New York. After the EU adopted the deal, enough nations ratified it to make the pact effective on November 4, 2016. The accord will be signed by 193 UNFCCC members in November 2021. The only big emitter among the four non-ratifying UNFCCC members is Iran. The US left the pact in 2020 but returned in 2021.

This would significantly lessen the consequences of climate change. The Paris Agreement's long-term temperature objective is to keep the rise in mean global temperature well below 2°C. Emissions should be decreased rapidly to zero by the middle of the century.

It tries to help parties adapt to climate change and raise funds. The Agreement requires each country to prepare and report on its contributions. No one requires a government to establish precise emissions objectives, but each should be higher than the last. Distinctions between industrialized and developing nations are confused, and the latter must submit plans for carbon reductions.

Some environmentalists and economists criticized the Agreement for not being sufficiently binding. The Agreement's usefulness is debated. A mechanism of greater ambition is available under the Paris Agreement if present promises are insufficient (Falkner, 2016).

3. WHAT IS THE PROCEDURE AND WHAT SHOULD BE DONE?

We have gone through statistics, grading systems, sustainable materials, and sustainable construction examples, but we haven't yet gotten into the heart of the issue, which is how the sustainable building process works. In this chapter, we'll look at how to manage sustainable structures and what factors to consider when using labor, equipment, and materials to get certification as a sustainable structure.

Before we begin, let us define sustainability and sustainable design so that we have a thorough understanding of these terms:

3.1 Sustainability

Ripley and Bhushan (2016) aimed to bridge disciplines, create a new genre, bioarchitecture, and outline future research, collaboration, and professional collaboration potential. Art is the formation of separate visual objects that are intended to be prized by others. Architecture is a form of design that expresses a hypothesis and contributes to the discipline's discourse. Bioarchitecture is a fusion of art/architecture and bio-mimetics/bio-inspiration that starts with a bio-inspired design and extends to all scales.

The primary motivation for sustainable progress is to ensure the survival of the human species. Human people are at the core of concern for sustainable progress says the Rio Declaration, which serves as the preface to Agenda 21 (Plessis, 2002).

Before delving into the term 'sustainable design', it's necessary to first examine the concept of' sustainability,' as the two are intertwined in terms of benefiting future human and environmental resources. Gro Harlem Brundtland In 1983 from the World Commission on Environment and Development invented the term "sustainability".

Brundtland's report urged businesses and individuals to pursue economic development in a way that would be sustainable for future generations without damaging natural resources or the environment.

Sustainability, according to Erek et al., is "a survival assurance that an economic, ecological, or social system should be conserved for future generations and, consequently, necessary resources should only be exploited to the extent that they can be restored within a regeneration cycle." This implies that corporations and individuals must safeguard current infrastructure in order for it to be reused by future generations. In the twenty-first century, the concept of sustainability has become increasingly important, as businesses and individuals are increasingly required to think in terms of delivering "solutions rather than products, and seek to define their markets in terms of customer activities and outcomes rather than products and services." (Jeffers, 2009).

Cost savings, resource preservation, compliance with legislation, improved reputation, happier customers and stakeholders, attracting capital investment, and capitalizing on new opportunities will all benefit from incorporating sustainability into corporate and individual strategies. Finally, according to Kendall and Kendall (2010), sustainability will benefit enterprises, stakeholders, individuals, and society as a whole.

The integration and deployment of a sustainability strategy in business should be tailored to the project demands and business proposals of a specific division, if not the entire organization. The adoption and application of sustainability in businesses, according to Weybrecht (2010), will result in the following benefits: cost reduction, resource preservation/saving, compliance with legislation, enhanced reputation that differentiates organizations, and securing excellent workers (Weybrecht, 2010).

3.2 Sustainable designs

Sustainable design, according to Stelzer, is "fundamentally a subset of good design, with requirements for the construction of a healthy environment and energy efficiency finally being included in the description of good design." Silberman and Tomlinson debate the relation with both sustainable design and human-computer interaction, confirming that prior HCI research focused on "What do users do?" When? How often do you do it? Why? What are their thoughts on it? What do you know about their activities? "How did they figure that out?" (Silberman and Tomlinson (2010).

Lastly, sustainable architecture will be the means by which we may improve our world. However, we must have the correct drive, consciousness, knowledge, determination, trust, and loyalty in order to do this. In order to protect raw materials for the next generation, people must act swiftly to consider excellent and sustainable design by incorporating sustainability into their company plan.

Materials, energy, water, land, and, in the spirit of sustainability, ecological systems are the basic'stuff' or resources required for construction. The latter is included because it is becoming increasingly clear that ecosystems can and should be connected with buildings to provide a variety of functions, including heating, cooling, stormwater uptake, ecological quality, waste treatment, and even food.

3.3 Sustainability and Architecture

Sustainable architecture is a new way of thinking about architecture that addresses a variety of current concerns about the effects of human activities. The fundamental to architectural sustainability is to interact with nature rather than against it; to understand, carefully exploit, and prevent hurting natural systems,

There have been many approaches to defining sustainable architectural through the introduction of terms such as sustainable development, green architecture, environmentally responsive design, and ecological design, with examples such as the "Six Green Design Principles," which include energy conservation, water conservation, working with the climate, minimizing new resources, respect for users, and respect for the site. It can be traced back to the 1970s that ecological, green, and environmental are terms that encapsulate the idea that architectural design should take into account the natural environment and its influence Williamson et al. (2003).

However, "ESD" is a nebulous phrase that is occasionally used to allude to sustainability. The letters 'E' and 'S' represent for environmental and ecological, respectively, whereas the letters 'D' and 'D' stand for development and design. The three elements (systems) of sustainability, which are environmental, sociocultural, and economic, are commonly referred to as the "triple bottom line," and are used to evaluate the feasibility and success of design Williamson et al. (2003).

3.4 How to Start a Sustainable Project

Specialty contractor proposals should be evaluated not only on the basis of experiences and price, but also on the basis of the specialty contractor's understanding of its part and duties in attaining the project's long-term goals and third-party evaluation system papers requirements. The contractor should choose the project's preferred specialist contractor based on this judgment.

3.4.1 Subcontractor selection

The process for selecting subcontractors on a green building project should be no different than that for a standard building project once subcontractors have been qualified. Establish the method for choosing subcontractors for the project as the first step in the selection process. These selection criteria may differ for different subcontractors on a green building project, based on their role and duties in achieving and documenting the project's green building criteria.

A drywall subcontractor, for example, often has a considerably larger responsibility in satisfying green building standards than an HVAC subcontractor. As a result, the contractor may choose an HVAC subcontractor based on the integration of green building abilities and cost, with pricing being a secondary consideration given the HVAC subcontractor's critical role in a green building project.

An HVAC contractor's prior work experience, as well as his or her ability to work successfully with other contractors, such as the building owner, mechanical engineer, controls contractor and licensing organization should all be considered. Because the installation of the HVAC system is more critical than the drywall work in a green building, the drywall subcontractor could only be selected on the basis of price from a pool of certified contractors (Glavinich, 2008).

Following the determination of the selection criteria, the contractor must obtain subcontractor proposals or offers based on the criteria. Specialty contractors must be informed of the selection process, especially if considerations other than cost will be regarded. If the selection criteria are not adequately communicated to specialty contractors, their proposals may not adequately address the contractor's criteria, and the contractor may not chose the right specialized subcontractor for the project since it lacks a complete picture of the subcontractor's qualifications and ability to assist the contractor in achieving project success. Following the receipt of offers, the contractor must analyze the specialist subcontractor offers against the eligibility requirements.

The contractor should discuss the project's green goals, the specialty subcontractor's role and duties, the green construction processes and procedures, and any necessary inspection or documentation throughout negotiations and before completing a subcontract with the preferred specialist contractor. This is necessary to avoid any miscommunication between both the contractor and subcontractors about the green project requirements and their influence on the scope of work and cost of conducting the task (Glavinich, 2008).

It is necessary for a subcontractor to provide additional items as part of a green construction project. These items are in addition to the usual shop drawings and samples as well as product data and literature from the manufacturer(s). These requirements will be determined by the project's green building criteria or score system, as well as the subcontractor's work plan. A few examples of green building submissions include:

- Materials Salvaged and Refurbished List
- Recycled Materials List
- Regional Materials List
- Certified Wood Products List

In addition to submitting material lists, the contractor must inform subcontractors when project requirements demand them to send material cost reports and receipts showing the percentage of a specific type of material, such as a local material, which is used on the job to achieve green requirements (AGC Document No. 200, 2000).

3.4.2 Managing the green design process

An architect-contractor working on a green building project must know how to handle both the design and construction phases. The design of a green building is more complicated than the design of a standard building. In order to ensure that a building will suit the needs of the owner and meet industry standards and energy norms, as well as green rating systems, sustainable design often includes a thorough study of alternative materials, systems, and architectural models and simulations (AIA Document A101-1997, 1997).

3.4.3 Green construction manager at-risk

All project delivery methods need a construction manager to supervise the project's scheduling, cost control, constructability, project management, building technology, bidding, or negotiating construction contracts, and the construction of the project. Despite the term, construction managers may help the owner with planning and design of green construction, despite the moniker suggesting just administration of construction. With construction management, it is possible to keep a better eye on budget and schedule during design and construction, as well as to benefit from their knowledge of green building design. They also benefit from the fact that green building projects often require a more extensive commissioning and closeout process.

At-risk project delivery system shown in Figure 3-1 For new construction projects, a construction manager is hired by the owner's counsel who acts as the general contractor in terms of hiring and coordinating subcontractors. The owner and construction manager might agree on a set fee, a percentage of the total cost, or a guaranteed maximum price for the services given by the construction manager. In the early phases of a project, the general contractor may not be engaged until the owner decides to proceed with a design-bid-build model. As a result, the owner is forced to depend on the architect's estimations of both costs and completion dates. It is not the role of the architect to procure materials or equipment, nor to plan the building of a project. With an expert construction manager's assistance, the owner of a green building project might considerably profit. To reduce waste, improve construction efficiency and decrease overall project costs, construction managers may choose to conduct constructability and value assessments in addition to their routine budget and schedule audits (AIA Document A201-1997, 1997).

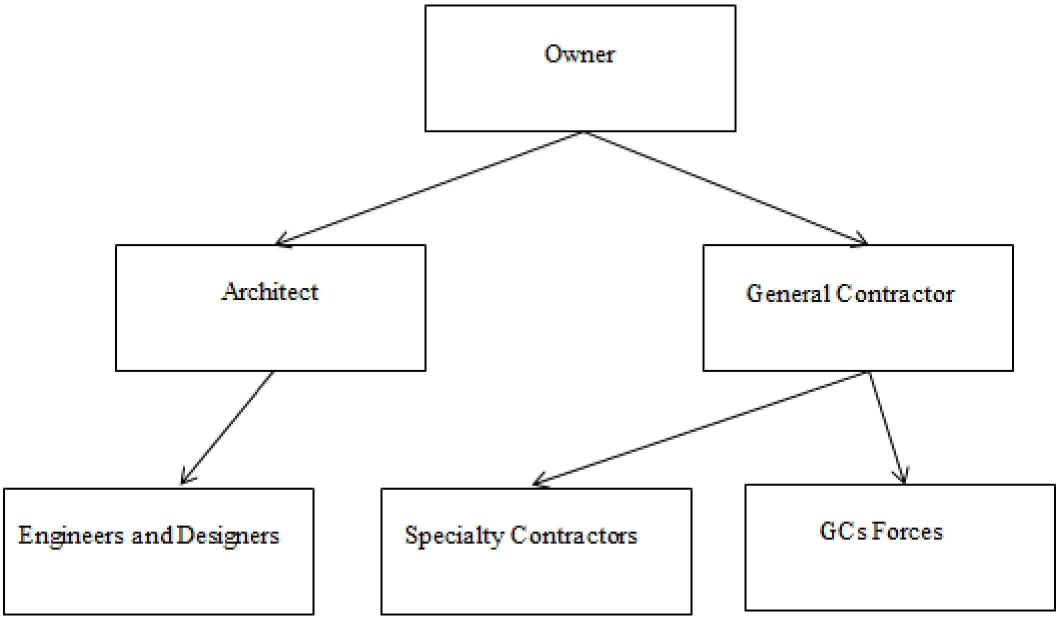

Figure 3.1: Construction manager – At-risk project delivery system

3.4.4 Subcontractor green submittals

On a green building project, the subcontractor will have to submit additional submittals in addition to the regular shop drawings, prototypes, product information, suppliers' literature, and other submissions. The green building criterion or scoring system to be used on the project, as well as the work plan of the subcontractor, will decide these submittals. The following are some examples of green building submittals:

- Materials Salvaged and Refurbished List
- Recycled Materials List
- Regional Materials List
- Certified Wood Products List

Along with material lists, the contractor must ensure that subcontractors are aware of when project requirements demand them to submit material cost reports and receipts that demonstrate the amount of time a certain sort of material, such as a regional item, is used on the job to meet green criteria (The Associated General Contractors of America (AGC), 1998).

3.4.5 Building product life cycle

McDonough, Braungart, and other architects began vocalizing their worries about the toxic effects of substances used in buildings in the mid-1980s. They urged architects and builders to conduct more study into the substances and air techniques utilized in commercial buildings, thus criticizing American construction standards. Architect Thomas Herzog, for example, was conducting similar studies at the same time. These trailblazers are acknowledged for bringing a new level of attention to physiological difficulties in environmentally sensitive design. This focus offered renewed purpose in the realm of green construction at a period when fuel prices were once again low. This study pushed product and substance life cycle assessments (LCA) to the forefront. The majority of Americans utilize items that have a birth to death life cycle rather than the more environmentally friendly birth to birth life cycle. Products are made, utilized, and ultimately thrown away in dump sites in modern civilizations. Products are made to go on for a limited period before being replaced with a similar-looking alternative. From raw material extraction or harvesting to reuse, recycling, or disposal, a construction product's life cycle is depicted in Figure 3.2. The selection and usage of machines and resources for green building projects requires a thorough grasp of the building product life cycle. Each phase in the life cycle of a construction product is described in depth in the sections below McDonough and Braungart (2002).

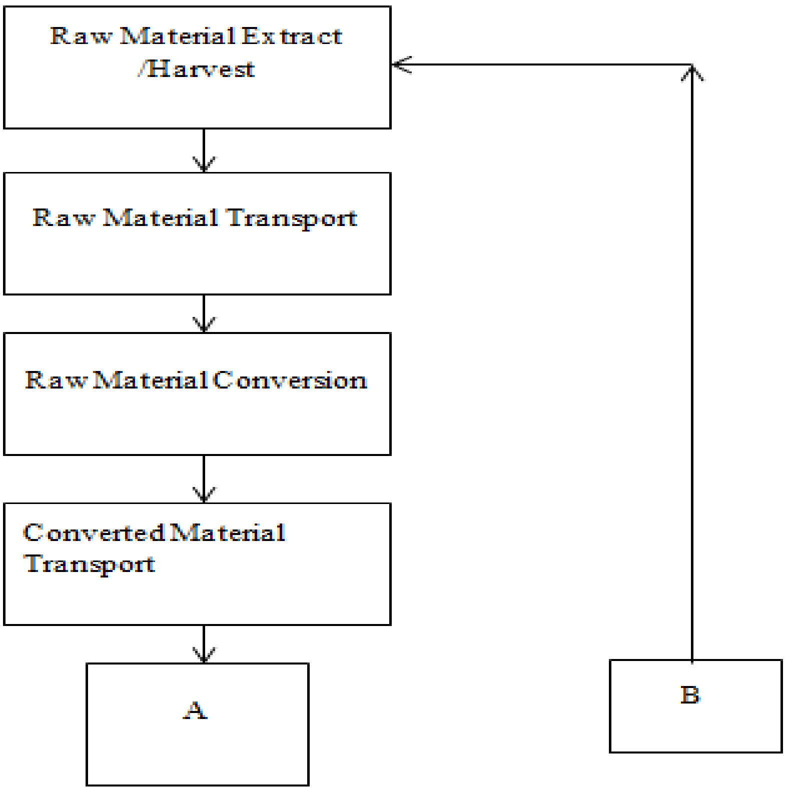

Figure 3.2: Building Product Life Cycle

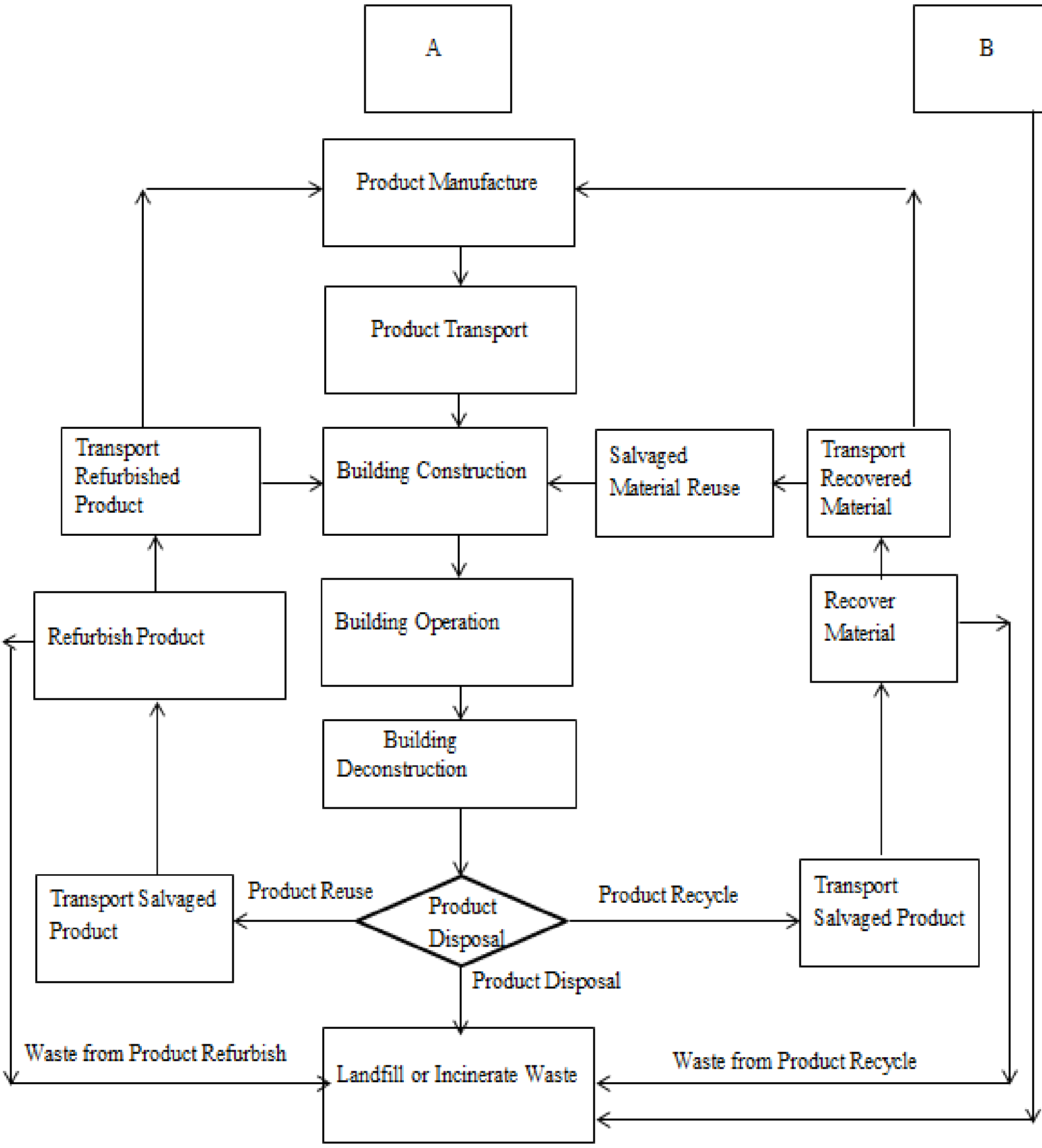

Figure 3.3: Continued

- Raw Material Extraction/Harvesting

The extraction or harvesting of the raw material that will be utilized to manufacture the completed building product is the first step in the life cycle of a building product. Building materials like stone and wood are typically made of a single substance, however they may contain additional elements. Extraction is the process of extracting a nonrenewable raw material from the ground, such as stone. Harvesting is the process of acquiring raw resources such as wood, which are typically plant-based and may be regenerated over time. This distinction is crucial from the perspective of green construction. The usage of raw materials that must be taken from the soil can have a negative influence on the environment throughout the extraction process, including damaging the earth itself, altering subterranean and aboveground water supplies, and possibly contaminating the atmosphere. Furthermore, by using these virgin elements, future generations will be denied access to them. Whether or not the contract papers require it, the use of extracted materials in green building construction should be restricted to a bare minimum. Although harvested resources may be grown back and supplied, the harvesting of plants for wood products, such as trees, has an environmental impact. Plant life is necessary for the earth's ecological balance, and harvesting trees and other plants has the potential to affect air quality, animal life, and soil erosion. Furthermore, various species of plants mature at different rates. Bamboo, for example, may be used in place of wood since it regenerates fast after harvesting, but hardwoods like oak take decades to develop to the point where they can be collected again Froeschle and Lynn (1999).

- Logistics of Raw Materials

The necessity to move raw materials from the point where they are mined or harvested to the point where they will be transformed from raw materials to bulk materials that can be utilized to make a finished building product is known as raw material transportation.

- Conversion of Raw Materials

The raw material or materials are converted into a bulk material that may be utilized to make a building product in this phase of the building material life cycle.

- Transport of Converted Goods

The converted bulk material is transferred to the place where the finished construction product is created after raw material conversion.

- Fabrication

The ultimate construction product is created in this stage. This phase, like others in the building product life cycle, may entail numerous production processes as well as transportation of the product in process between different manufacturing locations.

- Deliveries of goods

From the production plant to the construction site, the manufactured building product is supplied. This stage may also include a number of intermediate stops at manufacturer distribution centers, construction material distributor facilities, and even retail building product shops. All transportation and storage between the final product manufacturing location and the building construction site is included in final product transport.

- Setup of Construction Products

The building product can be integrated into the structure once it is delivered to the project site. When material passes to the installing contractor, this process is activated. This stage comprises not only the actual integration of the building product into the construction project, but also the contractor's storage on or off-site, as well as transit between short-term storage locations and the final installation place (The Associated General Contractors of America, 2007).

- Building Product Disposition

Building products can be removed at any time during or after the useful life of the structure. Deconstruction can lead to the discharge and substitution of one or more construction products during the course of a structure's life. Discharge and substitution of one building product may be due to (1) the building's service life being shorter than it is to the entire structure, as in the situation of a boiler; (2) technological redundancy, where it is more cost-effective to upgrade the current building with a more efficient form, as with the situation of windows; or (3) simply an adjust in occupancy or appearance, as in the situation of wall and floor finishes. When renovating a whole or portion of a structure, deconstruction would need the methodical removal of several building products. Likewise, when the structure reaches the end of its lifespan, it will be dismantled, which entails the methodical disassembly and elimination of building components for recycling, reuse, or destruction. Construction disassembly and demolition both have the same goal: to remove a portion or all of an existing structure that has outlived its usefulness. Construction disassembly, on the other hand, differs from demolition in that it involves the methodical disassembly of a structure with the goal of reusing or recycling as much of the structural components as necessary. The primary goal of building demolition is to demolish an old structure from a site to create way for new construction. While structural elements are recycled or reused during removal, they are auxiliary to the primary goal of eliminating all or part of the structure (The Associated General Contractors of America, 2007).

- Disposal of Construction Materials

Building deconstruction necessitates a choice on what to do with the building product or items that are removed from the current structure. A construction product that has been removed can be reused, repurposed, or discarded. The owner-contractor arrangement will determine how a specific building product is disposed of, as well as if it contains any specific criteria for the disposal or ownership of components eliminated by the contractor throughout removal. If not, and the contractor possesses the discarded construction goods, the contractor must figure out the most cost-effective manner to dispose it. If there are items that may be reused cheaply, the contractor may consider selling them and using the earnings to offset part of the deconstruction expenses, making it even more affordable. The contractor must decide the most cost-effective means of removing items from the project site, whether they will be recycled or disposed of (The Associated General Contractors of America, 2007).

Salvaged Product: Whether the building materials are reused or recycled, it must be moved from the deconstruction site to a place where it will be renovated if they are reused or recycled. The distance between the deconstruction site and the place where the building product will be restored or recycled might be across town or over the world. The cost of transportation is a major factor in determining whether or not it is economically possible to reuse or recycle a construction material.

- Product refurbishment

The structural component is reconditioned in this process so that it may be utilized for its original use or for another. Lighting fixtures are an example of a product that has been refurbished and used for its original purpose. Antique gas or electric lights are frequently rewired and supplied with lights, preserving the fixture's character while adding an appealing architectural aspect to a new or refurbished room. Similarly, relatively recent lighting fixtures that have appropriate photometrics for an application and are being removed from an old building can be dusted and tested, then rewired and relamped where needed with energy-efficient bulbs and power supplies and utilized in a new application. A construction component can also be reconditioned and repurposed. Casework, for example, might be taken from a current framework that is being demolished or restored for another use and reused in a new structure for the same or a different purpose. Bricks and roof tiles from demolished structures can also be restored and repurposed. Waste generated during the refurbishment of a building that cannot be reused or repurposed is disposed of in a landfill or burned. Any trash that may be recycled and reused as a result of product refurbishment should be collected and repurposed (The Associated General Contractors of America, 2007).

- Refurbished Product Transportation

The restored building product can be sent straight to a construction site for installation, or it can go via the building material supply chain and be stored by a supplier until used. The distributor would then remove the building goods from storage, deliver it to the worksite, and implement it into the construction.

- Material Recovery

The material recovery procedure begins after the building is delivered. For a uniform construction product, this could be a one-step procedure in which the valuable material is retrieved directly. Or, it could be a multistage process in which the construction product is first subdivided into its many recyclable elements, and then each of these elements is treated at the same site or moved to other recycling facilities that specialize in a certain material.

- Recovered Components Transportation

The bulk material is collected and transferred from the recovery facility to the production site, where it is used to create a new construction product.

- Waste to be disposed of in landfills or incinerated

Building components recovered from demolished buildings, as well as trash from product refurbishment or material recovery procedures are either landfilled or incinerated and released to the environment. Because landfills and burning garbage has a negative environmental impact, the objective is to reduce this waste (Glavinich, 2008).

3.5 Features of Green Construction Materials

3.5.1 Waste minimization

The following are waste avoidance measures that the contractor might use throughout the construction goods purchase process:

- Just purchase what is truly required.

- Reduce the amount of transportation and packaging of materials used.
- When feasible, use standard products.
- Consider using materials that have been custom-fabricated.
- Consider off-site prefabrication of material assembly.

Each one of these waste reduction measures is discussed in details in the following.

Just purchase what is actually required. Purchase just what is required to reduce waste. Careful planning, tight collaboration with suppliers, and continual monitoring of future work, production levels, and on-site inventory are typically required. Product shortages are a danger of ordering only what is needed, which can result in wasted time and productivity, as well as the expense of unproductive personnel and equipment. On-site vendor-managed inventory (VMI) is one approach for the contractor to guarantee that workers have the products they require whenever they need and that there is no loss from overordering. The contractor is invoiced monthly for goods utilized by the supplier, who keeps the trailers supplied with the products typically required on the project. The supplier removes the trailers with the leftover goods at the end of the job, leaving the contractor with no surplus items to store, dispose of, or pay a buyback charge to the supplier. Furthermore, the provider may be liable for the disposal of all shipment and packing items. If a project requires wood framing, this approach can also be used. After products take and cut list have been created, the frame component of the project may be ordered. Having material provided from a cut list prevents materials against being lost on the job site and helps to save time during the field execution (Green Seal, 2007).

Reduce the amount of transportation and packaging of materials used. The contractor should cooperate with suppliers to reduce material transportation and packaging whenever possible. Whenever feasible, designate reused or returnable material transportation and packaging materials as the optimal option. This will reduce waste and remove the need for on-site disposal of shipping and packaging products.

When feasible, use standard products. The contractor should examine the project designs to see if the design is consistent with standard-size construction supplies to eliminate the requirements for onsite manufacturing and modifications. The contractor can plan the project using standard-size materials and ask the design team to make revisions so that standard-size construction goods can be used whenever practicable (Green Seal, 2007).

Consider using materials that have been custom-fabricated. If standard-size materials are unavailable or unacceptable, the contractor can negotiate with his or her suppliers to get products with the required dimensions, even if they are nonstandard. Custom-fabricated products may be more expensive, but they will save time and money in the field.

Consider off-site prefabrication of product components. Off-site manufacturing is becoming increasingly frequent, and it may help decrease waste and boost efficiency on the construction. Fabrication of ducting, plumbing, and other components can be done off-site in a controlled setting, and the prefabricated components can then be supplied and installed on-site. Off-site prefabrication in a controlled setting not only reduces the amount of waste, but it also reduces the possibility of pollution on-site. Furthermore, due of construction air-quality issues, off-site manufacturing in a controlled setting may enable the use of paints, sealants, or resins that would otherwise be prohibited on-site (Green Seal, 2007).

3.5.2 Indoor air quality

Green materials and techniques with the following qualities can enhance indoor air quality (IAQ) during and after building:

- Low or non-toxic chemicals
- Minimum chemicals release
- Resistance to humidity
- Possibility of healthy maintenance

Each of these building product qualities that contribute to a healthy indoor atmosphere for both building workers and building occupants is discussed in the sections below.

Low or non-toxic chemicals. These materials or consumables emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.

Chemical Releases are kept to a minimum. Minimum volatile organic compound (VOC) emissions are required for products to achieve the minimal chemical emissions standard. Product restrictions on chemical emissions will be established by project requirements or a third-party grading system.

Resistance to humidity. This group of products resists moisture to prevent biological pollutants from growing in buildings.

Possibility of healthy maintenance. Simple, low-VOC cleaning procedures are all that are required for these goods.

Consider Bloomington Central Station in Minnesota, where Reflections' inoperable windows provide a marketing benefit to customers with respiratory concerns. The feature that the windows are not operable— uncommon in apartment design—is perhaps the most striking feature of Reflections architecture. The outstanding mechanical framework is structured around this feature, ensuring that the air inside the building is cleaner than the air outside: it is processed three times prior to actually entering the residing units, which are repeatedly exhausted and receive one total air change per hour on average. In addition to the high level of interior air quality, the building's paint satisfies the LEED criteria for low-VOC content (South Coast Air Quality Management District, 2007).

3.5.3 Efficient energy use

This category includes products such as building equipment and devices that are meant to be energy efficient and are frequently needed to be evaluated and certified to satisfy a certain standard. Energy Star, which is cooperatively managed by the US Environmental Protection Agency and the US Department of Energy, is an example of an energy-efficiency program. Energy Star's mission is to safeguard the environment by promoting energy-efficient goods and activities (EPA and DOE 2007).

3.5.4 Conservation of water

This group of building items preserves or prevents the use of water in their functioning. These items, like energy-efficient products, have been evaluated and satisfy a certain criteria.

Take, for example, the Navy League building in the United States. The structure embodies "green building" advancements and has a high "Silver Rating."

The structure is equipped with a cutting-edge water efficiency technology that attempts to reduce the quantity of freshwater resources used by the project while also lowering storm water runoff. The storm water collection system collects rainwater and stores it in a huge vault in the basement, where it can be used to irrigate the building's plants and bushes as well as flush the building's bathrooms. When compared to traditional office buildings, low-flow faucets, dual-flush bathrooms, and the utilization of recycled water for chiller re-supply would lower water usage by nearly 30%. The building uses around 60% less fresh water overall thanks to the combination of the storm water reuse system and high water efficiency pipework.

We should be able to deduce from the above case that What is a net zero water building?

The goal of a net zero water building (new or rebuilt) is to:

- Reduce overall water use as much as possible.
- Make the most of alternate water sources
- Reduce the amount of wastewater discharged from the facility and restore the water to its original source.

The quantity of alternative water utilized and water restored to the initial water source equals the total water usage of the structure, resulting in a water-neutral building.

The purpose of net zero water is to protect the amount and quality of freshwater resources with the least amount of degradation, depletion, and redirection possible alternative water sources and water efficiency methods to decrease the consumption of provided freshwater. This idea may be applied across the entire campus. In the end, a net zero water facility (or campus) totally balances water use with alternative water and water restored to the source. Restoring water to the initial water supply is unlikely if the facility is not situated within the watershed or reservoir of the initial water supply. In such instances, a net zero water approach would rely on the usage of alternate water sources (Fowler, 2017).

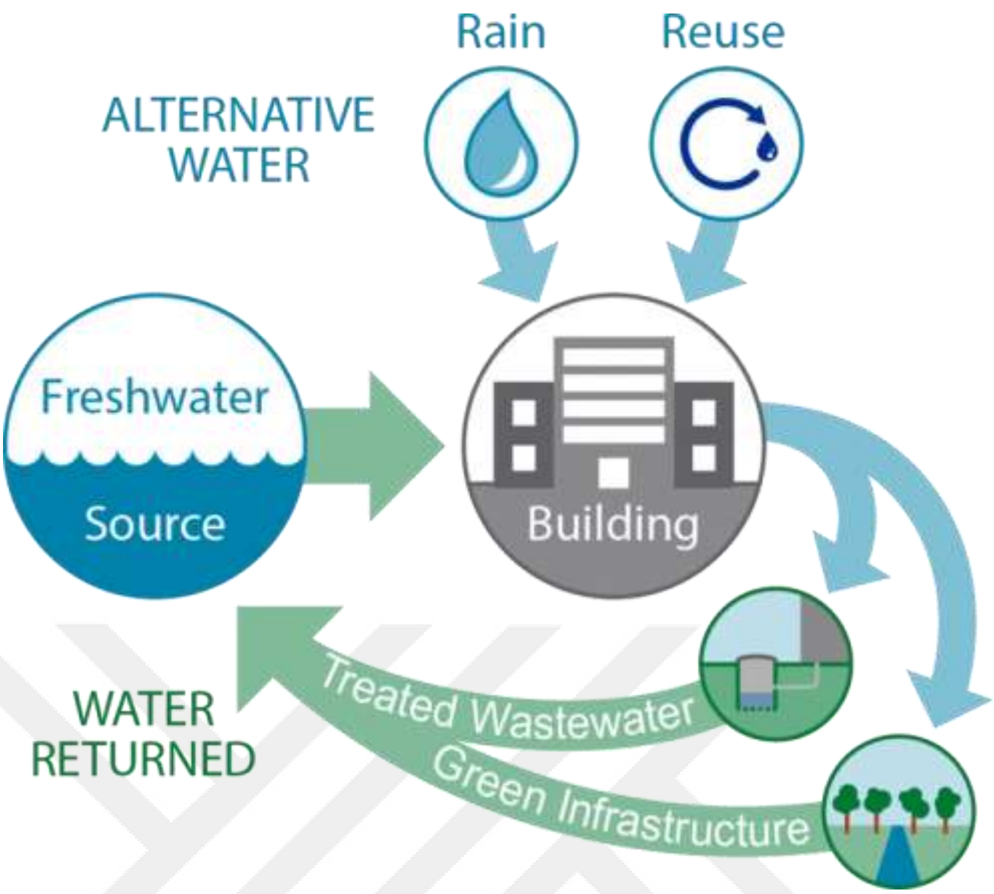

Figure 3.4: Net-zero Concept.

Source: Fowler, (2017)

3.6 Green Building Product Screening Process

The sustainable buildings item filtering procedure should be performed by the design engineer and represented in the component properties. When the designer has not thoroughly evaluated the items, the contractor may be required to conduct the filtering procedure. As shown in Figure 3.4, the sustainable buildings screening procedure consists of three steps:

- Step 1: Research
- Step 2: Evaluate
- Step 3: Select

The next sections explain each of these three phases (South Coast Air Quality Management District, 2007).

3.6.1 Step 1: research

This phase entails acquiring technical data on the construction component under consideration. Material Safety Data Sheets (MSDSs), IAQ test data, product warranties, source material characteristics, recycled content data, environmental declarations, and durability data are all included. This stage should also entail looking up construction laws and guidelines to see whether the item you're looking at may be utilized.

3.6.2 Step 2: evaluate

Evaluation includes the inspection and validation of the technical information to guarantee that it is comprehensive and fits the project criteria. it is simple when comparing construction materials depending on the same environmental criteria (e.g., a comparison of recycled content among various products), while when comparing multiple construction goods that fulfill the same job, evaluation becomes more complicated. This process will result in a list of eligible construction goods, which will be compared in Step 3.

3.6.3 Step 3: make a decision

The last stage in the selection procedure is to compare the features of a group of suitable building materials defined in Step 2 and choose the preferable building material for construction (U.S. Environmental Protection Agency and the U.S. Department of Energy, 2007).

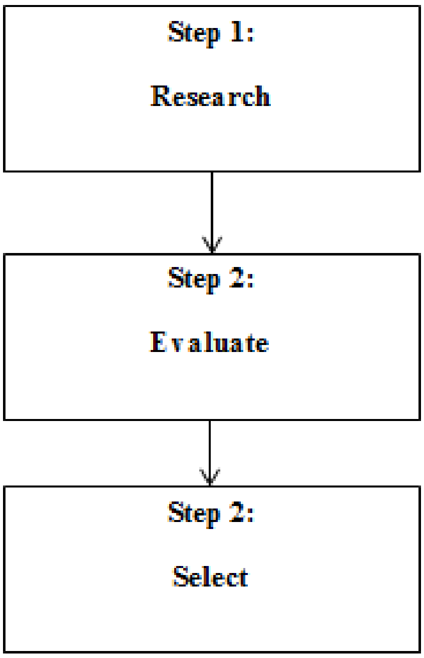

Figure 3.5: Green Building Product Screening Process

3.7 Creating an Environmentally Friendly Jobsite

Beyond the agreement papers and third-party sustainable structure grading standards, the contractor can do a number of actions to establish an ecologically safe worksite. Greening is becoming a style of conducting business for many contractors, and they are reaping the benefits of more effective processes, lower power expenses, and higher labor productivity. The following are some of the activities the contractor can do on the worksite:

- For building tasks, set rules for light settings and illumination efficiency. Exterior illumination is required for construction work both in the nighttime and early in the daytime. Interior activity away from windows and other types of sunlight, on the other hand, need the use of temporary artificial lighting until the actual facility illumination is built and functional. Throughout work, both outside and indoors, the contractor should explore creating rules for illumination degrees and efficiency. The project's excellence, speed, and protection will all benefit from adequate illumination.
- For project electricity, employ green power alternatives. This is actually being done in the highway construction business, where solar cells (PV) plates are used to generate electric signals. PV panels on a construction worksite might be employed to power batteries, which could then be used for safety lights at nighttime (SMACNA Inc., 1995).
- Choose and employ energy-saving lighting options. For temporary illuminating, several work areas still employ conventional lighting. Although conventional lighting is cheap and simple to use, it is ineffective and does not necessarily give the ideal illumination for the job. The contractor should look at using more energy-efficient luminaires on the job field, such as compact fluorescent lamps, particularly if the illumination will be employed as safety lighting and remained on all night (SMACNA Inc., Undated).
- For safety lights, apply motion detectors. On most work locations, safety lighting is left on all night. Some sites must be illuminated continually throughout the nighttime for protection and safety purposes, but many others do not. To save power and money, the contractor might explore using motion detectors on safety illumination.

- Save the night sky by avoiding illumination pollution. Whether nighttime illumination is utilized for safety or work activities, the contractor must consider the effect of jobsite illumination on nearby residents and the night sky. To prevent illumination pollution and safeguard the night sky, the contractor should consider positioning and targeting light fixtures. Additionally, where suitable for the work at hand, the contractor should try employing luminaries with a high cutoff to further decrease light pollution (SMACNA Inc., 1995).
- Create illumination management areas depending on the order of construction. Whether or not there is work in a particular section, all of the illumination at a jobsite is frequently switched on. When no work is being done in the location or when the sunlight accessing the workplace is suitable, the contractor should explore placing light switches for temporary illumination so that the lights can be switched off when no activity is being done.
- Gather rainwater and greywater and put it to good purpose. When drinkable water is not necessary, the contractor should explore storing and employing rainfall and greywater in work and cleanup operations, as well as for watering site plants and dust management (SMACNA Inc., 1995).

3.8 Construction Equipment Selection and Operation

Fuel consumption and pollution from construction equipment and vehicles may be reduced by a variety of methods used by the contractor. As well as being good for the environment, these tactics will save the contractor money and boost output. In order to enhance the working environment, boost productivity, and minimize expenses, the contractor should consider the following:

- Minimize cycle time by planning equipment dispersion. Increasing productivity and lowering fuel costs may both be achieved by optimizing equipment types and amounts to decrease cycle time. Renting a piece of equipment that is better suited to the job needs may be more cost efficient than using equipment that the contractor currently owns or leases on a project. Green construction projects that need extensive earthwork may necessitate a more thorough analysis of the operation by the contractor, who may then pick the finest equipment for the task. With the use of simulation software, equipment dealers may help the contractor choose the appropriate equipment spread (SMACNA Inc., 1995).

- Educate operators on how to best use their equipment. Operators who know how to run a piece of equipment may not necessarily know how to operate it effectively. Operators of heavy machinery should be educated on how best to use their equipment.

Avoid wasting time and money by wasting time and money on unneeded equipment idle. For equipment operators, the contractor should set standards that specify a maximum idle duration and include a shutdown procedure for equipment when the operator suspects he or she will go over that time limit.

Use battery-powered vehicles and equipment. On-site vehicles like pickup trucks and other heavy machinery should be replaced by battery-powered vehicles like golf carts wherever practicable.

- Alternative fuels should be used in lieu of traditional fossil fuels. The contractor should investigate employing alternative fuels in its car and truck fleets if they are accessible and compliant with engine specifications.

- Promote the usage of mass transit and carpooling among employees. Carpooling or using public transportation may help save fossil fuels and cut down on greenhouse gas emissions. Using a bulletin board at the construction site, the contractor may help employees who live nearby and are interested in carpooling to get in touch with each other. Public transportation timetables and routes may also be posted throughout the workplace to get people interested in using public transportation.

Quality growth principles are followed at the Navy League site, for example, including consideration of location, density of building stock, design elements such as cultural and racial diversity as well as transportation, accessibility, and environmental factors. One block from the Arlington Courthouse Metro station and on various bus lines, this renovation project is "transit-friendly." A four-level underground parking deck has charging stations for electric cars, as well as designated spaces for carpools and other forms of mass transit. The building's inhabitants may also store their bicycles and use changing facilities there. As a result, parking is limited to the bare minimum permitted by municipal zoning ordinances (SMACNA Inc., 1995).

3.9 Documenting Green Construction

Before the commencement of building, throughout building works, and at job completion, a green construction project normally necessitates the contractor preparing and submitting extra documentations. These documents differ from one project to the next. It's critical that the contractor understands what project documents are expected, when they're due, what format they should use, and how they'll be reviewed and approved. Green project documentations may involve the following plans, which must be provided, authorized, and recorded in order to be compliant:

- Waste Disposal and Recycling Plan
- Project Management and Use Plan
- Plan for Indoor Air Quality
- Plan for Product Supply and Storage

Likewise, project documents detailing the kind and amount of the following product types, such as the ones below, may be needed:

- Products that have been salvaged and refurbished
- Products with Recycled Elements
- Products from the neighborhood
- Accredited wood components.

Material details and certificates, in addition to the standards in the technical properties, may be needed for green building projects. This material detail and certification submission procedure is often in addition to, and sometimes simultaneous with, the standard shop drawing procedure. The goal of these submittals is to show that the green project standards were satisfied and to what degree they were accomplished. These documents are often submitted as part of a proposal for third-party accreditation as a green building. The following are some examples of product details and certifications that may be needed on a green building:

- Roofing

- Lighting Cutoff
- Water Consumption by Plumbing Fixtures
- Air-conditioning equipment that does not use CFC refrigerant
- HCFC (Hydrogenated Chlorofluorocarbon) Refrigerant

The contractor must understand what green construction paperwork is required. The project contract terms and any third-party green building certification system utilized on the project will usually include requirements for green construction paperwork (SMACNA Inc., Undated).

3.10 Active Sustainable Design Processes

Methods of harvesting energy utilizing natural renewable sources like solar, air, or water are known as active sustainable design techniques. As previously noted, the evolution of such techniques is owing to an increase in society consciousness of energy conservation and environmental problems.

Active design approaches do not ensure energy efficiency since the quantity of energy used is entirely determined by the user's behavior. Still, extracting energy from renewable resources has the goal of having a lower environmental effect (McLennan, 2004).

To put the concept of active sustainable energy in a nutshell, the sun transfers the heat toward the earth, which is collected by the atmosphere and begins the energy transmission. The planet then responds to the energy gained by devising various techniques for capturing these sources of power Bartmann and Fink (2009).

Renewable sources, such as sun and aeropower, have started to offer a small bit to the electricity market, despite the fact that other kinds of energy are mostly generated in bigger numbers.

Even still, energy efficiency, the primary goal of sustainable design, is an important consideration. Despite the fact that solar and aeropower is not currently popular energy sources, their energy efficiency are improving. Because electricity is a critical source of power in most households.

As a result, sustainable design must seek to use and improve active renewable technologies, given the future evolution toward renewable energy sources and the increasing quality of these systems Guy and Farmer (2001).

The Alberici Corporate Headquarters in Missouri (LEED-NC Platinum) is a case of using active design principles, with on-site renewable sources providing over 20% of the facility's necessary power. Yearly, a 65-kilowatt wind turbine generates 92,000 kilowatt-hours, or 18% of the building's electricity demands. Preheating hot water is done with photovoltaic panels. The lighting power density in the model is around a quarter of what is generally utilized to illuminate an office building Hanson et al. (2016)

3.11 Passive and hybrid design strategies

Passive Building Design (PBD) is commonly regarded amongst the most successful solutions for reducing building energy consumption Lam et al. (2006). A passive building is described as "a structure built to produce a suitable interior environment without the need of single active heating systems". Passive structures can achieve the minimum energy demands by creating a balance between heat losses and gains in relation to the specific climatic conditions of the facility's region Jochem (2009). Passive design encompasses numerous approaches of building design, such as main façade and window alignment, wall depth, heat insulation, window features, passive solar heating solarium, shading systems, and so on Aksoy and Inalli (2006). While passive methods strive to lessen dependency on active methods by providing more energy efficient architectural components such as building envelopes and roofs Sadineni et al. (2011).

Passive solutions were shown to have a modest extra capital investment cost when compared to the potential benefit in energy savings in most studies. As a result, several green and sustainable design standards encourage passive design. By depending on architectural design, passive design is a low-energy-intensive approach of maintaining a building cool. The construction incorporates heat mitigation strategies, natural lighting, and natural cooling ways to reduce energy usage while enhancing comfort conditions. The advantages of passive design are noticeable: a substantial decrease in maximum demand for the energy provider, increased convenience, cheaper energy bills, and little added expense for the builder.

Architects typically have a poor understanding of building physics owing to their education. As a result, architects' decisions for the building's exterior to optimize energy use frequently have a detrimental influence on the building's energy efficiency. For example, when designing a building for a cold environment, the major option for enhancing the structure's energy performance is to raise the insulation depth or enhance the effectiveness of the windows' panes. Although these methods are considered passive solutions, their wrong implementation might result in increased costs and environmental concerns associated to the manufacture of insulating materials. As a result, it is vital to change the thinking of building designers by implementing the integrated design model and bringing in new professional knowledge, such as energy or environmental specialists, into the design cycle (Butera, 2013).

Innovative areas of knowledge in building science can be adopted to systematically tackle the two long-standing challenges in the construction industry (energy and environmental efficiency). Along with other professionals participating in the design phase, such as architects, mechanical, and electrical engineers, these analysts can effectively participate in the process of building design. The impacts of eight aspects of passive design methods on building energy consumption, including "thermal insulation," "thermal mass," "glazing," "window size, shape, and location," "color of external surfaces," "external shading devices," "building orientation," and "building form." These variables should primarily be considered during the design phase of the construction process Omrany and Marsono (2016).

Sanyogita Manu et al. (2018) evaluated six modern institutional and office buildings in warm-humid, hot-dry, and composite climatic zones to assess the thermal performance of climate sensitive buildings. They used a variety of passive and hybrid design solutions, such as various shading devices, courtyards, solar chimneys, hollow walls, multiple thermal mass combinations, day and night airflow, and evaporative cooling. They observed each facility for a year and evaluated its efficiency in terms of the behavior of chosen components as well as its overall reaction to the outside environment. They analyzed efficiency utilizing temperature gradients overlay on wall sections, heat maps, and linear regression analysis, in addition to the observed variables, to comprehend the link between outdoor and inside conditions and identify the nature of each building's "climate responsiveness."

All of the structures taught us a lot about how to choose design tactics. It was discovered that no one technique will always work in a structure or in a certain climate zone and that it will be more effective when used in tandem with other tactics.

The research also emphasizes the significance of employing diverse climate response techniques to address a variety of problems. Different tactics may be more helpful at different seasons of the year, or they may need to be paired with others to be more effective. To better comprehend the store of unique and context-specific solutions, future field research should focus on combinations of climate responsive design techniques rather than solitary ones Manu et al. (2019).

3.11.1 Various shading devices

Mousavi and Alibaba (2015) reviewed the literature on the benefits and drawbacks of double skin façade technologies in hot environments, as well as screening systems and ventilators in these conditions. The findings show that this method works well in hot settings when heat gain is mostly decreased.

The primary purpose of a shade technology is to keep the open areas of a structure from harmful sun radiation. Stationary shading methods, moveable shading methods, and other shading techniques are the three categories of shading systems. By blocking entering daylights, a shading device can alter the building's energy use. Palmero-Marrero and Oliveira (2010)investigated the impact of shading devices on building thermal efficiency in cities of varied elevations and climates. It has been demonstrated that shading devices have a significant influence on conserving energy and enhancing thermal efficiency in workplaces in a variety of climates.

Manzan (2014) used genetic optimization (GO) to create a fixed shade device for two climates, Trieste and Rome, using an office area with a south-facing window. In both winter and summer, the efficiency of the shading system was evaluated by evaluating the shades supplied over the window to minimize cooling demand in summer, but also influenced heat loads in winter by restricting solar gains. When compared to the unshaded window, a decrease in basic energy usage of up to 19% for Trieste and 30% for Rome was realized.

Chou DC. et al. (2015) created a model that combined horizontal louver shading devices with solar collectors and tested how it affected facility energy performance. They claim that with enough solar radiation, this method may achieve great absorption without the use of supplementary heating systems. It was determined that by incorporating the model, the cooling demands may be reduced. A proven approach to minimize incoming solar radiations is the employment of shading devices in the exterior walls to shield open parts. This item must be created with care, taking into account the best size, location, and type for installation. To improve energy efficiency, shading device techniques can be combined with modern technologies such as Photovoltaic panel. Photovoltaic cells may be utilized as a shade device, intercepting the received radiations while also generating electricity.

3.11.2 Courtyards

As a passive cooling approach, a central courtyard works as follows: as the day goes toward evening, the air in the courtyard grows warmer. Cool air is kept in laminar layers in the courtyard and moves into the buildings around it. In the morning, the heat in the courtyard gradually rises, enabling the courtyard to stay cool until sun radiation passes directly on it. Unless baffles are constructed to divert airflow, warm wind travels over the house throughout the day and does not reach the courtyard, causing eddies within Soflaeia et al. (2017).

Climate-sensitive architecture is shown by traditional courtyard dwellings, which were built with careful consideration to the local climate and cultural contexts. A wide range of passive cooling techniques were used for a long length of time in reaction to environmental considerations, such as Showdan and Khishkhan and Shabestan and Hozkhaneh, central courtyard, wind catcher, air-vent of dome roof, etc.

3.11.3 Solar chimneys

Passive solar heating and cooling may be achieved by the use of a solar chimney, which can be used to both regulate and exhaust a building's temperature. An energy-efficient building design may be achieved by using a solar chimney such as Trombe wall or a solar wall.

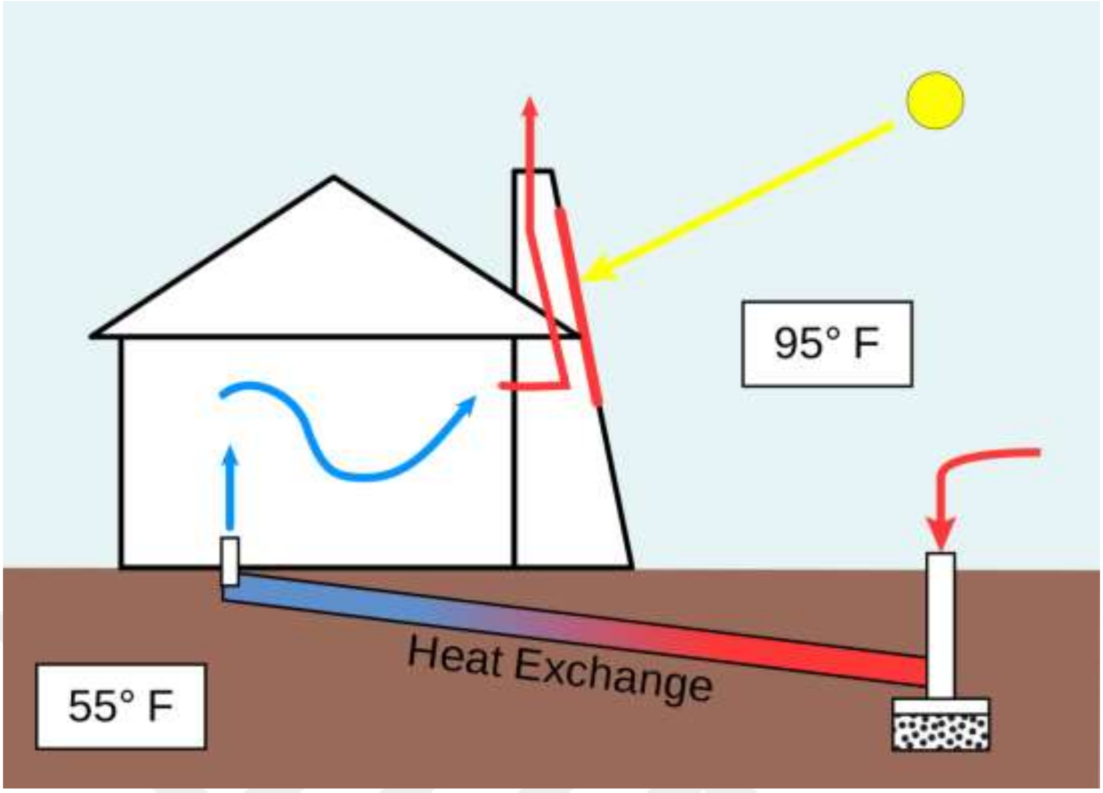

Figure 3.6: Solar chimneys

As the chimney exposed to the heat, the buoyancy action caused the warm air within the area to become lighter and rise, pulling it in via different inlets. Chung et al. (2015). The façade would allow the outside air to enter the inside. The sun aided stack effect ventilation system was developed to promote natural air circulation based on the buoyancy concept Khanal and Lei (2011). The solar panels are separated from the metal roof by a space of 300 millimeters to enable for aeration. Evacuation fans installed in each chimney helped with evacuation when the stack effect failed.

3.11.4 Cavity walls

Brick cavity or brick rain shield walls, as they're called in the United States, are a typical kind of external wall in North Western Europe. These structures, which were constructed until the first energy crisis in 1973 using perforated huge format bricks or calcium silicate blocks and a 9–12 cm thick cladding, had an air gap (the hollow) and a 9–19 cm thick inner leaf. Despite its age, this architectural style gained the greatest traction after World War II. This was due to its exceptional rain-tightness. Capillary break: The hollow acts as a capillary break, allowing water to be absorbed by the veneer wall and then flow off the other side of the cavity wall. In addition, the building style offered better thermal quality than a large wall. Clear wall thermal transmittance ranged from 1.4–1.9 W/m2 for the inner leaf and 0.17 mK/W for the air space, while the brick veneer's wetness had no influence on the inner leaf's thermal resistance (m2 K). In light of the wall's mass, this value was judged adequate. During the 1973 energy crisis and the necessity to enhance energy efficiency, cavity filling became a common technique. Between the 1970s and the early 1990s, clear wall thermal transmittances of 0.6 W/ (m2 K) or less were regarded the standard. A whole-wall thermal transmittance of 0.2 W/(m2 K) became a new standard in Belgium's cold climate in the 1990s, when low-energy and passive-building concepts arose in the aftermath of the Kyoto Protocol. Hens et al. (2007).

3.11.5 Evaporative cooling system

All cooling methods employ water as a coolant. The water evaporating method functions by converting water from a liquid to a vapour, wasting energy and absorbing heat from the air, reducing the heat and raising moisture. Evaporative cooling is a method of conditioning that has been used in our everyday life from ancient times. Evaporative cooling is demonstrated by the fountains, the sea wind, as well as the occurrence of sweating. The evaporative device provides for a 75 percent reduction in motor energy consumption and can run on processed water. The injectors feature 0.7 mm holes that generate a 12 micron water drop, which aids evaporation and improves efficiency Irulegi et al. (2014).

3.11.6 Thermal mass

The tendency of objects to receive (convectively and radiate) and keep heat input throughout a warm time and emit it throughout a cold time is referred to as thermal mass. Thermal mass is classified into two groups. I) the exterior thermal mass, which immediately subjected to the outside and inside temperatures. Outside elements that are connected to the outside climate and inside areas, like walls and roofs, are often included in this group. II) interior thermal mass, such as furnishing or inner concrete barriers, that is not related to the outer climate. The basic mechanism of thermal mass is to capture heat from the interior air when the temperature of thermal mass is lower than the temperature of the interior air, and to release the captured heat into the interior air when the temperature of thermal mass is greater than the temperature of the interior air Yang and Zhang (2014).

Facilities' compositional mass can be constructed to retain interior sunlight thermal gains, hence lowering electricity demand for interior cooling and lowering temperature fluctuations. Atmosphere, alignment, window area, insulation, airflow, load demand, and habitation behavior of structures all work to determine the efficacy of thermal mass in facilities. Where the daytime temperature fluctuation is large, thermal mass is more feasible to deploy. Several researches looked at the impact of thermal mass on building power usage. The influence of thermal mass on the heating and cooling demands of constructions in Cyprus was investigated by (Kalogirou, 2002). Thermal mass was discovered to greatly decrease heating needs while marginally increasing cooling needs in facilities. Aste et al. (2009) investigated the impacts of thermal mass in an Italian facility by comparing the power efficiency of wall systems with similar U-values but differing thermophysical parameters, such as heat transfer surface, specific heat capacity, thermal conductivity, and solar regulating parameter. They discovered that the most energy-efficient walls had an effective mix of dynamic thermophysical features, namely a larger heat transfer surface, rather than the best thermophysical properties. As a result, the heat transfer surface impacts the efficacy of thermal mass for energy conservation, necessitating careful design and management measures. In Australia, Gregory et al. (2008) published a comparative examination of the impact of thermal mass in simplified construction units. Thermal mass, they discovered, greatly lowered space heat needs, especially when it was put on the interior side of the insulation.

3.11.7 Ventilation

Airtightening a structure entirely does not imply it can't breathe. By applying motorized systems, passive buildings are capable to breathe a regulated quantity of air instead of inhaling un-measurable air intake via unmanaged leaking. Motorized ventilation helps to regularly circulate a specified quantity of outdoor air inside the passive building while also assisting in the exhaustion of defined amounts of stale air. A balanced motorized ventilation device, which must be exceptionally power saving, is used for air ventilation in a passive building. The adequate supply of air movement by a passive building may ensure that residents have good interior air quality (Klingenberg, 2013).

3.11.8 High-performance windows

Between 20 and 40% of a building's total power loss may be attributed to windows. In order to reduce energy consumption, the design of windows should take into account the individual environmental conditions of the building Cotana F. (2014). Many recent studies have shown that a variety of glazings, including aerogel glazing, vacuum glazing, smart glazing, and prismatic glazing, may successfully improve the energy efficiency of windows Cuce and Riffat (2015).

4. CASE STUDIES

To mitigate the devastating consequences of climate change on the built environment, Edward Mazria and Architecture 2030 have launched The 2030 Challenge, a program requiring all new construction and major renovations to be carbon neutral by 2030. Nearly 40% of yearly Greenhouse Gas (GHG) emissions come from buildings, construction, and operating activities; hence, there is more room to stabilize and reverse emissions in this sector, in order to prevent further global warming from reaching a tipping point. Architecture 2030, a non-profit group, does not regard climate change as a difficult problem, but rather as an opportunity to adopt energy-efficient planning and design The 2030 challenge-Architecture 2030.

4.1 Shangrıla Potanıca Gardıns (USA)

4.1.1 Project overview

A study and research institution, Shangri La Botanical Gardens and Nature Center is located on 252 acres near Orange, Texas. The Stark Foundation's Shangri La initiative links all generations to nature.

The Nature Discovery Lab exhibit, a lab, and three exterior workshops in the cypress swamp give hands-on educational activities. There's also a stage, an educational children's landscape, a workshop, and a water display garden that exhibits how vegetation cleanse contaminants. An administration building and administrative areas are also provided.

Hurricane Rita struck the Shangri La property in September 2005, just as project started. Instead of accept defeat, the crew seized the chance to salvage dead trees for use in the new infrastructure or for other initiatives.

4.1.2 Design and ınnovation

The rehabilitation of the property, which had been officially closed for five decades, was the first step in the project. The main purpose was to create a facility design that combined accessibility with the site's protection.

Shangri La's architecture reacts to both the urban and natural settings. The ancient decorative gardens are accessed through the visitor center, which is surrounded by a wetlands display garden. Outside airflow is common, with broad canopies providing shade and protection from the heat and rain. The nature exploration laboratory and balcony, outside workshops, bird blind, and boat house in the natural regions, hovering above the ground on helical foundations and electrified by solar cells.

The project was awarded the first LEED Platinum for New Construction certification (The American Institute of Architects (AIA), 2009), (Glavinich, 2008).

4.1.3 Regional/community design

Shangri La's additions were created with the goal of being a community hub, with an aim of offering a site for native ecosystem accessibility, learning, and exploration. Most significantly, the institution is a living museum that aims to engage school kids with nature while also allow participants of all generations to discover its ecosystems.

Shangri La's objectives involve:

- Offer increased economic activity to rural Southeast areas;
- Protect natural environment that are in danger for coming generations;
- Make continuous environmental investigation easier; and
- Serve as an example for responsible development for tiny Gulf Coast towns.

4.1.4 Land use and site ecology

Helical pier bases are used for all project facilities in sensitive places to reduce short- and long-term environmental consequences, like water flow disturbance. Noise and disturbance in wildlife regions were minimized through building techniques and planning. For example, building was planned to avoid disrupting hatching (The American Institute of Architects (AIA), 2009), (Glavinich, 2008).

4.1.5 Designs for a bioclimatic environment

The project team concentrated on delivering sufficient comfort in the hot, humid environment while reducing reliance on active equipment. The following are some of the methods used:

- Restricting mechanical systems to Theater, café, bookshop, lab, and offices in order to decrease first-time maintenance costs, expenses, energy consumption, and maintenance;
- Elevating the natural exploration facility and classes above the swamp edge, with screened walls to enable air to flow and huge overhangs to protect the area from rainfall and summertime sun;
- Installing solar cells to supply the facility with power (The American Institute of Architects (AIA), 2009), (Glavinich, 2008).

4.1.6 Air and light

Over than 75percent of the interior rooms are lit by natural light. Sunlight detectors adjust light sources to the needs of the situation, saving energy. Heat gain and sunlight are reduced with the use of outside shading devices.

Narrow ground plates provide views to the outside for 90% of the spaces, including sights of conserved zones and courtyard gardens. Thermal comfort, airflow, and illumination are all controlled through opening windows and other features.

Metrics

Daylighting at a way that enables lights to be turned off throughout the day:

Approximately 75%

4.1.7 Water cycle

To eliminate contaminants from Ruby Lake, which offers hatching area for over a 1000 birds? The lake water is circulated and aerated by floating photovoltaic pumps. The algae and duckweed collected from the lake are recycled and utilized in the gardens.

Nitrogen and other impurities are reduced through a succession of artificial filtration wetlands. The last wetland is within the orientation center and shows how natural aquatic flora purifies the water.

Rooftop rainwater is collected and kept in nine 3,700 gallon reservoirs (for a total storage capacity of 33,200 gallons), where it is used for gardening and bathroom flushes. When paired with water-saving faucets, this resulting in a 77 percent decrease in water use compared to a standard building (The American Institute of Architects (AIA), 2009), (Glavinich, 2008).

4.1.8 Energy flows and the future of energy

The management team restricted mechanical devices to the theater, cafe, bookshop, lab, and offices to keep initial and running expenses low. The outside workshops and natural exploration center are raised and positioned to take use of prevailing air.

A water heat pump is used in the mechanical system to give better heating and cooling efficiency by exploiting of constant groundwater temperatures. After converting heat to a tight piping system that provides air-water heat pumps, the system sends the water to the aquifer. This heat-exchange system creates a 10-degree temperature difference, allowing the mechanical system to function 60 percent more effectively than a traditional air-cooled system and 25 percent more effectively than a ground-coupled system. Using variable-speed pumps in the well-system cycle and closed-building loop improves the system even further. When compared to a baseline building, the design resulted in a 72 percent reduction in energy usage.

Shangri La is planned to generate 21% of its power from 36 solar cells dispersed across the site at optimal efficiency.

4.1.9 Materials selection

Hurricane Rita wreaked havoc on Shangri La in 2005, just as development was getting underway. Rather than accepting a delay, the project team processed dead trees on site and utilized them for outside seats, orientation center furnishings, and main hall frame timber.

The bulk of the buildings at the orientation center were built using recovered brick from a 1910 Arkansas storehouse. Flooring, slat walls, fence doors, and entrances were made of sinker cypress rescued from Louisiana waterways. The parking lot was made with reclaimed asphalt from the repaving of a nearby roadway.

By repurposing greenhouses, the project team was able to make the most of structural elements. Flexible-use classrooms are located outside, and more than 90% of the facility circulation occurs outside, decreasing construction intensity, material use, energy usage, and maintenance costs over time.

Structural elements were made within 500 miles of the project location in 49 percent of cases (by value), decreasing commuting effects and boosting the area economy. Contractors removed more than 79 percent of construction debris from landfills during building.

The project team also selected recyclable materials elements, such as the sidewalks that run across the marsh and are composed of a recycled plastic and wood composite. The recycled plastic utilized in the sidewalks is equivalent to the plastic found in 1.1 million milk bottles or 3.6 million plastic bags.

Helical pier foundations had a lower environmental effect in sensitive places, as well as a lower carbon footprint and material intensity than standard options.

4.1.10 Long life

The materials were chosen for their longevity and ease of upkeep. Brick from a local facility, naturally decay-resistant recycled wood, and galvanized steel are all long-lasting materials that don't require any extra surface, coatings, or sealants, lowering upkeep.

The use of helical pier foundations and modular components reduced site disruption and allowed them to be removed after the project was completed. These features also make it possible to shift structures if necessary.

4.1.11 Process and outcomes

- Predesign

The predesign process began with a one-of-a-kind collaboration between landscape and building architects. An ecological survey of the site, completed with the help of owner agents and an ecologist, enabled the team to design the buildings not just to reduce damages, but also to match the land. This strategy improved visitor engagement and gave them a greater grasp of the natural environment.

The ecological inventory identified chances to rehabilitate and maintain natural systems like Ruby Lake that had been harmed. Engineers and landscape architects work together to provide integrated solutions for both site and building concerns.

- Design

In team meetings and communications, the project team used the LEED rating system to track progress on green solutions. This process enables the team to keep track of and improve design metrics while remaining focused on the project's objectives. The building management team was brought in early on in the design process, which improved budget and schedule efficiency and ensured that design goals were followed out throughout the construction phase.

- Construction

They were able to optimize the building process to decrease site and habitat disruptions because the construction management team and the design team worked closely together from the start. Working with construction crews, for example, the design team was able to adapt the boardwalk structure to allow for the use of modular components, decreasing site effects and building time in sensitive environments.

- System of evaluation:

LEED-NC (Leadership in Energy and Environmental Design) is a certification program developed by the United States Green Building Council.

Result of the score or rating: Platinum level (The American Institute of Architects (AIA), 2009), (Glavinich, 2008).

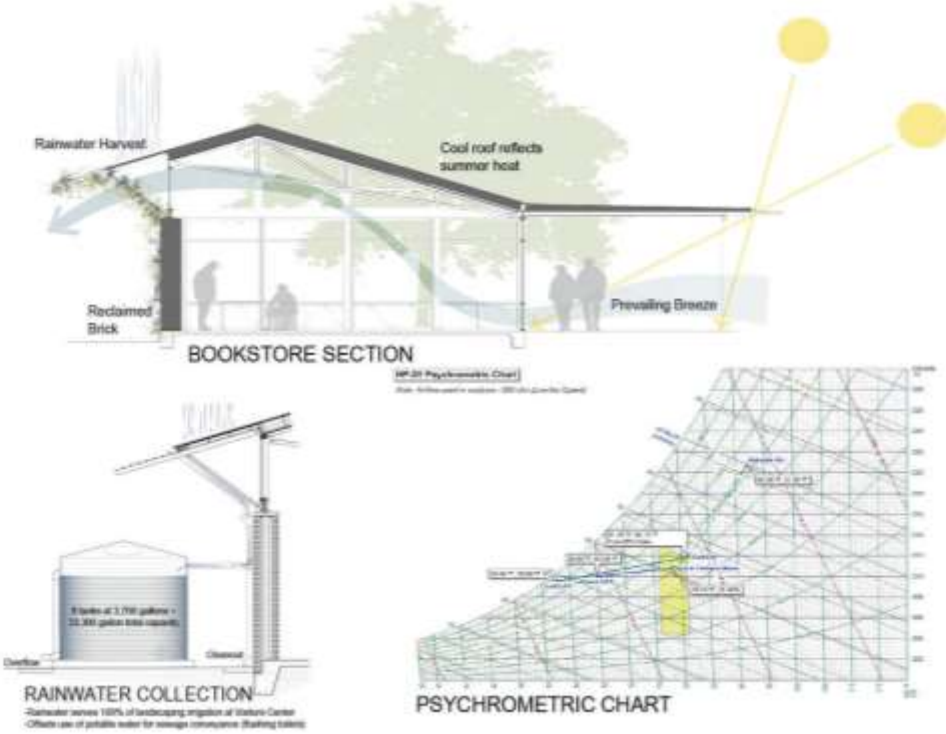

Figure 4.1: Passive design strategies in Shangri la botanical gardens

Source: (The American Institute of Architects (AIA), 2009).

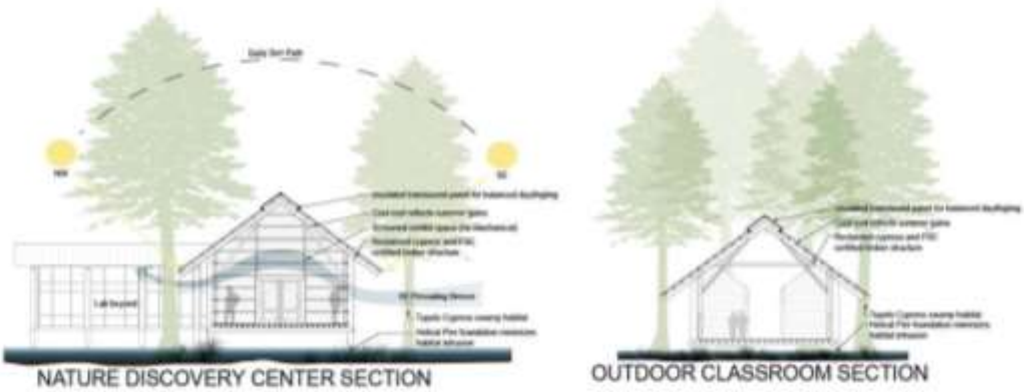

Figure 4.2: Passive design strategies in Shangri la botanical gardens.

Source: (The American Institute of Architects (AIA), 2009)

4.2 Civitas (Single Family Home)

The architect/owner sought to open up the design process across the entire firm to encourage learning and experimentation in design, construction, and operation, and to create a forward-thinking, environmentally responsible single-family home that fosters a meaningful experience through connected spatial relationships, transparency, and material continuity. The house is located on a 6,630-square-foot corner Greenfield plot in a new urbanism development on a peninsula in the heart of Memphis, Tennessee. It was strategically placed to frame the Mississippi River and Delta beyond, and its size is consistent with that of its historic neighborhood while also serving as a visual divide between the inside and outside to improve the quality of life for residents The American Institute of Architects (AIA), 2021 top winners.

The project's ultimate aim was to show how good climate change could be achieved a full decade before the AIA 2030 Challenge was set. The house challenges conventional notions of what constitutes an eco-friendly dwelling by seizing every chance to advance a wider and more expressive design effect. Substantial investigation revealed the area's extensive history of natural catastrophes. The site is at a higher risk of flooding and other severe weather events, such as straight-line winds and earthquakes, due to its proximity to the river, which causes annual water level fluctuations of up to 50 feet, and its location within the New Madrid seismic zone, the most active in the United States east of the Rocky Mountains.

The International Living Future Institute has recognized Civitas as the first Zero Energy and Zero Carbon single-family residence in the world, earning it the prestigious LEED Platinum rating for homes (ILFI). It has a 200-year design lifespan, so it may change and adapt to the demands of future families and the environment. With its wide application of high-performance methodologies for a range of typologies, the project serves as a learning lab that supports continuing research and has future project implications within our design practice. The American Institute of Architects (AIA), 2021 top winners.

4.2.1 Water

Civitas is built atop the third-largest aquifer in the United States, but it can function independently thanks to its advanced rain-harvesting technology and strict adherence to water conservation standards that go above and beyond existing regulations. Underneath the parking garage, there are cisterns that hold 3,400 gallons of rainwater, making the site suitable for zero-water consumption. These cisterns decrease stormwater runoff, store water for future use, and prevent the property's aquifer from being depleted. Eighty percent of the site's surfaces are permeable. In order to utilize collected rainwater as drinkable water on a regular basis for recharging the pool or in the case of a disaster, the client is collaborating with the local utility provider to develop a special use demonstration permit.

The landscaping at Civitas consists entirely of native plants that don't need any further watering than what naturally occurs in the soil or what is collected in the rain collection tanks, therefore there is no need for any additional irrigation. Once regulations in your area let it, you may collect greywater and blackwater and filter them using the existing plumbing. Water from the several bioswales and the vast majority of the roofed area is collected in cisterns.

4.2.2 Energy

Using a ROI strategy supported by several software tools (Tally and Sefaira) to justify initial costs based on simulations, the architect implanted its concept of "less with less is better" (i.e., less building with fewer dollars is better for the environment). Improvements in both detailing and installation resulted from rigorous testing of materials, processes, and outcomes. Prefabrication off-site cut down on construction's front-end price tag, final tally price, and duration. Savings of $54,000 in CLT by avoiding wood applied to ceilings, $15,000 by using repurposed steel, and $62,000 by using polished concrete instead of terrazzo were all informed by the use of innovative building techniques (structural insulated panels, cross-laminated timber ceilings/floors/stairs, tunable metal screens) and a robust resilient structure for this U.S. region. Geothermal mechanical system, radiant insulated slab with thermal breaks at perimeter, R-40 rated insulated exterior walls, R-50 rated insulated roofs, triple-pane low-E glazing, operable windows to allow for cross and stack ventilation, 100% daylit spaces, solar shading via the use of extensive overhangs, tunable metal screens to reject or collect solar gain, and other sustainable design techniques and passive systems all contributed to Civitas' lower operational costs. The American Institute of Architects (AIA), 2021 top winners.

5. CONCLUSIONS AND RECOMMENDATIONS

From the previous studies, we notice an increasing interest in the articles and research dealing with sustainability from 2003 upward. Also in the other hand we notice the upsurge in meetings and conferences of the leading countries especially the industrial countries to discuss the issue of global warming and CO_2 pollution, for example the Rio Declaration, which makes the introduction to Agenda 21, which reveals that "Human beings are at the center of concern for sustainable development"

Plessis (2003) explored the issues in Ecological Building. Even though we've achieved a lot of development in the last decade, it's possible we've unknowingly placed ourselves on a road of restricted options since we've been looking to solve issues in an Einsteinian approach. As Einstein phrased it, "the same thinking and mental processes that caused the problems cannot be used to fix them." Is it possible for us to develop an environmentally friendly constructed environment if nothing significant is changing in terms of power production, buildings temperature control, design and the building procedure? Einstein was accurate and we need to look beyond the box, relying extensively on ecology, biomimicry, and a broad range of other nature-based strategies that have been mostly neglected by popular green buildings.

There will be no truly environmentally friendly structures unless they are completely relied on renewable sources, utilize a factor of ten less resources than traditional construction, have deconstructability, and the materials can be reused and recycled, designed using as yet undiscovered ecological concepts and incorporated into a sustainable urban strategy, healthy for the inhabitants, process their disposal utilizing biological systems and have a lot of other similar features.

Fortunately, this isn't all a dream. Only one day into a long and tough task, the harsh reality is that the journey is far from over. At least we've taken the first step toward a sustainable built environment and are starting to grasp the fundamental principles required to do it. Chrissna du Plessis and Peter Schmid both believe that we can change from sustainable construction to "radical sustainable construction" and begin to think out of the box in a way that is fundamentally different from how we got into the dilemma we are in now (Kibert, 2003).

From the above, we can conclude that sustainability in buildings would clearly be noticed in large areas buildings (as we can see from section 3.11) where we can apply passive design strategies and add green areas in various levels and hence avoiding the heat island (Cities are typically warmer than surrounding rural areas (the heat island) due to higher building densities, larger thermal mass of construction materials, less vegetation cover and associated radiative processes) Wilby (2003). In addition, large areas building tend to consume more energy for air-conditioning, more water and lighting, so if we apply passive and hybrid design strategies, there will be a huge reduction in energy consumption. On the other hand, terraced small areas houses can limit the addition of passive and hybrid design strategies and green areas. Also there is the effect of heat island from the other houses not practicing sustainability.

Sustainable building alone cannot be efficient, where this process is integrated. We need to increase green areas (which reduce temperature Munir et al. (2017)) and reduce the dependence on air-conditioning (where the waste of AC increases the temperature (Salamanca et al. (2014)) this leads to decrease the temperature of atmosphere. Also increasing the awareness of people on this serious issue all this will lead not to only sustainable buildings but also to a sustainable community and sustainable cities.

Project owners may be reluctant to adopt sustainability targets in construction if it means an escalation in overall building costs of roughly 30%. It may be more expensive in the long run to adhere to and implement sustainable building practices than it would be to ignore them Ries and Wao (2016).

5.1 Recommendations and Limitations

A one-size-fits-all approach is not intended. Consider this framework as a starting point for comparing various sorts of structures and concepts. Limitations for example:

1. Lack of statistics (energy, water, land and materials).

2. Lack of sustainable materials products and appropriate database which is available for all stackholders, investors and people interested in this field.
3. In order to assess the project's social effect on the neighborhood, a social analysis would gauge how well buildings and the community collaborated. The economic evaluation would determine the financial viability of the suggested ideas and look for other solutions if they were not financially viable. As a result of the environmental impact assessment, it would be possible to reassess the influence of suggested ideas on the environment.
4. The heavy duty is on the media which plays a critical role in raising community consciousness about the importance of sustainability and in encouraging the use of sustainable practices.

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