LIMITATIONS OF TRADITIONAL BUILDING MATERIALS FOR SUSTAINABLE CONSTRUCTION IN SRI LANKA

WICKRAMANAYAKE. N.D.[1], JAYALATH. J.A.C.D.[2]*, KULATUNGA. U.[3] & SIRIWARDHANA. S.D.[4]
[1,2,3]Department of Building Economics, University of Moratuwa, Sri Lanka
[4]Department of Civil Engineering, Monash University, Australia
[1]nanduni.wickramanayake98@gmail.com, [2]charuka960808@gmail.com, [3]ukulatunga@uom.lk, [4]senudisara@gmail.com

Abstract: The global construction industry has long been a significant driver of economic growth and a major force behind environmental degradation, given its heavy resource and energy consumption. This study reveals the drawbacks of conventional building materials through an analysis of their limitations in terms of environmental, economic, and social impacts. The review of literature and expert interviews highlighted that traditional materials have high embodied energy, high greenhouse gas emissions, depletion of resources, and inefficiencies that result in costs and time overruns. The study emphasizes the urgent need for the construction industry to adopt sustainable practices, such as reducing waste, recycling, and reusing materials, to mitigate aforementioned impacts. Furthermore, the importance of selecting environmentally friendly materials that meet both user needs and societal development goals is emphasized as a critical factor in achieving sustainability. The findings suggest that overcoming the challenges posed by traditional materials requires a comprehensive approach that includes identifying barriers to sustainability within the Sri Lankan context and implementing targeted strategies. This research serves as a pilot study, laying the groundwork for future exploration into sustainable construction practices with a focus on material application in Sri Lanka's construction industry.

Keywords: *Building materials, sustainability, environmental challenges*

1. Introduction

The construction industry encompasses manufacturers and suppliers of construction materials, customers, contractors, consultants, and end users of facilities who plan, develop, produce, design, construct, modify, or maintain the built environment(Baloi, 2003). The construction sector has been identified as a potentially harmful practice to the surrounding environment, as well as one with significant potential for enhancement(Addis & Talbot, 2001). The construction sector is often being criticized for having adverse impacts on the environment(Lima et al., 2020). Building construction negatively impacts the environment directly through material and energy wastage, and indirectly by the means of often inefficient infrastructure(Halliday, 2007). More than 30% of natural resource extraction and 25% of solid waste production worldwide are attributed to the construction industry(Benachio et al., 2020). According to ICRA Lanka (2011), Sri Lanka's construction industry is plagued by a major issue: high building material costs. The construction sector has a considerable negative influence on environmental sustainability as it consumes 40% of global energy and accounted for a quarter of CO2 emissions becoming the largest source of global greenhouse gas (GHG) emissions(Hong et al., 2014). One of the main issues facing modern civilization is the rise in energy consumption brought on by the rapid urbanization rate and rising standards of comfort resulting from the over usage of energy from non-renewable sources, which has negative environmental effects(Cunha & Aguiar, 2020). Guna et al. (2019) argues that the production of conventional building materials uses significant electrical and thermal energy which is resulting in a higher building cost(as cited in Maraveas, 2020). Such production procedures cause pollution of land, air and water, and higher carbon footprint(Maraveas, 2020). Global policies acknowledge the need for immediate mitigation measures in the construction sector to reduce greenhouse gas emissions, climate change, and resource depletion(Ghaffar et al., 2019). In this context, based on the identified qualities of traditional building materials, a definition can be adapted as non-renewable resources with high embodied energy throughout their life cycle. These materials can be created artificially or derived naturally from the natural resources, often contributing to environmental challenges, including high waste generation with resource depletion.

On the one hand, Sri Lanka is obliged by international environmental commitments such as Montreal Protocol, and Kyoto Protocol, and on the other hand, it must properly manage its natural resources, which are converted into construction materials(Abeysundara & Babel, 2010).Thus, in order to change the current scenario of high resource consumption and high environmental pollution, the construction industry desperately has to investigate and establish the sustainable development paradigm(Shi & Liu, 2019). There has been a demand for more environmentally friendly buildings as people become more conscious of their enormous impacts on resource depletion and pollution emissions(Chau et al., 2007). The significant role

*Corresponding author: Tel: +94705029337 Email Address: charuka960808@gmail.com
FARU Journal: Volume 11 Issue 02 DOI: https://doi.org/10.4038/faruj.v11i2.326

of energy in human development, quality of life, and sustainability is recognized by modern civilization (Pietrosemoli & Rodríguez-Monroy, 2019). Sustainable construction is a new scientific discipline that tries to incorporate general sustainable development concepts into traditional construction processes(Matar et al., 2008). The sustainable concept consists of three aspects; environmental sustainability, economic sustainability, and social sustainability(Hussin et al., 2013), in contrast to the traditional approach, where the primary considerations were economy, utility, and durability(Baloi, 2003). According to Baloi(2003), the construction industry's contribution to sustainability is a great concern. The global construction industry is reluctant to adapt technological advancement due to its decentralized nature, inadequate collaboration, lack of skilled workforce, and insufficient knowledge transfer between projects(Goh et al., 2020). Awareness of and adoption of sustainable practices by clients play a crucial role in the implementation of sustainable construction as the construction industry is client-driven in nature(Davies & Davies, 2017).

The background study revealed a lack of research on identifying the limitations of traditional building materials and implementing sustainable construction practices to overcome these limitations, particularly in the context of building materials in Sri Lanka. Therefore, this research was conducted to address these gaps by identifying the limitations and challenges associated with the application of traditional building materials in Sri Lanka and to achieve sustainable construction practices within this context. To fulfill the aim of the research, the following objectives were established: 1) Identify the importance of building materials for construction, 2) Identify the impacts and limitations of traditional construction materials, and 3) Assess the importance of implementing sustainable practices to overcome the limitations of traditional building materials and their current status. Data collection was conducted solely within the Sri Lankan context, involving professionals from the construction industry and subject matter experts in Sri Lanka.

2. Literature synthesis

Building construction negatively impacts the environment directly through material and energy wastage (Halliday, 2007). Saghafi and Teshnizi (2011) stated that the material selection is the most hard and challenging step of any sustainable building project(as cited in Samani et al., 2015). Material selection should consider environmental, economic, and social issues in addition to physical, mechanical properties and technological aspects(Samani et al., 2015). At the same time, the construction industry has always been particularly resistant to change, especially when it comes to the building materials and procedures used (Djokoto et al., 2013). Hence, prior to identifying the impact and the limitations of traditional building materials, there is a need to identify the importance of building materials for the construction industry.

2.1 IMPORTANCE OF BUILDING MATERIALS FOR CONSTRUCTION

According to UNEP (2009), buildings have an extremely significant environmental impact. They are the main source of emissions in the majority of countries and account for more than one-third of the world's energy-related greenhouse gas (GHG) emissions(Kumanayake & Luo, 2018). The production of construction materials is responsible for around 50% of all CO2 emissions worldwide(Fayomi et al., 2020). Kubba (2017) described that any component that is used in construction can be referred to as a building material (As cited in Omer & Noguchi, 2019). These materials can be created artificially by humans (synthetic materials), such as brick, insulation, metal, and plastics, or they can be derived naturally from the environment, like clay, sand, and wood(Omer & Noguchi, 2019). Further to the authors, the first building supplies were biodegradable and short-lived (for example, Leaves and animal hides) and many new construction materials (such as metal and concrete) were later discovered due to the industrial revolution, which was followed by the development of machinery and large-scale industrial manufacturing.

The type and aesthetic quality of any structure are determined by the materials used and help for the selection of construction techniques and enhancement of the visual quality and structural ability(Mishra & Das, 2014). Because of the enormous strain on the earth's resources brought on by population growth and economic expansion, the building industry in developing nations constantly faces issues and challenges(Jayalath & Gunawardhana, 2017). Buildings use energy at varying rates throughout their entire life cycle and much of this consumption is made up of building materials(Yüksek, 2015). Therefore, Yüksek (2015) identified that a key factor in assessing a building's energy efficiency is the amount of energy used by the materials used in construction throughout the lifespan of the building. Energy efficiency addresses the use of energy sparingly and the proportion of energy usage and production, whereas material efficiency considers the use of natural material resources sparingly, effective management of side-streams, waste reduction, and recycling(Ruuska & Häkkinen, 2014). Throughout the lifespan of a building, the construction process and operation use a significant number of materials(Ding, 2014).

The life cycle of building materials has a variety of environmental consequences from the extraction, processing, and transportation of raw materials to the construction, use, and eventual demolition and disposal of buildings(Huang, et al., 2020). The extraction of raw materials, processing and manufacture of these raw materials, transportation, construction, and repurposing, use and maintenance, destruction and waste management, disposal, and circular processing through reuse, recycling, and recovery are all stages of the full life cycle of a building material as shown in the below figure(Lei et al., 2020).

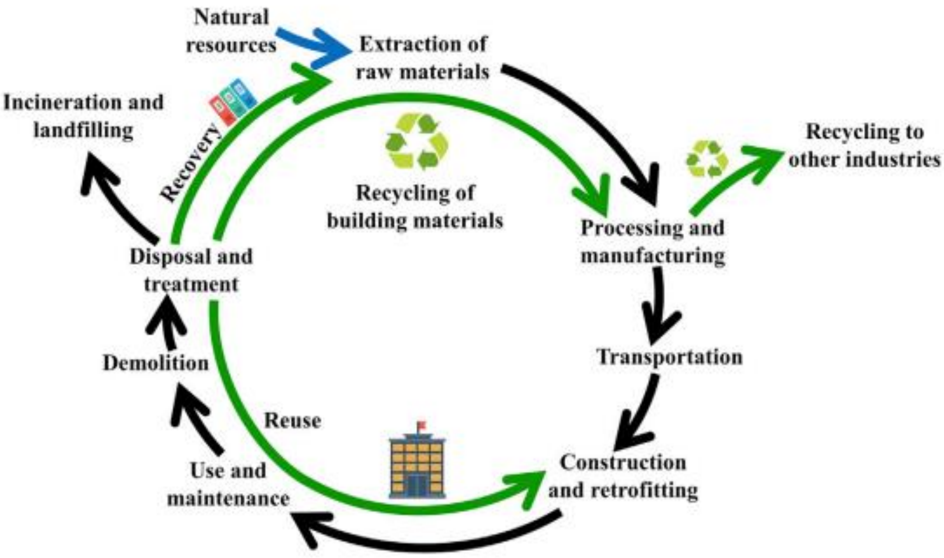

Figure 2.1: Conceptual Diagram of Building Material Life Cycle (Lei et al., 2020)

Life cycle assessment (LCA) is a method for evaluating the potential environmental effects connected to a product which can assist in evaluating the environmental consequences connected to all phases of the life of building materials as shown in Figure 2.2 (Huang, et al., 2020).

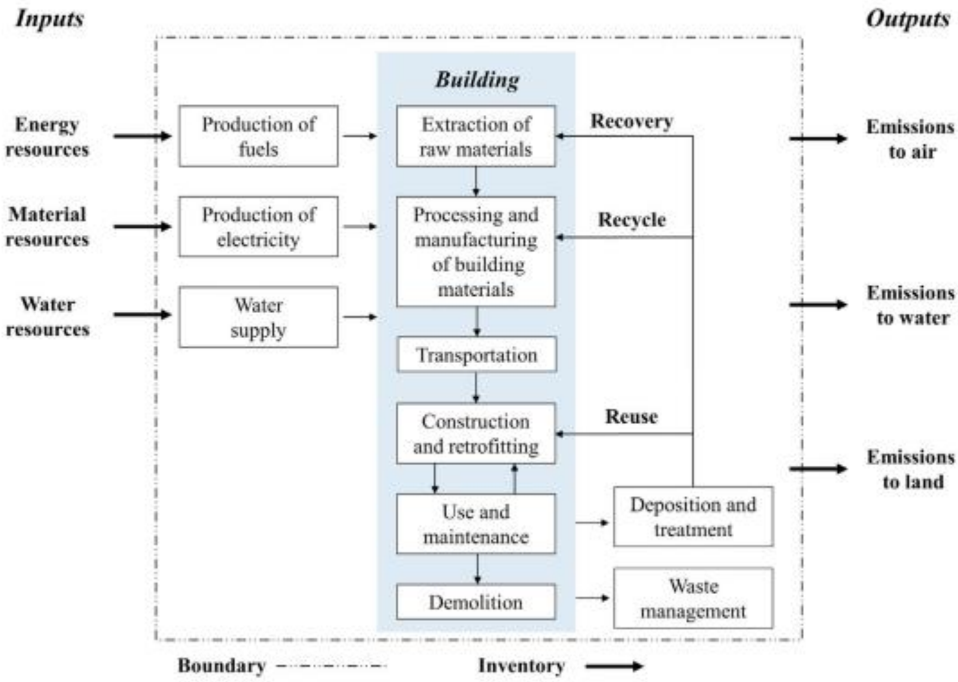

Figure 2.2 : Life Cycle Assessment Application Framework for Building Materials (Huang, et al., 2020)

2.2 IMPACTS OF TRADITIONAL CONSTRUCTION MATERIALS

The building sector has a significant negative influence on the environment. In industrialized nations, it accounts for 12% of potable water, 40% of electricity dissipation, and 40% of raw material extraction and manufacturing(Fayomi et al., 2020). Fayomi et al. (2020) further elaborated that the financial impact of this is equivalent to about 6% of the world's gross domestic product (GDP). The building industry has a multiplier effect on not only economic and social activities but also the built and natural environments, which have a significant impact on the quality of life. The influence on the environment includes contamination of the atmosphere, biohazards in waterways, garbage, and land(Fayomi et al., 2020). A depletion in resources and loss of biological diversity are typically caused by the extraction of raw materials, manufacturing, and transportation, whereas acid rain and global warming are the results of high energy consumption(Oke et al., 2019).

The construction sector is facing innumerable challenges due to the diminishing natural resources and increasing population(Maraveas C. , 2020). Since pre-industrial times, greenhouse gas emissions, including those from construction, have increased globally(Kumanayake & Luo, 2018). Between 1970 and 2004, the annual emissions of carbon dioxide, the most significant greenhouse gas, increased by roughly 80%. (IPCC, 2007). Global warming potential (GWP) is impacted by building energy use(Gustavsson & Joelsson, 2010). The importance of life cycle energy and carbon emission assessment has increased as a result of the urgently dangerous problem of global warming brought on by greenhouse gas emissions(Kumanayake & Luo, 2018). The construction industry faces serious and persistent problems such as adverse impacts on the environment, uncontrolled natural resource consumption, cost overrun, time overrun, and waste generation(Hussin et al., 2013). The construction industry consumes a substantial amount of materials, energy, water, and natural resources(Omer & Noguchi, 2019). Petkar and Sanket(2014) ascertained that three billion tons of raw materials are used annually to produce building materials worldwide (As cited in Fayomi et al., 2020). A substantial portion of the reason for the built environment's significant negative ecological effects is the massive number of materials used in buildings. Construction, due to its size, is one of the largest users of energy, material resources, and water, and it is a major polluter(Arpad, 2004). Enormous volumes of materials are buried, burned, and discarded because of simultaneous construction and demolition projects(Zari, 2019). Building material wastage can be defined as the disparity between the value of materials distributed and accepted on site and those properly used as defined and accurately measured in the work after subtracting the cost-savings of replaced materials transmitted elsewhere in which unnecessary cost and time may be risen by the material wastage(Bekr, 2014).

According to Maraveas (2020), the construction sector must reconsider its strategies toward sustainable construction materials due to the severe climate changes. Environmental burdens primarily involve a material's embodied energy and emissions added to the environment during each process of that material's life cycle(Abeysundara et al., 2009). Further to the authors, it is a measurement of the amount of energy utilized from raw material extraction to production process necessary to generate a completed product and it also covers the energy expended in transporting raw materials to the manufacturer and completed goods to the consumer. Materials containing high embodied energy require initial high levels of energy consumption during production, which is linked to high levels of greenhouse gas emissions (Bribian et al., 2011). The procedures and materials employed in the conventional construction processes have adverse impacts on the environment and society(Baloi, 2003). Massive amounts of natural resources, such as water and a variety of energy sources, are consumed by construction activities(Oke et al., 2019). Guna et al. (2019) argued that the production of conventional materials uses significant electrical and thermal energy which is resulting in a higher building cost(As cited in Maraveas,2020). Conventional material production processes account for a higher carbon footprint, polluting water, air, and land (Maraveas, 2020). It is crucial to develop building materials that are not only more environmentally friendly and sustainable but also more cost-effective without reducing building quality(Maraveas C. , 2020). Invidiata et al. (2018) stated that the design, construction, operation, and maintenance of a structure constantly consume a significant amount of energy and natural resources, which has a significant negative impact on the environment(As cited in Omer & Noguchi, 2019).

Many environmental issues relating to climate change and global warming have evolved alongside the building materials sector. No society can achieve sustainable growth unless the construction industry, which supports it, undertakes significant reforms because it stands out among human activities as one of the sectors that consume more raw materials and energy and has a major environmental impact at every level of the construction process(Marques & Loureiro, 2013). The smart use of resources and the environmental issue have been marked as some of the most frequently discussed topics in all spheres of society. As a result, the public is more aware of the issues related to the construction sector because this condition has been caused by it(Marques & Loureiro, 2013). Hussin et al. (2013) stated that traditional construction methods concentrate mainly on cost-cutting, performance, and quality goals, but sustainable methods also aim to minimize resource depletion, and environmental degradation, and promote a healthy built environment(As cited in Jayalath & Gunawardhana, 2017). The below table (Table 1) provides an overview of the limitations of traditional building materials.

Table 2.1: Limitations of Traditional Building Materials

Limitations of traditional building materials	Depletion of natural resources	Oke et al. (2019) Maraveas (2020) Hussin et al. (2013) Omer & Noguchi (2019) Petkar & Sanket (2014)
	Loss of biological diversity	Oke et al. (2019)
	Greenhouse gas emissions	Kumanayake & Luo (2018) Bribian et al. (2011)
	Waste generation	Hussin et al. (2013)
	Cost and time overrun	Hussin et al. (2013)
	Use of significant electrical and thermal energy which results in a higher building cost	Guna et al. (2019)
	Higher carbon footprint	Maraveas (2020)
	High embodied energy	Bribian et al. (2011)
	Sever climate changes	Maraveas (2020)

3. Research Method

This research consists of background study, comprehensive review of literature, data collection through expert interviews and data analysis respectively. Background study provides the context underlying the research indicating the basis for the study, and the problem statement. Literature review summarizes previous research relevant to the objective 1 and 2 by referring books, scholarly articles, and other relevant sources on that specific research area. Data was collected through expert interviews and collected data were critically analyzed in order to achieve the final research objective through validating literature findings and further expert opinions.

4. Data Collection, Analysis and Findings

4.1 RESPONDENT PROFILE

Semi structured interviews were carried out with 10 experts in the construction industry who have exposed to the area of using sustainable materials. Interview guideline was developed based on the research objectives. Findings of expert interviews were analyzed by using manual content analysis. The below table (Table 4.1) presents the profiles of the interviewees participated for the expert interviews.

Table 4.1: Profile of the interviewees

Expert	Designation	Organization	Experience
E1	Civil Engineer	Contractor	Above 15 years
E2	Chief Quantity Surveyor	Consultant	Above 10 years
E3	Chief Quantity Surveyor	Contractor	Above 35 years
E4	General Manager/ Civil Engineer	Contractor	Above 20 years
E5	Senior Lecturer	Academia	Above 10 years
E6	Architect	Consultant	Above 20 years
E7	Project Manager	Contractor	Above 15 years
E8	Civil Engineer	Consultant	Above 10 years
E9	Quantity Surveyor	Contractor	Above 10 years
E10	Structural Engineer	Contractor	Above 15 years

As shown in the table, all experts selected for the interviews had significant experience in the construction industry, material selection, and sustainability, with each having more than 10 years of expertise in their respective fields. To ensure an in-depth understanding across all disciplines relevant to material selection in the construction industry, participants included civil engineers, structural engineers, architects, quantity surveyors, project managers, and academic lecturers. Each of these disciplines, including quantity surveyors play a major role in cost analysis, feasibility studies, and resource management, which are essential when evaluating the practical implementation of sustainable materials. "The Expert Interview Guideline" is consisted of 09 questions to achieve the research objectives.

4.2 LIMITATIONS OF TRADITIONAL BUILDING MATERIALS FOR SUSTAINABLE CONSTRUCTION.

Numerous limitations of traditional building materials were identified and validated through expert interviews. E1, E3 and E6 identified that high wastage and over usage of natural resources with the increasing population as limitations of traditional building materials towards sustainability. E1 stated "*With the time the population on the planet becomes higher. Therefore, it is essential to construct more houses and other building facilities to incorporate humans' daily activities. Therefore, the amount of construction carried out becomes higher. Material requirement for construction is also got increased with the time*". To produce the building materials, more raw materials need to be extracted from the environment. Sources of raw materials are natural resources which take a considerable amount of time for their generation on the planet. But humans are extracting those materials at a much higher rate than their rate of natural generation. Hence, the natural resources on the planet are gradually depleting which is a huge impact to the environment. E3 stated "*Since most of the conventional materials do not have the ability of recycling and reusing, they generate construction waste which are harmful to the environment*".

E2 and E8 elaborated that high prices due to scarcity of resources limit the traditional building materials implemented into sustainable construction practices. E2 stated "When *it comes to availability and maintainability, there are some issues in traditional building materials. When it comes to environmental considerations, if we take the life cycle of the material, starting from the extraction of materials, most of the traditional materials consume virgin materials which is a very big problem. The embodied energy of traditional materials is extremely high. Because of that if we consider traditional materials, most of them are not environmentally friendly*". It is obvious that the usage of materials with high embodied energy demotivates implementing sustainable practices.

As the population gets increased and natural resources get depleted, the availability of materials will come into consideration. The production of traditional building materials will decrease and that creates an issue of non-availability. That will also cause high prices of traditional materials. If the building cost increases because of using traditional materials, that impacts the economic aspects which is a part of sustainability. E4 highlighted inefficiency and high labour requirement as further limitations. Several traditional materials require a high amount of labour for the construction process. That makes the whole project inefficient by wasting time and labour resources for unnecessary work. E5 and E10 identified high carbon emissions as one of the limitations of traditional building materials. E7 also stated "*Most of the traditional building materials account for a huge percentage of CO_2 emissions. Therefore, conventional building materials can be considered as one of the major contributors for greenhouse gases which is the main reason for global warming*". Severe climatic changes are caused by global warming such as rising ocean, severe storms, droughts, etc. Further, it causes loss of species, health risks, and food crisis in the world. Hence, it affects the world in environmental, social, and economic aspects.

4.2.1 Discussion

The limitations of traditional building materials have been validated through both literature and expert interviews. Past literature by Maraveas(2020) also identified that the construction sector is facing innumerable challenges due to diminishing natural resources and increasing population. This aligns with the expert opinion shared during interviews. E1 noted, "*the population on the planet becomes higher and therefore material requirement for construction is also increasing*." Further, according to Hussin et al. (2013), the construction industry faces serious and persistent problems such as adverse impacts on the environment, uncontrolled natural resource consumption and waste generation. Additionally, Petkar and Sanket(2014) ascertained that three billion tons of raw materials are used annually to produce building materials worldwide(As cited in Fayomi et al., 2020). This information advocates the significant overuse of natural resources, contributing to environmental depletion. However, this overconsumption has gradually resulted in scarcity and increasing prices for construction materials (Kariyawasam & Jayasinghe, 2016).

Moreover, Experts mentioned about cost challenges related to the scarcity of resources: E2 stated, "*the embodied energy of traditional materials is extremely high"* and literature by Yüksek(2015) and Ding (2014) corroborates that building materials contribute significantly to a building's energy consumption throughout its lifecycle, impacting sustainability efforts. The findings of the expert interviews and literature findings ascertained that when considering the life cycle of traditional materials, starting from the raw material extraction to the demolition, embodied energy of traditional building materials is high.

According to Marques and Loureiro(2013), no society can achieve sustainable growth unless the construction industry, which supports it, undertakes significant reforms because it stands out among human activities as one of the sectors that consume more raw materials and energy and has a major environmental impact at every level of the construction process. This high labor requirement aligns with the expert's statement :" "*Several traditional materials require a high amount of labor for the construction process, making projects inefficient by wasting time and resources*.". These are emphasized the need for reform the construction practices due to the sector's high consumption of energy and raw materials.

Experts identified that traditional materials significantly contribute to CO2 emissions, which contribute to global warming. This supports Maraveas(2020), who highlighted that conventional material production processes lead to higher carbon footprints and pollution. As mentioned in both the interviews and literature findings, these impacts contribute to severe climate issues, including global warming, which affect the social, economic, and environmental dimensions.

In summary, the findings from expert interviews align with existing literature, emphasizing that traditional building materials are limited by their high embodied energy, inefficient resource use, significant carbon emissions, and rising costs due to resource scarcity. The below table (Table 4.2) provides an overview of the findings of literature and interviews.

Table 4.2: Limitations of Traditional Building Materials - Literature Findings vs Interview Findings

Literature Findings		**Interview**
Fact	**Author**	
Depletion of natural resources	*Oke et al. (2019)* *Maraveas (2020)* *Hussin et al. (2013)* *Omer & Noguchi (2019)* *Petkar & Sanket (2014)*	High wastage
Loss of biological diversity	*Oke et al. (2019)*	Over usage of natural resources
Greenhouse gas emissions	*Kumanayake & Luo (2018)* *Bribian et al. (2011)*	High prices
Waste generation	*Hussin et al. (2013)*	Issues in maintainability
Cost and time overrun	*Hussin et al. (2013)*	Issues with availability
Use of significant electrical and thermal energy which results in a higher building cost	*Guna et al. (2019)*	Embodied energy is high
Higher carbon footprint	*Maraveas (2020)*	Inefficiency

High embodied energy	*Bribian et al. (2011)*	High labour requirement
Sever climate changes	*Maraveas (2020)*	High carbon emissions

4.3 IMPLEMENTATION OF SUSTAINABLE PRACTISES TO OVERCOME THE LIMITATIONS OF TRADITIONAL BUILDING MATERIALS.

Although it is well recognized that the building industry significantly contributes to the environmental degradation of a country, it also plays a significant part in the social and economic growth of that country (Oke et al., 2019). It is urgent to restructure the construction industry globally given the rate at which the earth's resources are depleting(Oke et al., 2019). Therefore, it is crucial to establish innovative and more environmentally friendly building techniques within the construction sector(Santos et al., 2019). In sustainable construction, all construction operations, from the planning to the completion stages, are carried out in a manner taking into account the economic, social, and environmental implications(Willar et al., 2020). Consequently, UN's sustainable development goals can be dramatically enhanced by the sustainable construction sector (Omer & Noguchi, 2019). Sustainability and its use in the development of construction projects have drawn the attention of academics and industry experts in the fields of design, engineering, and construction(Carvajal-Arango et al., 2019). Alsanad (2015) identified reduce resource consumption (reduce), reuse resources (reuse), use recyclable resources (recycle), protect nature (nature), eliminate toxic materials (toxins), apply life-cycle costing (economics), and focus on quality (quality) as principles of sustainable construction. The below figure (Figure 2.3) demonstrates how the above-mentioned sustainable construction principles relate to the building lifecycle.

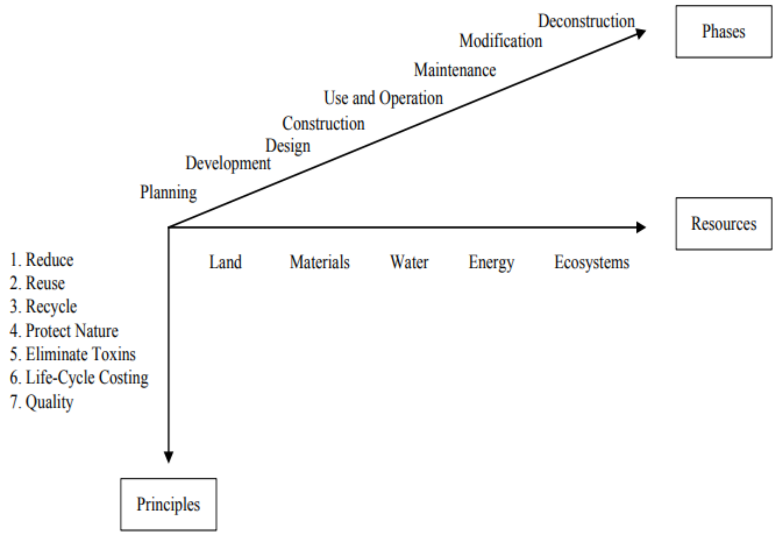

Figure 4.1: Principles of sustainable construction in relation to the lifecycle of a building (AlSanad, 2015)

According to Aysin (2009), the three components of sustainable development include economic growth, social advancement, and effective environmental protection(As cited in Omer & Noguchi, 2019). It focuses on the use of techniques to lessen the negative effects that construction projects have on the environment, the economy, and society at large (Torres, 2014). Findings of Kibert (2016) ascertain that the term "sustainable construction" describes the building of a sustainable structure as well as the use of environmentally friendly and resource-efficient procedures throughout the life cycle of a building, which includes planning, design, construction, operation, maintenance, renovation, and demolition (As cited in Chamikara et al., 2016).

When focus on the materials used in building construction, it should be chosen to meet the user's perceived needs as well as the society's development needs, while minimizing environmental effect(Reddy & Jagadish, 2003). According to Martins and Gonçalves (2012), building materials have been incorporated into the sustainable development concept, which is a crucial goal for the construction industry to minimize the negative environmental effects of buildings(As cited in Omer & Noguchi, 2019). Adhering to guidelines for material selection, sourcing, and construction techniques as well as a design ethos are necessary for sustainable construction in order to enhance the performance(Kulatilake et al., 2022). Buildings are of great economic significance and have a significant impact on the environment and quality of life, making the construction sector one of the pillars for the sustainable development of society (Santos et al., 2019). Therefore, sustainable construction is best defined as a subset of sustainable development applied to the construction industry(Ametepey et al., 2015). Further to the authors, the construction industry encompasses all those who plan, develop, create, design, modify, or maintain the built environment, as well as the suppliers and producers of construction materials, customers, contractors, consultants, and end users of facilities.

As a result, sustainable construction is best regarded as a subset of sustainable development, encompassing issues such as tendering, site planning and organization, material selection, recycling, and waste minimization(Langston & Ding, 2001). As potential obstacles to the adoption of proactive environmental strategies, Murillo-Luna et al. (2011) identified a lack of information and ambiguity regarding environmental legislation, rigidity of legislation and bureaucratic complexity, limited development of the environmental supply sector, high costs of environmental services/technologies, and challenges resulting from competitive pressure. Lam et al. (2010) examined the issues that prevent the successful application of green building requirements. Lack of green technology and procedures, reliability and quality of specifications, leadership and accountability, stakeholder involvement, and benchmarking and guidance systems are among the factors mentioned. The construction industry is client-driven, and client awareness and adoption of sustainable construction play a significant role in implementation(Davies & Davies, 2017). Further to the authors, the majority of clients are unaware of sustainable construction, and those who are aware are more concerned with the initial cost than with the long-term benefits of sustainable construction. Client affordability is a fundamental limitation to sustainable construction, implying that sustainable construction is more expensive to adopt than traditional procedures(Pitt et al., 2009).

As a conclusion, buildings are crucial to worldwide efforts to reduce negative environmental effects and advance sustainable development(Kumanayake & Luo, 2018). Sustainably constructed buildings are intended to reduce their environmental effect and improve environmental quality by minimizing the use of non-renewable resources, eliminating or reducing the usage of toxins, and reducing energy use(Manoliadis et al., 2006).

5. Conclusion & Recommendations

The construction industry can be identified as one of the most prominent industries in the world. It is a major contributor to the global economy. But it accounts for numerous impacts to the environment. From the building lifecycle's inception to demolition, it consumes a substantial amount of energy and is responsible for greenhouse gas emissions. Materials and processes used for construction can be identified as the main reason for energy consumption and gas emissions. Hence, building materials play a major role when achieving sustainability.

Most commonly used building materials in the construction industry have high embodied energy, resulting in significant total energy consumption over their life cycle. Further, most of those materials account for greenhouse gas emissions. Therefore, when achieving sustainability in construction, building materials play a vital role. Hence, selecting the materials which are less harmful to the environment as well as society and economy, is crucial in construction. Moreover, traditional materials often cannot be recycled or reused, leading to waste generation, which poses a barrier to sustainable construction. The increase of carbon footprint is also caused by use of conventional construction materials which contributes to the global warming and severe climatic changes. As conventional materials cannot be reused and recycled, each production of new conventional materials require extraction of raw materials from the environment which causes to depletion of natural resources. Hence, it contributes to the loss of biodiversity as well. As the population gets increased, demand for construction also gets increased. Therefore, demand for construction materials gets higher. Due to the slow regeneration rate of natural resources compared to their extraction rate, raw material scarcity becomes an issue. Hence there will be availability issues as well as high costs due to non-availability. Further, some construction materials need a high labor requirement which also results in wastage of time due to unnecessary work. That will ultimately result in inefficiency of the project.

To address the challenges and limitations of traditional building materials, sustainable construction practices must be implemented in the Sri Lankan context. Sustainable construction may include reducing the waste generation, recycling and reusing of materials, minimizing the embodied energy of building materials, etc. This sustainable construction practices, which integrate economic, social, and environmental considerations from planning to completion, can enhance the UN's Sustainable Development Goals. Principles such as reducing resource consumption, reusing materials, and minimizing environmental impacts are crucial for sustainable development and Challenges include lack of information, high costs, and client reluctance due to perceived higher expenses. However, Sustainable construction remains a critical component for achieving long-term environmental and societal benefits. Moreover, it is needed to be identify the methods to mitigate the negative impacts of building materials particular reference to Sri Lankan context. Hence, this study can be considered a pilot study for implementing sustainable construction practices, with a special focus on the application of materials in the construction industry in Sri Lanka.

6. Reference

Addis, B., & Talbot, R. (2001). *Sustainable Construction Procurement: A Guide to Delivering Environmentally Responsible Projects.* London: CIRIA.

Baloi, D. (2003). Sustainable Construction: Challenges and Opportunities. *19th Annual ARCOM Conference* (pp. 287-297). Brighton: Association of Researchers in Construct ion Management.

Benachio, G. L., Freitas, M. D., & Tavares, S. F. (2020). Circular economy in the construction industry: A systematic literature review. *Journal of Cleaner Production*, 260, 1-17.

Cunha, S. R., & Aguiar, J. L. (2020). Phase change materials and energy efficiency of buildings: A review of knowledge. *Journal of Energy Storage*, 30, 1-13.

Davies, O. O., & Davies, I. O. (2017). Barriers to Implementation of Sustainable Construction Techniques. *MAYFEB Journal of Environmental Science*, 2(2), 1-9.

Ding, G. K. (2014). Life cycle assessment (LCA) of sustainable building materials: an overview. *Eco-efficient Construction and Building Materials*, 38-62.

Fayomi, O. S., Okwilagwe, O., Agboola, O., Oyedepo, S. O., & Popoola, A. P. (2020). Assessment of composite materials in advance application: A mini overview. *Materials Today: Proceedings*, 33, 1-4.
Halliday, S. (2007). *Sustainable Construction.* London: Routledge.
Hong, J., Shen, G. Q., Feng, Y., Lau, W. S., & Mao, C. (2014). Greenhouse gas emissions during the construction phase of a building: a case study in China. *Journal of Cleaner Production*, 103, 1-11.
Huang, B., Gao, X., Xu, X., Song, J., Geng, Y., Sarkis, J., . . . Nakatani, J. (2020). A Life Cycle Thinking Framework to Mitigate the Environmental Impact of Building Materials. *One Earth*, 3(5), 564-573.
Hussin, J. M., Rahman, I. A., & Memon, A. H. (2013). The Way Forward in Sustainable Construction: Issues and Challenges. *International Journal of Advances in Applied Sciences (IJAAS)*, 2(1), 31-42.
Jayalath, A., & Gunawardhana, T. (2017). Towards Sustainable Constructions: Trends in Sri Lankan Construction Industry - A Review. *International Conference on Real Estate Management and Valuation*, 137-143.
Jayalath, C., & Perera, B. A. (2019). POLICY GAPS THAT DETER FOSTERING SUSTAINABLE CONSTRUCTION IN SRI LANKA. *Proceedings of the 8th World Construction Symposium* (pp. 484-492). Colombo: CIOB.
Kariyawasam, K., & Jayasinghe, C. (2016). Cement stabilized rammed earth as a sustainable construction material. *Construction and Building Materials*, 105, 519-527.
Karunasena, G., Rathnayake, R. M., & Senarathne, D. (2016). Integrating sustainability concepts and value planning for sustainable construction. *Built Environment Project and Asset Management*, 6(2), 125-138.
Kumanayake, R. P., & Luo, H. (2018). Cradle-to-gate life cycle assessment of energy and carbon of a residential building in Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 46(3), 355-367.
Lei, J., Huang, B., & Huang, Y. (2020). Life cycle thinking for sustainable development in the building industry. In J. Lei, B. Huang, & Y. Huang, *Life Cycle Sustainability Assessment for Decision-Making* (pp. 125-138). Shanghai: Elsevier.
Lima, L., Trindade, E., Alencar, L., Alencar, M., & Silva, L. (2020). Sustainability in the construction industry: A systematic review of the literature. *Journal of Cleaner Production*, 271, 1-15.
Maraveas, C. (2020). Production of Sustainable Construction Materials Using Agro-Wastes. *Materials*, 13(2), 1-29.
Marques, B., & Loureiro, C. R. (2013). Sustainable Architecture: Practices and Methods to Achieve Sustainability in Construction . *IACSIT International Journal of Engineering and Technology*, 5(2), 223-226.
Matar, M. M., Georgy, M. E., & Ibrahim, M. E. (2008). Sustainable construction management: introduction of the operational context space (OCS). *Construction Management and Economics*, 26(3), 261-275.
Oke, A., Aghimien, D., Aigbavboa, C., & Musenga, C. (2019). Drivers of Sustainable Construction Practices in Zambian Construction Industry. *Energy Procedia*, 3246-3252.
Omer, M. A., & Noguchi, T. (2019). A conceptual framework for understanding the contribution of building materials in the achievement of Sustainable Development Goals (SDGs). *Sustainable Cities and Society*, 1-22.
Reddy, B. V., & Jagadish, K. S. (2003). Embodied energy of common and alternative building materials and technologies. *Energy and Buildings*, 129-137.
Yüksek, I. (2015). The Evaluation of Building Materials in Terms of Energy Efficiency. *Periodica Polytechnica Civil Engineering*, 45-58.
Zari, M. P. (2019). Ecosystem services impacts as part of building materials selection criteria. *Materials Today Sustainability*, 1-9.
.