The Impact of Green Building Ideology on Ecosystem and Society Health: A Review

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***Abstract*—The First Green Building Movement that marked the beginning of an ideological revolution of the era occurred in the Late 19th Century. Climate Change and Global Warming have always been a major concern for humanity and justify the need for the development of innovative and greener technologies to help conserve natural resources for the future. This Paper presents a review on the Historical Progress of Green Buildings so far and their impact on the occupant's health and productivity. The term which emerged in the context of green buildings as a result of these movements is *High-Performance Green Buildings*. Construction Industry is considered to be the largest consumer of power and contributes about 1/4 of Global Green House Gas emissions. The Green Building Movement was an initiative to emphasize the need for a sustainable Built Environment. This paper presents the findings of a survey conducted on the occupants of GreenTech Malaysia, a certified Green Building, and the results which are somewhat counter intuitive in nature are analyzed.**

Keywords—Climate Change, Global Warming, Green Buildings.

I. INTRODUCTION

Green buildings address these major issues in society Occupant Health, Resource Efficiency, and environmental impact of the conventional construction practices on the natural environment. Resource efficiency in the context of sustainable construction means less power consumption(Electricity) by the building during its operational phase, less water usage through methods like rainwater harvesting, appropriate land use, and landscaping, using environmentally friendly materials and limiting the building's design and operation's life cycle consequences.

Buildings in the United States accounted for 73.6 percent of total electricity expenditures and around 40% of total carbon emissions in 2012, according to the US Department of Energy . As a result, new building technologies should be implemented on a regular basis to reduce electricity consumption and the building's negative influence on the environment[1].

Evermore experiments are being conducted in the field of sustainable construction. The Green Building movement had a major impact in accumulating more and more innovative ideas around the globe, specifically in developing countries where the real estate market, building design, and construction industry has a bigger role to play in the economic growth. As for the developed countries, Since the US Green Building Council (USGBC) was founded a decade ago, the number of buildings requesting for green building certifications has increased tremendously. This represents the green building movement as an important or more so the driving force in the development of construction, design, and real estate markets. Many state govt, universities, and private sector firms are endorsing green building and sustainable construction for their upcoming projects.

Human activities have been responsible for the exploitation of the environment, disturbing ecological systems. The built environment for residential/commercial use has a long-term effect on the biosphere. In the developed western countries around 7 billion tons of material is transported annually for the manufacturing of basic building components. According to research 90% of all materials ever extracted reside in today's building and infrastructure in one form or the other [1]. Waste generated in the construction process has a big contribution to environmental degradation. In the U.S 0.6 tons of waste per person is generated each year. Waste from renovation, refurbishment occurs at 318.900 KG per sq meter[2]. The demolition or dismantling of a structure after its life cycle generates a staggering amount of waste with little to no re-use or re-cycle occurring. The manufacturing process of cement contributes a significant amount to the global greenhouse gas emissions i.e around 2.4%[3]. Many experts and environmentalists believe that human society is on the verge of a major crisis, and difficult decisions must be made to address concerns such as climate change and the degradation of natural resources, which are threatening the human race survival[4]. Energy released in the form of CO_2 when fossil fuels are burnt is the major cause of climate change.

For a long time, the growth in greenhouse gases has been a topic of discussion. Energy consumed by Buildings and automobiles is to blame for a rapid rise in temperature that exceeds expectations[5]. The earth's climate is dynamic, and systems theory has proven that it is non-linear, meaning that a proportional increase in CO_2 concentration in the atmosphere would not result in a proportional change in the temperature. Aside from climate change, there are a number of other repercussions that are causing concern for society-

- Loss of bio-diversity.
- Loss of topsoil.

• Infertility of soil.
• Depletion of major fisheries.
•Toxification of air, water due to release of synthetic chemicals.

WHY GREEN BUILDING

There are 3 basic reasons behind the success of these high-performance green buildings.

First, there is a perceptive response to society's welfare. A traditional building that complies with a set of building codes makes minimal efforts to reduce energy consumption and water usage, and fully disregards material waste and the effects of construction activities on the environment[6]. The approaches and methodologies to conserve the environment are not particularly covered by building codes. Green buildings adhere to a much more conservation oriented code specifically developed over the years for this purpose. Preserving the environment and efficient use of resources is of primary importance in the design and construction of the building. The entire life-cycle of the components to be used in a green building is thoroughly researched. It is necessary to do so as it allows the professional to make provisions for its reuse, recycle, or proper disposal at the end of its life. The use of renewable energy, recycling, reuse of water, and the materials used are of significant importance in the construction process. Life Cycle Costing (LCC) is an economic analysis tool used for predicting the life cycle of various systems[7].

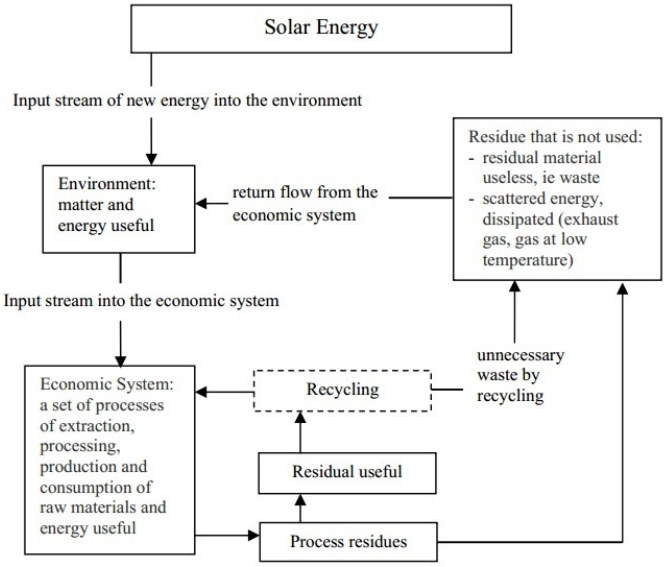

Figure 2. Integration of renewable energy sources environment conservation methods with Green Buildings [28, p.19].

Second, Green construction is a long-term investment. Due to several complex and innovative tools for less energy usage, advanced temperature management systems that continuously monitor exterior climatic conditions and temperature fluctuations, the initial cost or capital cost of a green building project may be considerable. water conservation through rainwater harvesting systems requires additional pipings, controls, pumps, collector tanks, filtration tanks, storage units. These tools when integrated into a conventional building with proper management and maintenance provide a return on investment in a relatively short time[8]. As the demand for energy and water is continuously increasing due to the increasing population and technological advancements, the price of these resources increases due to limited supply.

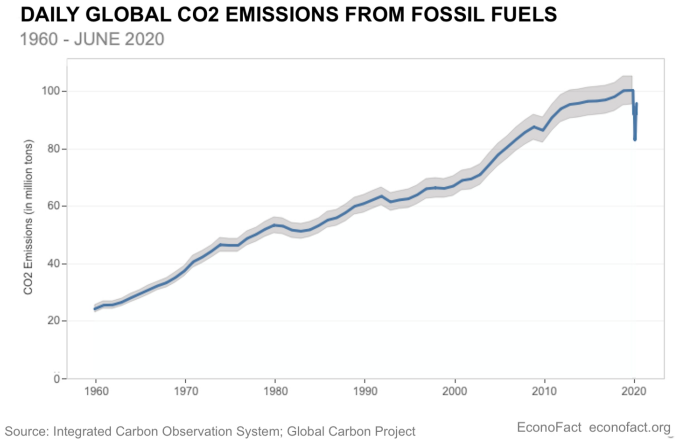

Fig 1. *Source:Derived from Econofact(Release, August 18, 2020)*

The above graph shows the change in Global energy-related CO_2 emissions 1990-2020. The largest annual drop in energy emissions since World War-I can be observed in the year 2020 owing to the COVID-19 pandemic[9]. The emissions rebounded strongly and rose above the 2019 level in December 2020. The energy demands increased rapidly due to many recovering economies some of which are seeing emissions above the pre-crisis level.

"The resurgence in global carbon emissions at the end of last year is a clear reminder that more needs to be done to speed up renewable energy transitions globally. If nations do not act fast to implement the correct energy policies, the world's historic potential to make 2019 the definitive peak in global emissions could be jeopardised said Dr. Fatih Birol, the IEA Executive Director. "The International Energy Agency (IEA) recommended governments to prioritise clean energy in their economic stimulus programmes in March 2020 to ensure a long-term recovery. However, the figures suggest that carbon-intensive firms are once again on the rise. This year is critical for worldwide climate action – and it began with great hopes – but the newest figures highlight the enormous challenge that society faces in fast changing the global energy system.."

Third, Green Building addresses the rising concern of the poor performance of conventional buildings regarding human health. Evidence collected from various countries around the world has shown that 40% of illness occurring is due to the building where people live/work/eat[10]. A typical building code of a certain region completely ignores the issues such as Sick Building Syndrome(SBS), Building Related Illness(BRI). Green building readily addresses these concerns and promote occupant health basically by effective lighting(More natural light), ventilation, sanitation, and temperature control systems.

II. HISTORY

Before we get any further, let us take a look at the historical progress of Green Buildings. Two events occurring in 19th century have played a major role in causing a shift in the mindset of the people and compelling them to think about more clean and resource-efficient ways of habitat. The inaugural Earth Day in 1970, as well as the establishment of the United States Environmental Protection Agency, marked the beginning of a sequence of developments in the building industry that eventually led to the current situation[11]. The foundation of the movement was laid by early environmentalists like Barry Commoner and lesser Brown. The first serious concern regarding resource depletion arose as a consequence of the oil shocks of the early 1970s the Arab-Israeli conflict. Following these events, there was a surge of interest among politicians, policymakers, the Federal Govt and private sector entrepreneurs in energy efficiency, solar power, wind power, and retrofitting technologies. The Government provided tax credits for investments in these revolutionary though developing technologies. By the late 1970s, building codes were modified and many of the above-mentioned efforts became standard practice. However, the interest was fading due to falling relative energy prices. People began to seriously wrestle with environmental issues like climate change, ozone hole, and wildlife endangerment after the publication of Our Common Future, also known as the Bruntland report, in 1987, the AIA meeting in 1989, and the establishment of the Committee On the Environment (COTE) and Rio Conference[12].

Figure 2. Timeline of various developing GBRS around the globe [29-31].

The U.S Green Building Council (USGBC) was formed by the AIA in 1993 in Washington, DC, and held its first meeting in March 1994[13]. At the same time, other countries reciprocated the concern, and state committees were being formed to address the issues.BREEAM(Building Research Establishment Environment Assessment Method) a rating tool, was formed in 1992. LEED(Leadership in Entrepreneurship and energy Design) was developed later in the 19th century along with the efforts to develop a standard for green buildings by ASTM(American Society for Testing and Materials) However, due to the much more profound and universal nature of USGBC to create a standard, it became the forefront. One of the first buildings to be renovated to conform to the newly formed green building guidelines was the Audubon House in New York City in 1992. As the making of LEED certification was not completed until late 1990. The architects and design professionals were working earnestly on this building as an example for the making of LEED guidelines[14].

ORGANIZATIONS

The agenda of Green buildings led by the environmentalists, social workers, and policymakers have been supported by various organizations around the world U.S Green Building Council, The U.S Department of Energy, The National Association of Home Builders, The Department of Defense to name a few. The work that these organizations did as a team has driven the Green Building movement to come at the forefront. By providing new ideas, green technologies these groups have proven to be a potent force having the potential to change the design and construction industry in the near future. iiSBE and CIB have a large contribution in building assessment and experimenting to develop new sustainable ways by trial and error method in different geographical conditions[15],[16]. Their main goal is to make the general public aware, spread the information. They hold conferences on this particular topic like Sustainable Building Conference. The most recent of these was the 12 July 2021 - International Conference on High-Performance Green Building and Building Performance Analysis (ICHPGBBPA) in Ottawa, Canada.

III. OCCUPANT'S SATISFACTION/COMFORT

So far, this article has covered the design and management of green buildings, as well as the numerous Green Building rating techniques that have been established.

The impact of green buildings on their occupants is of the same importance as the other aspects. In a typical office building, residents work for 5 days a week, 8 hours a day so it is important to dictate whether a healthy work environment or more so a healthier work environment as compared to a conventional building is provided or not. For this purpose, a survey was conducted on residents of GreenTech Malaysia. The positive impact of a healthy work environment on the employees may result in higher productivity which means greater financial gains for the firm

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IV. METHODOLOGY

Various methods for measuring the productivity of residents of green buildings, their adaptation in various geographical regions around the world, and their familiarity with the concept have been presented[17]. A survey form with 25 questions and four components was created, tested in three rounds, and given to over 500 construction firms and professionals. Hong-Trang Nguyen and his team adopted this methodology to validate the barriers that exist in the current state of Green Buildings in Vietnam[17].

Kimberly R. Bunz and her colleagues used yet another way to compare sustainable design rules and practises[18]. The framework for this type of analysis is the building life cycle. The programming phase, design phase, building construction, building operation, and eventually building demolition are all studied for comparison, and the sustainable guidelines established in North America, Europe and Asia are identified and discussed[18].

A survey form was designed consisting of questionnaires in the context of the known theoretical benefits of green building and was distributed to the 85 occupants of GreenTech building, Malaysia. The form contained 2 sections having different objectives. Section A focused on gaining information on the respondent like gender, age, work experience, educational background, and time in this building. Section B sought to assess the factors affecting the comfort and level of satisfaction of occupiers of GreenTech[19].

In section B, respondents were required to select a number between one and five, one being strongly dissatisfied and five being strongly satisfied. This reflected the overall positive and negative views of the respondents. This technique was developed by Likert in 1967 to seek the views of respondents on a particular subject[20] . Data obtained from the survey were compiled and analyzed using IBM SPSS, an IBM software for statistical analysis[21].

V. RESULTS

SECTION A

77 occupants responded to the survey forms distributed and were used for analysis. It was found that the male to female ratio (M/F) in the building was 0.79. A relatively higher portion, 27.7% of GreenTech occupants were of the age range 31 to 40 years, 28.6% were aged 20 to 30 years, 23.4% were aged 41 to 50 years, and 10.4% were above 51 years old. As for the educational background, 51.9% hold a bachelor's degree and were in the executive position. A relatively smaller percentage 1.3% represented the people holding Ph.d. rests were Diplome and SPM holders. Innovation Department, Energy efficiency, and environmental conservation departments all had nearly identical numbers of respondents. Support services (22.1 percent) and administrative (6.5 percent) departments had the most and least respondents, respectively[22].

SECTION B

With an average grade of 3.19, 73 of the 77 replies showed a reasonable level of experienced comfort. After analyzing the remaining four responses, it showed that ventilation was the cause of their disappointment.

Scale Category	Index Range	Level of Satisfaction	Ave. Score
Very Satisfied	3.31 – 3.42	Employment Productivity	3.38
		Health	3.38
		Rainwater Harvesting	3.35
Less Satisfied	3.07 – 3.18	Noise Level	3.16
		Privacy / Personal Space	3.13
		Use of Eco-friendly Goods or Equipment	3.13
		Lighting	3.09
Not Satisfied at All	2.95 – 3.06	Ventilation	2.95

Table 1. Green Building Benefits and Levels of Satisfaction

Residents are fairly content with these elements, as evidenced by high scores in Employment Productivity, Health, and Rainwater Harvesting. Lower average scores in various areas, such as privacy/personal space, use of environmentally friendly goods or equipment, and lighting, indicate a need for more research and innovation. As previously stated, the main source of resident unhappiness was ventilation, which received the lowest average score.

VI. DISCUSSION

Many GreenTech, Malaysia residents think that the rainwater harvesting system is an excellent addition to the building because it addresses the growing global issue for effective water management[23]. Many of the building's residents are pleased with the use of environmentally friendly materials in the design of their workspace since it results in a less loud atmosphere, allowing them to concentrate better on their work. Many tenants believe that greater natural light during the day and energy-efficient lighting solutions are important factors in their overall effectiveness throughout the day[24]. However, when it comes to ventilation, a couple of the residents disagree. Some people believe that modern mechanical ventilation systems have improved the indoor atmosphere by making it more refreshing and clean, while others believe that natural ventilation would allow them to focus better on their work[25].

VII. CONCLUSIONS

Over the last decade, the green building movement has exploded. In the United States and many other nations across the world, the LEED Building Assessment Standard is the most widely utilized technique for certifying green buildings. Understanding how natural processes around us can be integrated into a building to provide for its requirements for the appropriate functioning is the key to success in creating a sustainable environment, as a result, the structure aids the eco-system by maintaining it and giving the required nutrients for it to thrive. It is necessary to have a mutual relationship in which one caters to the wants of the other.

In addition, this article has provided the findings of a survey done on the GreenTech Malaysia Building to examine how various elements contribute to the inhabitants' overall productivity. Employment Productivity, Health, and Rainwater Harvesting were found to be the most satisfying components. Furthermore, a few of the building's inhabitants were unsatisfied with the ventilation system. Hence, more research is needed to learn how an indoor environment can be made equally beneficial for all of its occupants. Despite the movement's development, much work has to be done in terms of understanding ecological design and producing ecologically responsible technologies.

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