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Review

A State of Review on Instigating Resources and Technological Sustainable Approaches in Green Construction

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Abstract: Green building is a way to reduce the impact of the building stock on the environment, society, and economy. Despite the significance of a systematic review for the upcoming project, few studies have been conducted. Studies within the eco-friendly construction scope have been boosted in the past few decades. The present review study intends to critically analyse the available literature on green buildings by identifying the prevalent research approaches and themes. Among these recurring issues are the definition and scope of green buildings, the quantification of green buildings' advantages over conventional ones, and several green building production strategies. The study concludes that the available research focuses mainly on the environmental side of green buildings. In contrast, other crucial points of green building sustainability, such as social impacts, are often neglected. Future research objectives include the effects of climate on the effectiveness of green building assessment methods; verification of the actual performance of green buildings; specific demographic requirements; and future-proofing.

Keywords: economy; eco-materials; energy; environmental impact; lean construction; pollution; sustainability

1. Introduction

In this modern era, it is necessary to protect the environment. The demand for housing and its development plan has increased daily since the population growth rate is higher than ever. It becomes a challenge for engineers and architects to find a way to preserve resources while also incorporating environmentally friendly technologies into the building [1]. The Earth's resources are classified into renewable and non-renewable materials. With the advancement of modern technology, the construction industry has surpassed all other sectors in exploiting non-renewable natural resources, consuming approximately 3000 metric tonnes per year [2]. Continuing to extract raw materials for construction activities ultimately deprives them in the long run, resulting in a significant environmental burden. Among the several environmental impact agents, the construction sector was identified as one with the greatest failures and shortcomings related to the sustainability issue.

The extraction of raw materials for construction depletes the environment and has emerged as a significant source of pollution. It was long believed that construction activity harmed our environment through adverse impacts such as biodiversity loss. Such a result is mainly due to raw material extraction, landfill problems, worker inefficiency, resource depletion, acid rain, global warming, poor air quality, and smog production during the manufacture and transportation of building products [3]. Due to rapid availability and low cost, concrete and mortar are modern construction's most employed building resources. As the daily demand for cement increased, it led to a corresponding boost in production [4]. Each year, it is estimated that cement manufacturing alone causes 7% of global CO_2 emissions and other harmful greenhouse gases (GHG) to the atmosphere.

The current quantity of CO_2 in the atmosphere is 550 ppm (Parts Per million), with an annual increase of 2.5 ppm. As a result, the mean air temperature is rising alarmingly. Construction impacts are categorised by their effects on the ecology, natural resources, and human health. Activities like quarrying and river sand mining can harm the ecosystem and human health. Fine contaminants are created in a dust form during large-scale development and exploration. Workers and tenants still confront health hazards despite building bylaws and environmental controls. Toxic compounds and particles in the materials may alter indoor air quality, increasing the risk of early death and long-term respiratory disorders such as asthma and silicosis. Inhaling "respirable crystalline silica" in limestone and aggregates might cause health problems. To address this issue, sustainable and green construction display a set of practices that focus on raising environmental awareness and promoting eco-friendly labelling to battle pollution [5].

To fulfil sustainable guidelines, the Architecture, Engineering, and Construction sector (AEC) must operate within the planet's capacity to absorb the waste and pollutants generated by its activities and continuously develop stricter requirements for raw materials extraction and transformation. The created environment presents us with a tremendous obstacle [6]. The construction, operation, and eventual demolition of buildings have significant environmental impacts through material and energy consumption. These processes result in pollution and waste, which often strain inadequate infrastructure. Additionally, the built environment substantially impacts individuals, communities, and organisations' both physically and financially. A high standard and an aesthetic structure enhance the surroundings and teach designers how to manufacture more sustainable facilities. On the contrary, a substandard building will have the opposite effect. Buildings and physical environments are undesirable and unsustainable when they degrade the community, contributing to poor health and social isolation and generating excessive financial obligation.

Numerous corporations, industries, and local, national, and international governmental entities have chosen sustainable development as their official policy. After more than three decades since the establishment of World Environment Day by the United Nations General Assembly in 1972, the environmental movement appears to be progressing in reversing unsustainable development tendencies. To meet the challenge, designers must enhance the quality of life for everybody by developing wholesome structures and environments that fit individuals and communities of the present and future. To fulfil the responsibility to protect other species and ecosystems, we must minimise resource use, waste, and pollution. Consequently, buildings and the built environment will be subject to increasing criteria, such as energy efficiency. The need for multi-criteria analysis for buildings and housing is necessary to assess the quality of housing, which requires consideration of several factors. Identifying and categorising quality factors is one of the most challenging tasks [7].

A wealth of materials is available to all professions to create sustainable structures. Still, the current practice barely applies to the basic sustainability concepts in most existing buildings. This results in less efficient, more expensive, and less environmentally friendly structures. Improving the sectors that supply building designers with materials, services, and knowledge might significantly influence the environment and quality of life [8]. The present review study intends to present the most accessible and accurate source of information on how to design and develop sustainable buildings and built environments. It provides a comprehensive review concerning the recent changes in sustainable and green construction, particularly in reducing the use of non-renewable materials and mitigating the environmental impact of construction and building operations. Additionally, it aims to answer how to make well-informed, universal judgments on a building design that benefits people's health and the environment in a sustainable way.

The goal of the green building movement is to lessen the destruction of natural habitats during the building process. Waste decreases, and eco-friendly materials and methods are utilized [9]. A more sustainable future can be achieved by implementing resources and sustainability principles in green construction. One of the most crucial parts of an eco-friendly building is using appropriate materials. Since bamboo and recycled plastic are used in construction, they require less power and display less carbon impact than conventional alternatives like cement and steel. The success of green construction approaches in mitigating environmental damage depends on careful monitoring of resource consumption at every stage of the project. The time it takes for materials to disintegrate after being removed from a site, the amount of energy needed during manufacture, and the volume of trash created during installation and maintenance are all factors to be considered.

Building priorities show a clear diversity of goals, which comes from putting emphasis on different environmental issues. One looks at things from an environmental point of view, and the other from a humanistic point of view. The evolving ecological goals in architecture bring with them potential dangers if there is a limited understanding of associated issues. Defining ecological goals consciously and correctly lays the groundwork for designing sustainable architecture. Modern examples of ecologically sound architecture should be based on a balance between human and environmental concerns [10].

The implementation of sustainable practices in buildings can contribute to a variety of goals and causes. Firstly, it seeks to lessen the negative effect that buildings have on the surrounding environment by reducing the number of non-renewable resources and materials that are utilized. Secondly, it has the potential to reduce energy consumption both during the construction and operation phases throughout the structure's lifetime. Thirdly, it can improve the health and well-being of building inhabitants by producing a healthier interior atmosphere. This, in turn, has the potential to increase productivity and decrease absenteeism. Last but not least, it can help to create a constructed environment that is more sustainable and resilient, capable to endure the effects of climate change. In general, the use of sustainable building practices can help to lessen the negative effects that buildings have on the surrounding environment, improve the health and well-being of building occupants, and contribute to a more sustainable and resilient built environment.

The paper is divided as follows:

Section 1 describes and provides an overview of the current state of research in the field. It can be useful for both researchers and students who are looking to gain a better understanding of the latest developments in a specific area.

Section 2 describes different methods for writing review articles, such as literature search, selection criteria, data extraction and analysis. We will also discuss how these methods can be used effectively to produce meaningful results.

Section 3 describes the idea of green building, which emphasizes the use of energy-efficient materials and technologies to reduce energy consumption and waste production. Additionally, modern construction projects often consider factors such as water conservation, air quality, and noise pollution when designing buildings.

Section 4 describes the components used in sustainable construction that play an important role in reducing the environmental footprint of a building. These components include green building materials such as recycled steel, bamboo, and timber; energy efficient insulation; renewable energy sources; water management systems; and air quality systems. Each component contributes to the overall sustainability of a structure by reducing its environmental impact.

Section 5 discusses the various phases of sustainability practice in modern construction, including resource management, energy efficiency strategies, green building materials, and waste management. It will also explore how these practices can create a more sustainable built environment.

Section 6 discusses how conventional construction techniques can significantly impact the environment. The effects of traditional construction can be far-reaching, from the use of energy-intensive materials to the release of pollutants.

Section 7 examines the current economic growth status in sustainable construction and potential scenarios where it can be applied. It also provides insights into how this type of construction can benefit both businesses and consumers alike.

Section 8 explores the life cycle analysis (LCA) of sustainable construction, looking at how it can be used to assess the sustainability of different materials and processes used in construction projects. It will also discuss potential scenarios for LCA and how it can help enhance sustainable practices in the industry.

2. Methodology

The construction of environmentally friendly buildings is gaining significance as people become more conscious of their impact on the surrounding environment. As a result, it is of the utmost importance to devise a stringent and comprehensive technique for evaluating green building construction projects. During this review process, consideration should be given to several issues, including energy efficiency, water conservation, choice of materials, indoor air quality, and noise control. Plus, the review procedure should consider the use of sustainable design techniques in addition to renewable energy sources. If a targeted and thorough evaluation plan is developed, we can assume that green building construction projects are designed and built with environmental stewardship in mind, addressing all requirements for health and safety.

The present study aims to cover peer-reviewed articles published primarily within the last ten years. 42.1% of the papers were published within the previous five years, 38.6% within the last ten years, and 19.3% more than ten years ago. The latter were thoroughly examined and discussed among all authors concerning their relevance to the topic and content quality. We resorted to the Web of Science, SCOPUS, MDPI and ProQuest search engines, complimented with unformatted searches to fill specific issues. Following this approach, we conducted searches using isolated keywords or keyword combinations related to each chapter. The keyword terms were: Brick, Building Energy Efficiency, Cement and Concrete, Demolition and Construction Waste, Eco-friendly Materials, Environmental Impact, Green Construction, Hempcrete, Lean Construction, Life Cycle Analysis, Natural Materials, Reuse, Recycle, Reduce, Sustainable Construction, Water Efficiency Strategies. Any uncertainties regarding the content and publications' relevancy were discussed between the authors until reaching a consensus.

3. Concept of Sustainability in Modern Construction

All living beings are connected and reliant on one another following the law of nature. According to the ecological principle, supervision of a healthy environment is based on effectively and efficiently handling its resources [11]. The term "sustainability" denotes the ability of an ecosystem, a society, or any framed community to function while limiting the use of available resources without harming the environment. The concept of green sustainable development is realized by honing the ability to live in harmony with the environment; thus, the green-sustainable idea in the AEC field has aided in achieving a stable, economically viable environment. While an engineer must design a building with the concept of green sustainable construction in mind, it is critical to understand the goal of sustainability, its history, and its economic implication [12,13]. The theory of "Ecological

Development" was followed by many countries from 1987 onwards due to the growth of industrialization, economics, and environmental sustainability. It is a concept that emphasizes the conservation of biodiversity and ecosystems, the responsible use of natural resources, and the advancement of environmental sustainability. All activities must be carried out in a way that protects the environment and provides enough resources to meet human needs. Given this, it demands meticulous planning and execution to accomplish this. Developing beneficial strategies requires incorporating stakeholders from various sectors, including governmental and non-governmental organizations, corporations, and communities. To ensure the long-term sustainability of our environment also entails monitoring efforts for any alterations or advancements made towards achieving ecological balance.

Green buildings are typically defined as structures that protect the environment and resources efficiently throughout a building's life cycle by carefully considering aspects such as design, construction, maintenance, operation, repair, and rehabilitation. The concept of "*green building*" has gained popularity and spread worldwide in recent decades, focusing on issues such as global warming, unpredictably changing monsoons, and controlling emissions from the construction industry [14]. The traditional construction method assumed that GHG were only emitted when fossil fuels were used directly for heating and electricity. However, construction materials emit GHG in most cases during manufacturing, transportation, construction, operation, and demolition [15]. In sustainable buildings, indoor air quality was naturally better, and occupants showed higher levels of comfort and satisfaction, positively affecting their happiness and health.

Generally, a green and sustainable building positively impacts human well-being over its lifetime. This building provides increased durability, reduced maintenance, and a pleasant indoor environment for the owner and users. Green sustainable construction is not the same in all countries because of regional features that differentiate based on their culture, climate, tradition, building types, economic status, social condition, and environmental priorities [16]. Green sustainable construction has several design, operation, assembly, and maintenance strategies. Choosing and utilizing appropriate materials is crucial during the design of such buildings. According to a recent report, implementing the Green Sustainable Concept in developing countries like India can save up to 8500 MW of power annually. Additionally, new green sustainable buildings enhance the local ecosystem by using locally sourced materials [17].

When creating green buildings, it is necessary to remember that we are generating a new ecosystem, the basis of which is plants. Green roofs are a typical anthropogenic ecosystem where human civilization determines the composition of the soil profile (substrate) and vegetation as well as the water regime. These factors interact and are confronted with the surrounding ecosystems. The results of the interactions and confrontations shape the further development of the green roof ecosystem [18]. In particular, the composition of the substrate layers and the water regime must comply with the requirements of the planned vegetation. The environmental requirements of individual plant species and the possible effects of the urban environment on vegetation have been studied by numerous authors [19,20].

Most engineers prioritize aesthetic, social, economic, and ecological features over designing green sustainable construction to achieve the best possible building standard. It was believed that through this construction method, chance would displace human dominance over nature and establish a fulfilled connection with the natural world. To ensure the successful implementation of green sustainable construction, several guidelines must be followed to eliminate the issues connected to impeding performance [21]. A separate chapter for green futures and green infrastructure is urban agriculture which aims to promote ecological sustainability, social justice, and local food security [22]. Implementing urban agriculture has architectural and urban planning potential for using green zones and vacant parts of the land, revitalizing post-industrial areas, and developing aesthetic and social possibilities. Nonetheless, it requires access to specific needs (soil, water, nutrients, human energy) and avoiding contact with environmentally hazardous substances [23,24].

While implementing this concept, it is crucial to incorporate renewable energy sources into buildings to maximize energy conservation and promote environmental protection. Throughout implementation, it is necessary to deliberate on green sustainable technologies, products, systems, and equipment utilization that preserve natural resources and the environment. The cost of a green sustainable building may appear higher during the design stage. However, during the construction phase, the output demonstrated the possibilities of savings through energy conservation, reduced maintenance, and effective utilization of waste materials [25]. It has been shown that incorporating green sustainable technologies into construction results in high building performance and productivity.

In 2022, the global market for green construction materials was valued at an estimated USD 200 billion, and this figure is projected to rise at a CAGR of 11.2% over the next few years. Increasing construction activity and government efforts to enact green and energy-efficient building rules are expected to drive market growth over the forecast period. As a stimulus against the recent global crisis, governments have emphasized energy efficiency and green construction, which may impact the demand for sustainable construction products. The availability of high-performance green building products and the rising energy cost are the primary factors propelling the market. Yet, expansion could be stunted by consumers who are too focused on price and erratic energy Policymaking.

The following statistics reveal the global green building materials market revenue until 2022. Due to their low carbon footprint and long service life at a reasonable price, structural products are predicted to expand at 11.9% throughout the projection period. Developing the construction market, especially in emerging economies, is anticipated to boost the market overall. The second largest market is expected to be interior materials, thanks to increasing consumer awareness of the environmental benefits of these products, such as increased aesthetics, lighting, and air quality. The ability to regulate humidity and improve air quality using these materials is also anticipated to contribute to the industry's expansion during the next few years. Due to its ability to conserve energy, insulation is predicted to be the largest application segment, with a value of USD 92 billion by 2025. This market is expected to expand throughout the projected period thanks to rising demand from the residential and commercial construction industries. Roofing finishing was the subsequent most common use. Rubber, slag, sludge, stone granules, and corrugated mixed paper are some of the recyclables that go into making these items. Non-toxic recycled rubber roofing is predicted to see rising demand from the roofing industry because of its resistance to weather and long lifespan.

North America is anticipated to represent more than 40% of the global market. Building rules and supportive laws governing the use of green building materials in the construction industry and rising rehabilitation efforts are projected to keep this pattern going for the foreseeable future. As a result of the expanding residential construction industry in the region, Asia Pacific is projected to grow at the quickest rate during the forecast period, with a CAGR of 15.0%. Product demand in the area is anticipated to be stimulated by the Paris climate accord signed by India and China to combat climate change and the expanding infrastructure development in both nations. The business increase in the application of green building is expected to rise by various governments across the area. Green building materials are expected to see increased demand in Europe over the projected period as efforts to cut maintenance and operational costs of structures gain prominence.

Raw material suppliers increasingly integrate forward in response to the market's rising demand and limitless expansion potential. The rising demand for imports will likely lead to a decline in the regional dominance of industry participants. During the following years, this pattern should persist, which will drive market expansion. Raw material suppliers increasingly integrate forward to address the rising demand and limitless expansion potential. The increasing demand for imports leads to a decline in the regional dominance of industry participants. During the next few years, this pattern should persist, which should help drive market expansion. The following Figure 1 shows the global green building material application area's annual revenue for 2022.

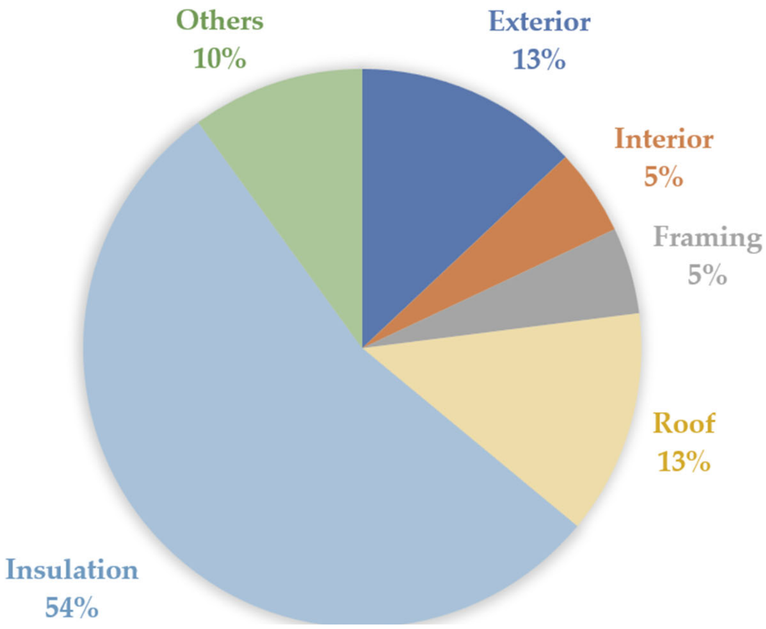

Figure 1. Different phases of sustainable construction (authors compilation).

4. Major Components in a Sustainable Construction

The planet Earth serves as a shelter for human beings, continuously protecting us from natural disasters while providing life-sustaining resources. However, life on earth is on the verge of extinction, and our actions as a species have been identified as the primary cause. Daily activities and common objects we use in our daily lives are among the primary contributors to the rate of carbon footprint and are considered a substantial contributor to climate change [26]. Our buildings' unmetered consumption of resources, energy, and water contributes significantly to environmental problems.

The green building concept can be a solution since it has the fewest negative consequences at every level, from the built and natural ecosystems of its immediate surroundings to broader regional and global contexts [27]. Using natural resources judiciously and effectively managing the building stock will save scarce resources, reduce energy consumption, and improve the overall environmental quality. Although this definition is straightforward, it is still too widely used in this context [28]. Therefore, it is essential to have quantifiable criteria for determining whether or not a building is "green". Understanding how a sustainable building is classified will allow us to recognize its qualities and the requirements that designate it as "*green construction*". Sustainable construction is a method of reducing the environmental impact of construction projects. It entails the use of environmentally friendly, energy-efficient, and cost-effective materials [29]. As illustrated in Figure 2, specific components must be considered to ensure sustainable construction. These include using renewable energy, water conservation techniques, and waste management strategies. It is also necessary to understand how to design buildings in such a way that they reduce their carbon footprint and use natural resources wisely. By incorporating these essential components into construction projects, we can create more sustainable buildings that benefit both people and the environment. Throughout the building's life cycle, including the predesign, design, construction, and operation phases, this should be executed with diligence, rigor, and thorough evaluation and judgement [30].

The performance indicators for buildings under design and operation/retrofit must be employed in green buildings. These relate the efficient use of energy and water, waste reduction, sustainable materials, structure durability, and indoor air quality improvement under the green construction design as a path to decrease the building's CO_2 emissions and environmental footprint shown in Figure 2.

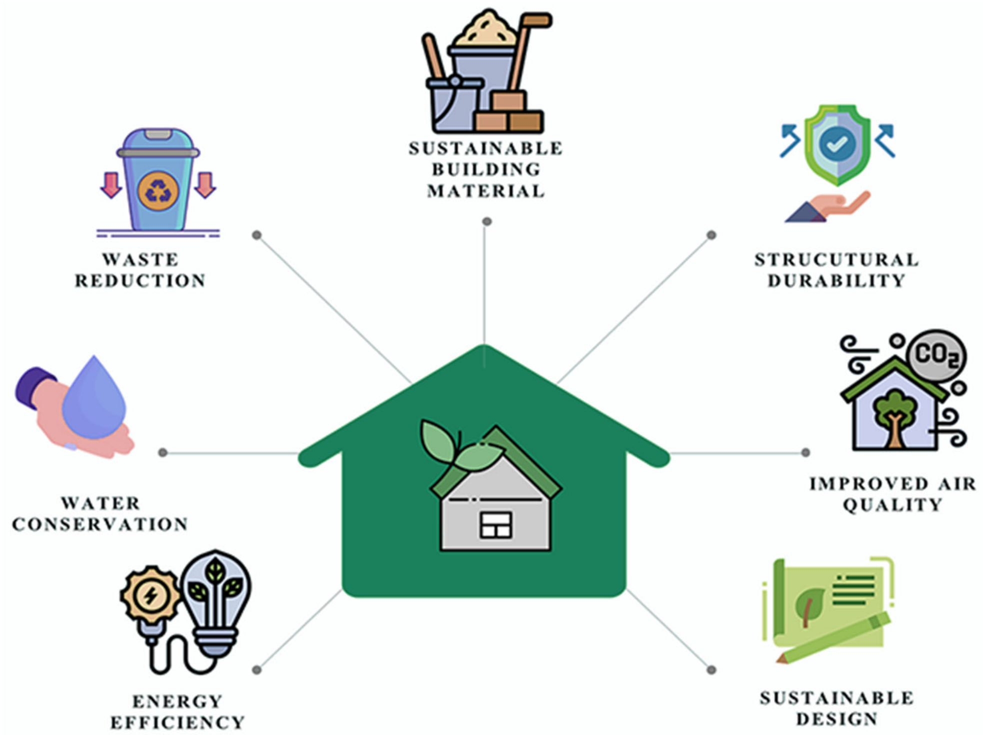

Figure 2. Essential components of sustainable construction (authors compilation).

5. Varied Phases of Sustainability Practice in Modern Construction

There are several approaches to modify and regulate the current nature of construction to make it less damaging to the environment without diminishing the positive outcomes of building activities. Potocnik's study suggests adopting a multidisciplinary strategy spanning a variety of components to construct a sustainable future in the building sector [31]. Other authors refer that to acquire an advantage from environmentally friendly construction techniques, they should be conducted in the context of the whole life cycle of a building [32]. Sustainable construction is becoming increasingly important as we strive to reduce our environmental impact. It entails using more environmentally friendly materials, processes, and methods than traditional building techniques. A construction project must go through several stages to attain sustainability, as shown in Figure 3. Planning, design, construction, and maintenance are examples of these. Each phase presents challenges that must be carefully considered to ensure the project meets all goals. The natural environment must be considered in planning, and energy efficiency and resource conservation must be considered in the design. During construction, materials should be chosen with an eye towards durability and recyclability while maintenance should focus on reducing waste and pollution. Understanding the stages of sustainable construction is the first step to designing eco-friendly projects.

Wise material and construction process decisions might help lower a building's energy consumption through reduced solar heat gain or loss, which reduces air-conditioning loads. The energy needed for extraction, processing, manufacturing, and transportation can be reduced by selecting materials with low embodied energy [33]. Due to the fragmentation of natural areas and ecosystems brought on by construction activities, the extraction and consumption of natural resources such as building materials, raw materials for producing building materials, and building materials themselves directly impact natural biodiversity. The built environment consumes a significant quantity of mineral resources, primarily non-renewable. Therefore, it is crucial to use fewer non-renewable resources. This approach should be considered during the design phase when selecting and prescribing materials and should account for and assess their environmental footprint, mainly their embodied carbon and energy.

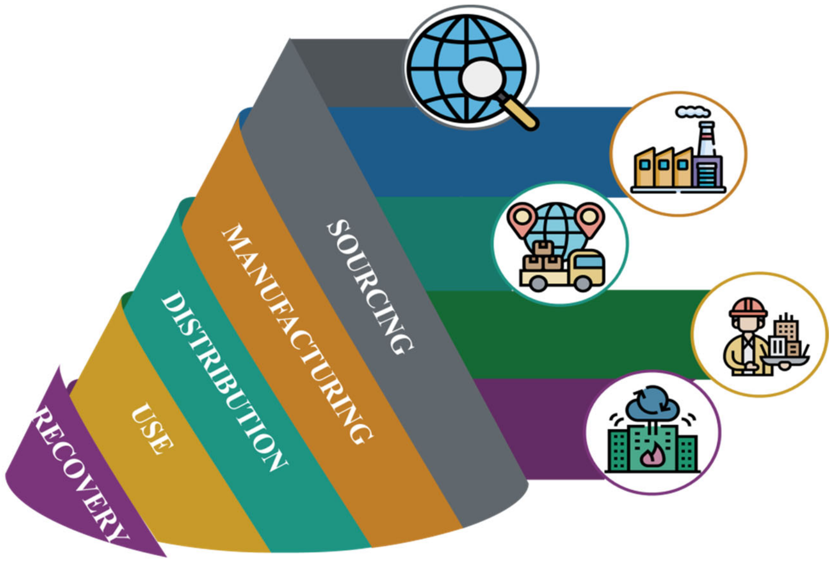

Figure 3. Phases of sustainable construction (authors compilation).

On the other hand, recycling positively impacts the environment by reducing waste output and resource usage. Reusing and recycling construction materials and components as alternatives to reintroducing them into the production chain has previously been established in the literature [34]. In this way, reusing materials such as bricks, glass, and tiles while repairing and dismantling buildings is an alternative for reducing Construction and Demolition Waste (CDW).

5.1. Sustainable Practice during Procurement of Construction Materials

Material procurement has caused problems for domestic economies and the environment affecting the construction sector. Hence it is necessary to highlight material procurement following sustainability requirements, and as a result, the construction industry's performance in material management, which right now is far from ideal [35]. When implementing a sustainable management strategy, the environmental, economic, and social impacts during the supply and flow of materials at various stages of a structure's life cycle should be considered [36]. Sustainable materials request a paradigm shift beginning with procuring raw materials and continuing throughout the journey of a constructed facility to reduce their environmental impact [37]. By affecting the amount of embodied energy and carbon released into the environment and diminishing natural resources upstream, the facility's positive effects can last well beyond its life cycle if the process starts with suitable materials [38].

In general, purchasing goods and services in a way that considers the economic, environmental and social impact of the purchase on people and communities is known as sustainable procurement [39]. It is also necessary for these purchases to increase the efficiency and value of the resources that are under use. Traditionally, procurement decisions were made exclusively based on price, quality, and time [40]. These factors still matter; however, in today's construction markets, emerging and established sustainable initiatives are combined with these well-established elements [41]. Environmentally friendly procurement should reduce material waste, CO_2 emissions and energy and water consumption, promoting biodiversity and equitable and sustainable economic development. Lastly, the sustainable way of acquiring construction materials must result in social benefits.

The issue of sustainability raises the question of energy and CO_2 consumption as well as landfill waste disposal. In the European Union, 38 million tonnes of glass waste are produced annually, and new goals for more sustainable waste handling were set for 2020. In particular, soda-lime, borosilicate, and lead-crystal glass are the glass families that may be combined in this experimental effort to be recycled as cast glass components. The kiln-cast technique prepared several mixes for melting at 970 °C, 1120 °C, and 1200 °C. An experimental splitting test was used for each sample to determine the force trend and fracture behaviour. Soda-lime-silica glass was discovered to be the most compliant glass recipe with the necessary physical and mechanical qualities [42].

5.2. Sustainable Water Conservation in Construction

Groundwater is one of the most common water sources for construction, as it is pumped from aquifers and used for various purposes. In remote areas, due to some natural and artificial obstacles, such as mountainous terrain, and groundwater for mining and construction activities, water supply is not always accessible and available [43]. Pumping groundwater is required for its use, requiring energy that contributes to GHG emissions [44]. It is essential to continuously supply water to ensure the community's needs for drinking, washing, waste disposal and sewages, swimming, and acclimatization in buildings. Also, stormwater that runoff from a driveway that connects roadways and roofs pollutes the waterways and causes flooding [45]. Direct and indirect water consumption is linked to water usage in a typical building. Generally, its immediate use can be calculated by the water consumed by construction workers during several activities, such as washing aggregates, preparing and curing concrete, suppressing dust, washing equipment, and cleaning hard surfaces [46].

The "indirect use" refers to using embodied water to make construction materials. The water conservation index assesses the average consumption of a building and compares it to overall water use, resulting in a "water savings rate". This rate indicates how much water is being conserved [47]. It is essential to evaluate the water-saving efficiency of kitchens and bathroom taps, including and considering the recycling of rain and second-hand intermediate water. At the design stage, it is essential to implement control systems for water resources and select more sustainable planning options [48]. As a result, it is necessary to align the building design and construction method to optimize water usage. During the project planning stage, we should consider water preservation measures such as using water-saving plumbing fixtures, rainwater harvesting systems, and a greywater system instalment [43]. Also, reducing water consumption during material production should be prioritized. Water reuse and recycling can help reduce embodied water usage in building materials manufacturing. Water pollution control on construction sites is another feature that should be evaluated.

Environmental assessment tools for construction must consider water pollution to minimize ecological impacts. The water consumed in buildings is determined mainly by the usage method and the sector type. Introducing environmentally friendly devices can improve water efficiency and decrease consumption through recycling or harvesting systems, one of the most important features to consider in new construction [49] under the "green" label. In the AEC sector, water sustainability differs from water conservation in that it reduces "waste" water while not interfering with daily needs or customer satisfaction. Rainwater and greywater harvesting, water-wise landscaping, and high-efficiency flow and flush fittings enhance building water sustainability [50]. Installing water-efficient fittings is now recommended to ensure that potable water is conserved in buildings rather than the traditional high-flow ones. These are measures that need some additional up-front capital investment. Nonetheless, studies have shown that this investment paid off in most cases, mainly in building with frequently used fixtures [51].

Water is required for both direct construction and embodied water production. Due to this, recycling water usage in construction is critical. To save water in the long run, it is imperative to calculate water usage throughout the infrastructure's life during the planning phase [52]. In many cases, such as collecting rainwater and heating it for domestic use, water usage is linked with GHG emissions. As a result, zero-energy and green buildings have gained popularity among the population [53,54]. It is also advisable to optimize the system by preventing water loss due to leaking pipes and faucets [55]. With increased awareness from an environmental view, favourable government policies, and ongoing lectures on the subject, efficiency related to water consumption in construction is expected to improve in the future.

5.3. Sustainability during the Usage of Alternative Construction Materials

The concrete industry has begun incorporating alternative industrial waste materials and CDW into structural concrete applications (Table 1). Its application has been more frequent in recent years due to the availability of waste from demolitions and the reduction in aggregate acquisition costs [56]. Those new applications will help the concrete industry reduce its carbon footprint and pursue sustainability.

Table 1. List of Environmental reutilized waste in construction.

Category of Waste	Type of Waste	Countries Acquire A Large Quantity of Waste	Citation
Industrial waste	Fly Ash produced from the coal power plant as a by-product	China, Canada, India and Vietnam	[11]
	Salvage steel fibre as a by-product of steel manufacturing	USA and Cameron	[25]
	Granulated blast furnace slag By-product of iron and steel-making	India and Great Britain	[28]
	Polyethylene terephthalate derived from Shredded waste plastic bottles	Nigeria and USA	[35]
	Calcium carbide residues from industrial gas	Burkina Faso	[36]
	Magnesium oxide derivative as By-product of mining & industrial company	USA & Spain	[37]
	Crumb rubber from recycled industry of transportation waste	India, China, Australia, and Spain	[38]
	Glass fibre reinforced polymer waste from water boxes manufacturing company	India and Brazil	[40]
	Waterworks sludge waste from water treatment plants	India and China	[41]
	Alumina filler and coal ash from an Aluminium foundry plant	USA and Spain	[45]
	Eucalyptus pulp microfibre from paper manufacturing	China, India, and Brazil	[46]
Agricultural waste	Straw bales from wheat, rice and barley	China, India, Egypt, Italy, Germany, Japan, France, Peru, Spain, Turkey, and Morocco	[49]
	Oil palm fruit bunch fibre after the extraction of palm oil	Indonesia and Malaysia	[50]
	Sugarcane bagasse left extracted after the juice in the sugar industry	India, Brazil, Ghana, Portugal, and Sri Lanka	[51]
	Cassava peels	Kenya and Colombia	[52]
	Henequen fibre (leaf)	Great Britain	[53]
	Sisal fibre	Brazil and Kenya	[46]
	Spent coffee ground and processed tea waste	China, India, and Turkey	[57]
	Bio briquettes	India and China	[58]
	Tobacco residue from tobacco industry by-product	Cuba and Turkey	[59]
	Olive waste fibre	Italy and Morocco	[60]
	Seaweeds fibre extraction from alginate	Italy and Great Britain	[61]
	Corn husk ash	USA & Nigeria	[62]
	Saw dust from wood-based industries	India, Brazil, and Mexico	[63]

The construction industry is ranked as the most environmentally impactful as it consumes vast energy and natural resources and generates massive waste [64]. In addition, conventional construction also incorporates a set of materials and substances that are harmful to living beings in the short and long term, leading to a series of health and environmental consequences (Table 2).

Table 2. Summary of non-eco-friendly conventional construction materials and their effects.

Conventional Constructional Material	Environmental and Health Impacts	Reference
Acrylonitrile	Irritates mucous membranes of the lung walls Affect habitants of aquatic organisms	[65]
Ammonia	Make water more acidic Increasing corrosive nature	[66]
Arsenic and its compounds	May damage the growth of the foetus Lead to cancer	[67]
Bitumen	Lung cancer Block percolation of groundwater	[68]
Borax and its substances	Poison to all kinds of living organisms	[69]
Cadmium	Damage to the function of the kidney, liver, and lungs	[70]
Copper and its substances	Affect habitants of aquatic organisms A Bio accumulative material	[71]
Epoxy	May trigger a strong allergy reaction	[72]
Fluorides	Decay the growth of the plant and aquatic organisms May reduce the strength of bones	[73]
Lead and its compounds	Related to kidney and brain damages	[74]
Nonyl phenol	React as environment oestrogen Increase the water acidity declining the growth of aquatic organisms	[75]
Styrene	Affect the lungs' function Cause damage to the reproductive system	[76]
Vinyl acetate	Increasing corrosive nature Affect habitants of aquatic organisms	[77]
Wood dust	Lung cancer May trigger robust allergy	[78]
Demolition Dust	Create eye irritation and breathing problem Reduce plant photosynthesis ability	[79]

Concrete is a commonly consumed product in the entire construction industry mainly due to its versatility and ability to be easily altered. Decreasing the concrete environmental burden can pave the way towards a more sustainable construction industry [80]. Most of this resource consumption occurs in developing countries such as China, India, and Brazil. From an environmental perspective, China and India appear to be struggling regarding this matter as the requirement for concrete rises, and natural resource depletion becomes an alarming problem. As a result, in the early twenty-first century, the work on green and sustainable technologies has taken center stage.

Due to the rapid urbanization of industrial areas, old buildings are being demolished and replaced with new ones with higher standards. In traditional construction, the CDW would have been disposed of in landfills or repurposed for the construction of pavements. The mining, processing, and transportation operations required to acquire and haul large amounts of aggregate consume significant amounts of energy, emit substantial amounts of carbon dioxide and harm the ecology of forested areas and riverbeds. Thus, finding a substitute for virgin aggregate has been a long-standing concern [81]. Recently, extensive research has been done on recycling demolition waste to determine whether it can be used instead of natural aggregates. In general, the recycled aggregates are extracted from discarded waste, generated by the demolition of concrete buildings, the use of unfinished concrete, the failure of precast concrete members, the expiration of concrete pavements, and the testing of samples in several laboratories [82]. Recycled aggregates include tiles, brick aggregates, concrete, marbles, bitumen, and asphalt. The term "recycled concrete aggregate" (RCA) replacement stands for typically processed aggregates made by crushing old or parent concrete like demolished concrete wastes [83]. Still, there has only been limited research on the partial usage of concrete wastes as a replacement for cement in concrete, which requires further investigation. Repurposing and reincorporating this kind of debris in construction will be a step forward to improve environmental safety [84].

Natural fibers have a major role in developing environmentally friendly composites. Their main advantages are low density, renewability, cost-effectiveness, flexibility, and recyclability. Several kinds of natural fibers are used to construct building materials; these include bamboo, palmyra, crushed coconut shell, peel of banana skin, sisal and jute fibers, bagasse, and fabric [85]. Using natural fibers as construction materials added the benefits of being eco-friendly and improving their properties. The rice husk is a highly efficient and widely used fuel in many countries in energy generation units [46]. Rice husk ash is a pozzolanic material formed due to this burning process. It has over 75% silica and retains rice husk at about 20%. Typically, this process dumps ash into nearby waterways, contaminating the water and causing environmental pollution [57]. Due to incomplete ignition and unburned carbon, ash made from rice husk has a lower pozzolanic effect at temperatures below 500 °C. Due to the transformation of silica to a non-crystalline or amorphous form, the temperature of 550–700 °C results in ash having improved pozzolanic characters. Numerous studies have been conducted on using rice husk ash in partially replacing cement with or without replacing fine aggregates in cementitious composites.

Another example is in Sakhare and Ralegaonkar's study, which investigated the possibility of combining cotton waste and lime powder to create an innovative lightweight and low-cost composite material for construction. The mechanical and physical characteristics of concrete composites containing a large concentration of cotton waste and Lime powder were analyzed. Results indicate that replacing the lime with the cotton waste does not result in immediate brittle fracture, even moving beyond the failure loads. Moreover, it demonstrates an energy absorption capacity of excellent levels, significantly reducing unit weights and introducing a smoother surface compared to currently available bricks of concrete [58]. Demir, aiming to promote environmental stewardship and sustainability in the long-term use of ferrocement, discussed the implications of previous research on using industrial waste materials in ferrocement works. The authors examined how different industrial waste materials affected mortar and mesh reinforcement behaviour [59]. Lamrani et al. have studied the viability of a novel method for making lightweight composite elements in a sandwich arrangement by encasing an aerated lightweight concrete core in a high-performance ferrocement box. The results are analyzed using control mixtures made entirely of aerated-type concrete. Results marked a significant increase in flexural and compressive strength and reduced water absorption to fractions of the specimens used as controls for the control specimens [60]. Salleh et al. study present agricultural, industrial and food wastes as agents forming pores in producing porous ceramics. Identifying waste material and clay confirms that processing conditions like sintering temperature, compaction pressure and material composition affect pore formation [86]. Zero waste in food, agriculture, and industry can alleviate environmental concerns and ease production in a closed loop. Porous ceramics of waste origin can help create more sustainable environments while expanding the economy, particularly in alternative building materials.

5.4. Sustainability in Masonry Materials

Brick masonry is a construction and building material widely used not only in the past in Egyptian, Mesopotamian, and Roman constructions but still today at a worldwide scale. Bricks are traditionally made by combining earth-based raw materials, then moulded, dried and fired until they reach a specified strength parameter or by using ordinary Portland cement (OPC) for concrete bricks [87]. Dove developed a variety of bricks from several waste and by-product materials to reduce pollution, waste generation, and raw materials depletion, thus contributing to a more sustainable and environmental practice. As a result of the limitations of the traditional brick-making method, over the last two decades, the brick-making process has shifted toward the use of waste materials [61]. To exemplify, Goel and Kalamdhad showed the feasibility of using municipal solid wastes in degraded form as input material in manufacturing bricks burnt at a concentration of 5 to 20 weight % and then burning the product at temperatures between 850 and 900 °C [88]. Another study by SP Raut et al. examined that different waste materials of varying compositions were combined with the raw material at several levels to create waste-origin bricks. Other waste materials have been used in brick production, including paper processing residues, cigarette butts, textile effluent sludges from the treatment plant, polystyrene foam, plastic fiber, fly ash, polystyrene and straw fabric [89]. Batagarawa et al. modified lightweight and porous bricks with adequate compressive strength and low thermal conductivity by adding paper processing residues to an earthen brick. Chemical analysis was done for raw material and paper waste. The mixtures of paper waste and brick raw materials were made in several proportions, up to 30% by weight [62]. Ayodele et al. probed the possibility of reusing sludge from textile effluent treatment plants in building materials. The engineering and physicochemical properties of this composite sludge specimen from South India were investigated to determine the sludge's suitability for both non-structural and structural applications with cement replacement [63]. Juel et al. investigated the possibility of using tannery sludge for manufacturing clay bricks. Various quantities of tannery sludge in 10%, 20%, 30%, and 40% were used to replace the clay. It was determined that 10% of tannery sludge by weight is the optimal constituent for it -amended tannery sludge. Raising the tannery sludge proportions and firing temperature caused a decrease in shrinkage, weight, and bulk density during the firing process. Additionally, it was demonstrated that incorporating a 10–40% tannery sludge content can save up to 15–47% of the firing energy. The findings show that combining tannery sludge allows to the production of bricks that meet the quality standards of the American Society for Testing and Materials (ASTM) [90]. Adazabra et al. inspected the use of spent shea waste replaced at a rate of 5–20% of weight while manufacturing clay bricks that are moulded, compacted, and ablaze for more than an hour at 900–1200 °C. Increasing the amount of used shea waste in clay material increased water absorption values in every tested scenario. As the produced brick showed lower strength by incorporating shea waste it was classified as a non-load-bearing part of structural construction [91]. Sutcu et al. analyzed the physiomechanical and thermal performance of porous clay bricks tested after adding an olive mill waste concentration of 0–10% of the weight to the mixture. With a 10% waste from olive mills, the samples' bulk density was reduced by up to 1450 kg/m^3. The porosity of the modified samples raised from 30.8 to 47.0% as the olive mill waste was taken from 0% to 10%. At 950 °C, the compressive strength fell from 36.9 MPa to just 10.26 MPa. The study demonstrated that olive mill waste effectively creates pores in bricks [92]. Ornam et al. studied the impact of waste sago husk on manufacturing bricks made of fly ash. Samples were moulded and dried in the sun before being burned at 550 °C for two hours with a zinc stove plate and aluminium foil. As the amount of sago husk in the bricks was higher, the bricks' strength gradually decreased. On the other hand, the specimen's density may decrease as the sago husk content increases, down to 1810 kg/m^3. The developed fly ash brick had the lowest initial absorption rate while adhering to ASTM C67 specifications and requirements. While waste-derived bricks have a few commercial applications and fabrication, a literature review reveals their potential and versatility as a partial or complete substitute for traditional raw materials as produced bricks meet a wide range of quality standards. Researchers can scale up promising findings by including all necessary data and methodologies and planning and designing experiments according to industrial manufacturing procedures [93].

6. Strategies for Reducing the Impact of Conventional Construction

Based on the previous scenario, building materials and construction processes should be targeted to reduce environmental impact. Several strategies were developed to assist sustainable forms of construction, aiming at building material manufacture and construction methods [65] (Figure 4). The advanced material manufacturing process has resulted in waste reduction. Resource conservation efforts are visible through reduced primary level production and increased recycling, development and use of partial and complete substitutes in case of using novel construction methods, materials of high impact, high-performance materials development coupled with eco-friendly materials [94]. Conventional construction has contributed significantly to global carbon emissions and climate change. To conserve the environment, we must limit the impact of the traditional construction industry. As depicted in Figure 4, many tactics can be applied to accomplish this objective. They include using environmentally friendly building materials, enhanced energy efficiency, and waste management strategies [95]. In addition, breakthrough technologies, such as AI-assisted design tools, can lessen the environmental effect of construction projects by increasing their efficiency and precision. By implementing these strategies, we are ensuring that the conventional construction industry will decrease its environmental footprint and no longer be a global warming and climate change protagonist.

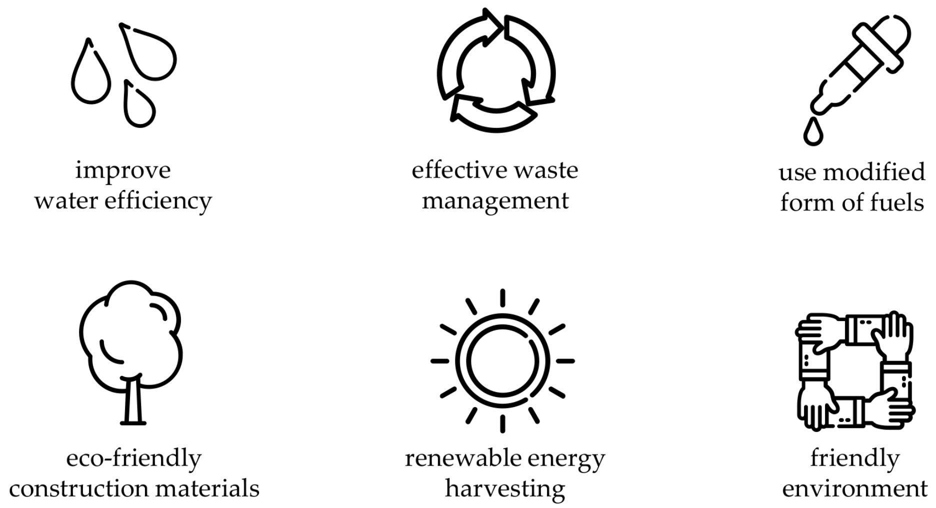

Figure 4. Strategies to control the environmental impact of conventional construction (authors compilation).

6.1. Impact Control through Improved Materials Production Processes

Implementing improved manufacturing processes reduces the amount of carbon emitted and energy consumed during the production of the materials. According to LCA studies, ferrous, cement and nonferrous metals are the materials with the highest environmental impact. Energy and carbon emission savings can be achieved by updating or optimizing existing manufacturing technology, including reutilized residual or waste heat in the furnace to generate electricity. The cement industry is an excellent example of this, as it uses waste heat recovery in manufacturing [66,96].

Only six of the eleven emerging economies with a significant cement production capacity have heat recovery systems, with India leading in total installed capacity and designed systems. An alternative to mitigate the harms of cement manufacturing on the environment is to reduce the clinker quantity in the final product [97]. This can be accomplished by replacing a certain amount of the clinker with materials that display a low impact and significant pozzolanic characteristics, as described above when the LCA of Portland cement production was conducted. To exemplify, cement made from pulverized fly ash and clinker has less environmental impact than traditional cement [98]. Furthermore, according to Garcia-Segura et al. blended cement not only produces fewer GHG emissions than conventional cement manufacturing, but it [97] is proven to have higher durability.

Edmundson and Horsfall and Rajdev et al. have described how blended combinations can significantly decrease the impact of cement production on the environment by substituting low-impact supplementary cementitious materials for a portion of the clinker [67,99]. Upgrading and improving cement manufacturing machinery continuously is a way to mitigate environmental damage progressively.

6.2. Impact Control by the Materials Recycling

The process by which used materials are transformed into new products that would otherwise be discarded is known as recycling. It's a powerful tool for increasing the efficiency of energy usage and lowering CO_2 emissions caused by the material industry [68,99]. The demand for raw materials is reduced by recycling, which saves energy and reduces carbon emissions. According to the World Steel Association recycling is crucial to produce metals like steel and iron and nonferrous ones like copper and aluminium because it reduces the reliance on natural resources [100].

Additionally, energy costs in steel production are almost 20% to 40% of the total price, according to the source of energy [100]. On the other hand, steel is 100% recyclable, and recycling this material can save up to 25% of energy. Steel, as one of the carbon-intensive building materials, emits 1.9 tonnes of CO_2 as a by-product of one tonne of raw steel manufactured [101].

Given this, recycling contributes to reducing the carbon footprint of steel production. Recycled steel has a carbon intensity of approximately 16% of virgin steel, according to the Inventory of Carbon and Energy (ICE), a database for building materials' carbon coefficients and embodied energy [102]. Another industry that employs recycling for reducing carbon footprint and energy is the aluminium industry. In their LCA study, Grimaud et al. discovered significant environmental advantages in recycling aluminium shredder cables [103]. Furthermore, Rajadesingu and Arunachalam described that the recycling of aluminium has benefited both the environment and the economy. Energy savings and a reduction in bauxite mining are two of the advantages. It also helps countries where secondary aluminium production is the primary metal source [69].

6.3. Impact Control through Material Substitution

Cement production is an energy-demanding and carbon-emitting process. Carbon emissions are also produced by the chemical processes involved. Most construction industry stakeholders may not have control over minimizing the impact of cement production on the environment through the option of renewable energy coupled with waste heat recovery processes. The construction industry's contribution to reducing the environmental impact of cement production by selecting suitable substitutes minimises the need for OPC. To reach low-impact alternative materials, the following additions can be used: rice husk ash, calcinated shale, volcanic ash, and calcinated clay. Incorporating supplementary cementitious material (SCM) into OPC has improved the material's durability, long-term strength, and workability [70]. Additionally, SCM improves cement-based structures' corrosion resistance and decreases their permeability and absorption [71]. As a result, incorporating SCMs as an OPC blend in structures reduces the use of OPC, thereby avoiding carbon emissions and saving energy associated with its production.

6.4. Innovative Construction Techniques for Impact Mitigation

The construction industry now has a predominance of materials harming the environment using energy consumption and emissions. Additionally, inefficient construction processes generate significant waste, accounting for 10% and 30% of total landfill waste [72] urging innovation in this field. Along with the search in finding durable and low-impact materials, novel building techniques that promote sustainability by resource efficiency are being evaluated. Both carbon- and energy-intensive construction materials, like steel reinforcement bars and cement, will always play a significant role in the AEC sector. The strategy is to discover new ways to use these materials to mitigate their total impact on the environment. Sustainable construction methods like offsite manufacturing, prefabrication and lean construction are recommended to minimize the waste produced due to in situ construction.

The concept of lean or lean thinking was created and implemented in the automotive industry to help maximize value by reducing waste [104]. Lean manufacturing and assembly processes have been dubbed revolutionary due to their application of lean thinking. The use of these lean manufacturing principles in the construction industry is termed lean construction, aiming to increase productivity while decreasing waste. Ismail and AbdelKareem have demonstrated that construction was the first industry to adopt the lean philosophy, which perceives construction as a process of transformation, flow, and value creation. Lean construction's primary goal is to boost productivity while lowering waste. Integrated project delivery is frequently related to lean construction. It is a process for delivering projects that jointly leverage all stakeholders' knowledge, insights, and abilities to increase product value, maximize efficiency and reduce waste. As a result, the term "Lean" has come to mean "Sustainability" and "any innovative way to improve the efficiency of building design and construction" [73].

6.5. Impact Reduction Using Eco-Friendly Renewable Materials

Sustainable materials may not necessarily satisfy the demand of a less technologically advanced society. When available, renewable products present a great opportunity. Studies show that using locally sourced materials efficiently reduces carbon emissions and energy during the embodied phase of construction [105]. Myers et al. conducted a study which discovered that by substituting renewable components for some traditional building components and materials, embodied energy could be reduced by almost 28%, i.e., 7.5 to 5.4 GJ/m^2 [106].

Hemp is being accepted as a renewable building component, particularly in the United States and Europe, as hemp cultivation is now legally encouraged [29]. For non-load-bearing walls, hemp concrete is more environmentally friendly than conventional concrete panels [107]. Pretot et al. conducted an LCA of a wall made of hemp concrete. They concluded that natural fibers of plant origin, like kenaf, showed promising results to be considered an eco-friendly construction product. According to this author, hemp house buildings in South Africa appear to be Africa's most sustainable structure [107].

Batouli and Zhu found that insulation materials made from kenaf fibers have less environmental impact than synthetic insulation components [108]. Bahranifard et al. study compared earthen and conventional plaster and discovered that earthen plaster made of clay has a significantly lower environmental impact than conventional plaster made of hydraulic lime or Portland cement [76]. Melià et al. concluded that although the production phase was found to have the most significant environmental impact, hemp concrete has a lesser effect on the environment than conventional construction materials. Additionally, the hemp plant's capacity for carbon sequestration via photosynthesis aids in mitigating climate change [109].

7. Status of Economy Growth in Sustainable Construction

Numerous studies indicate that green construction leads to significant economic savings through high employee productivity, enhancing health and safety benefits, and cutting down maintenance, operational and energy costs [77]. Mounting proofs show sustainable buildings economically benefit occupants, operators and building owners. Such buildings mark lower yearly operating costs due to insufficient water, energy, and repair/maintenance churn with operating expenses. Cost savings in this form do not have to be offset by higher initial costs. The initial cost for such a building would be similar to or lower than a typical traditional building through integrated design and innovative use of sustainable materials and equipment [78]. The economy of most nations relies heavily on sustainable building practices (Figure 5) as they have the potential to create jobs, lower energy prices, and enhance the environment. Nations adopt sustainable building methods, knowing how this affects their economies. This chapter will examine the economic impact of sustainable construction in several countries worldwide. Future economic growth could be aided by adopting sustainable building materials and techniques, which we will also consider.

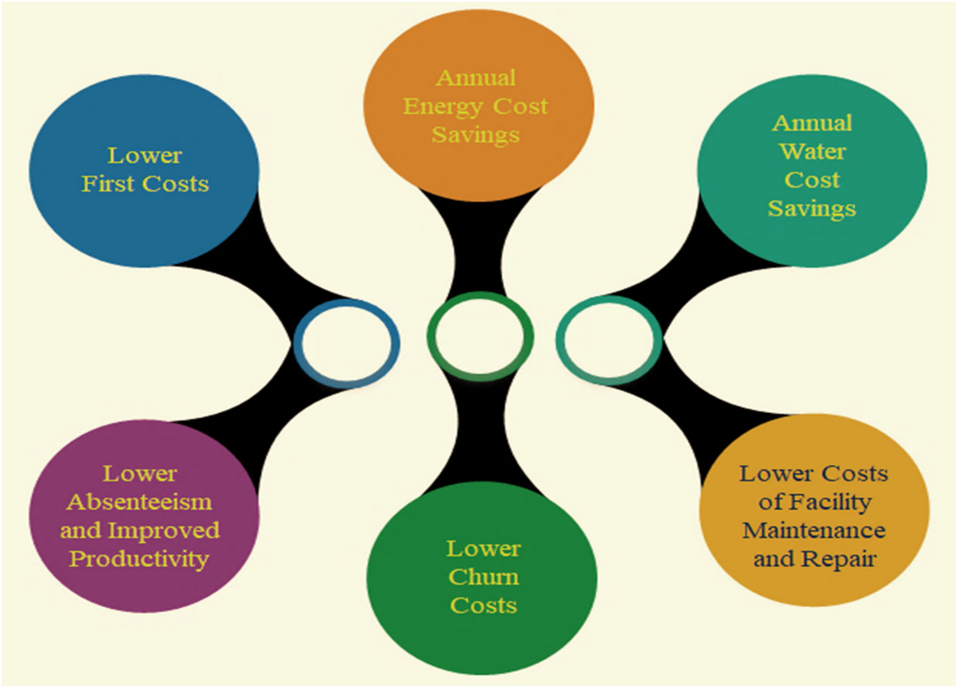

Figure 5. Economy status of sustainable construction (authors compilation).

Along with direct cost savings, sustainable buildings can provide dwelling owners with indirect economic perks just as features of a sustainable building can improve occupants' comfort, health and well-being, lower absenteeism, and increase productivity [79]. Building owners can benefit financially from various advantages, such as lower risks and longer-lasting structures. New chances to attract new employees, decreased costs related to complaint handling, reduced project permitting time and expenses, and community acceptance and support, will generate a consistent valuation of assets. Sustainable buildings also benefit society economically through smaller fees associated with damages related to air pollution and reduced infrastructure costs. Generally, investment is minimal, and the cost of life-cycle time is typically less than traditional buildings [110].

8. Life Cycle Assessment of Sustainable Construction

Life Cycle Assessment (LCA) is a technique for assessing the environmental implications of a product or service over its entire life cycle. It is used to detect and quantify the environmental implications of sustainable construction projects, such as energy usage, water consumption, and waste production. With LCA, we can evaluate the viability of construction projects before their construction. This ensures materials are responsibly obtained, and buildings are constructed to be as energy efficient as feasible. In addition, it enables us to discover areas with the potential to reduce the environmental impact of construction projects. There is a wide range of tools to assess the built environment, energy labelling, material selection, and indoor air quality [111]. In this section, we will examine how LCA may be used to evaluate the sustainability of building projects, as seen in Figure 6, and highlight some of the most important factors to consider when conducting an LCA analysis.

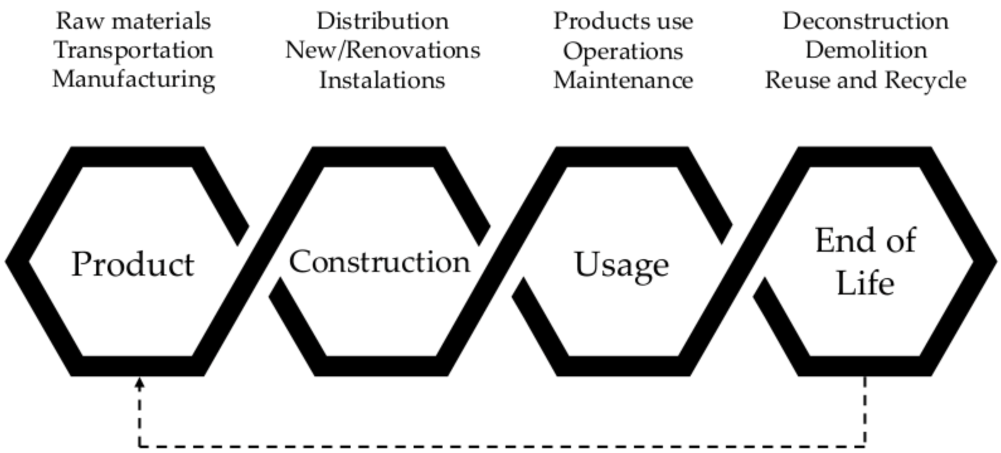

Figure 6. Life Cycle Assessment of Sustainable Construction.

LCA was first used for product comparison in the United States and Europe, but it is now widely used in product design, strategic planning, and government policy. Apart from the environmental assessment provided by LCA, it also delivers a method for reducing environmental impacts using trade-off analysis [112]. LCA is a complex concept focusing on energy, pollutants, and material flow at the inner and outer levels from a life cycle perspective to support better decision-making [113]. The effects in the construction industry occur at various life cycle stages, including manufacturing, processing, functional, and disposal of building materials. Recently, LCA was introduced to assess GHG emissions and embodied energy consumption during the initial stage of construction when using steel, concrete, and wood structural members in any form of building [114,115].

9. Future Study of Sustainable Practice in Construction

Sustainable and environmentally friendly building practices are becoming increasingly important as the global population rises. The challenge is meeting user needs while minimizing construction's negative environmental effects. The present study discusses how future buildings could be made more environmentally friendly, mainly through green construction practices. We also examined some real-world applications of green buildings and discussed how they might be implemented to improve the planet's long-term viability. "Green construction" refers to any technique used to construct a building that minimizes its negative effects on the natural environment. Despite the definition, there is no single approach to a green building; instead, it combines sustainable practices that consider local cultural norms to create a more sustainable future for our planet. These kinds of practices are rising in today's world. Green buildings can be made even more productive and economical with the help of digital transformation techniques like 3D printing and optimization strategies for design. This method of building has the potential to alter the construction industry pushing for higher qualitative and environmental standards. Architects can save time, energy and cut costs using 3D printing technology to create buildings bioclimatic suited to each location. These digital transformation methods pave the way toward environmentally responsible building practices as they become widely available worldwide.

10. Conclusions

After examining several studies, the following findings were developed. Nowadays, there is a massive disparity in sustainable design and construction research. A more comprehensive strategy must be devised to appreciate the interaction between urban design, buildings, building systems, and materials. Along with being spread throughout the building delivery process, from planning and design, to construction, operation and maintenance, this understanding is critical. The main objectives of this study were to comprehend sustainable building and its benefits. According to the study's findings, utilizing environmentally friendly materials and technologies can reduce the environmental impact that traditional buildings have on the environment, the economy, and people. New buildings should use resources like energy, water, and locally sourced materials more efficiently than in the past. Sustainable structures can acquire larger amounts of natural light and improve ventilation resulting in healthier indoor spaces. Plus, they incorporate high-performance systems, efficient rainwater collection equipment and harness renewable energy sources. The holistic approach creates a building with a reduced carbon footprint and lower energy consumption. Tools and rating systems like life cycle assessment, must be used during the process as they are key to understanding and implementing a sustainable approach to the construction industry.

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