Master's Thesis 30 credits - The year 2023

Utilization of reclaimed bricks to facilitate circular economy (CE) in the construction industry – "A study of Pakistan's construction industry".

By

Adil Atiq

Program	Leadership for Sustainable Development: Business Administration
Term	Spring 2023
Course	Leadership for Sustainable Development
Sub course	Master's Dissertation in Business Administration with a Focus on Sustainability
Supervisor	Arash Kordestani
Moment	Final paper
Date	2023-05-24

Acknowledgement:

I want to express my deep gratitude to Södertörn University for allowing me to be a part of this respected institution and for allowing me to broaden my knowledge in the field of Sustainability and Leadership.

I am grateful to Arash, Ann-Sofie, and Cecilia for their insightful guidance and continuous assistance throughout my research project. Their guidance has been invaluable in developing my thoughts and motivating me to explore deeply and thoroughly the subject matter. Their significant research knowledge has provided me with helpful insights.

I would certainly also like to express my gratitude to all my classmates who have been a part of this semester's journey. Your contributions and pieces of advice increased helped me to improve my thesis.

I am very grateful to the participants in my study who effortlessly volunteered and provided me with detailed information. Their significant contributions have been critical in the accomplishment of this research.

Thank you!

Abstract:

This thesis investigates the possible utilization of reclaimed bricks within the framework of circular economy (CE) and sustainable construction approaches, with a particular emphasis on Pakistan's construction industry. The research is based on the theoretical foundations of the Triple Bottom Line (TBL) and Resource Efficiency concepts. Qualitative methods were used to collect data, and a thematic framework was employed to analyse the results. The findings indicate that Pakistan's reclaimed brick sector aligns with the principles of the TBL theory, supporting sustainability in its social, economic, and environmental aspects. Through waste reduction, material reuse, and resource conservation, the industry demonstrates its commitment to environmental preservation. Furthermore, it plays a significant role in the economy by providing affordable infrastructure solutions and contributing to the growth of the construction industry. Additionally, the industry promotes social well-being by providing employment opportunities and financial stability. The study illustrates how Pakistan's reclaimed brick operations effectively integrate social, economic, and environmental factors to create a more environmentally friendly built environment. In summary, reclaimed bricks present a sustainable and resource-efficient alternative for the construction industry, in line with the principles of resource efficiency, preserving resources, minimizing waste, and promoting circular economy practices. The adoption of reclaimed bricks can help Pakistan and other countries achieve their sustainability objectives, reduce environmental impact, and construct structures that are longer-lasting and resource-efficient.

Keywords used: Circular economy, Sustainable construction, Clay bricks and environment, De-construction of infrastructure, Reclaimed bricks and its process, Circular economy business model, Resource efficiency, Material efficiency, Energy efficiency.

Table of contents:

List of Figures:

Chapter 1
Introduction

The primary focus of this study is to explore the practicality of incorporating circular economy principles into the construction industry, specifically with a focus on reclaimed brick utilisation. As a sustainable solution for various industries, the circular economy has gained considerable popularity. The construction industry has the potential to embrace circular economy concepts by prioritizing the reuse of previously manufactured construction materials. This chapter provides an overview of the research project, by outlining the fundamental concepts of the construction industry, circular economy, sustainability, and reclaimed bricks. Overall, this study aims to explore sustainable resource solutions for the construction industry to enhance sustainability. The findings of this study will make a valuable contribution to the advancement of sustainable construction practices. They will help in reducing environmental impact, create economic opportunities, and promote social stability.

1.1 Construction industry:

The construction industry is based on a large ecosystem of houses, buildings, and industrial infrastructure which is the foundation of the global economy and accounts for 13% of the world's GDP (McKinsey, 2020). According to Oxford Economics (2022), in its "A global forecast of Construction 2030", the global population will rise to 8.5 billion by 2030 and an estimated 2.5 billion urban population will increase by 2050 therefore, the need for civil infrastructure such as housing and build infrastructure is set to rise. Additionally, it is projected that the construction industry will play a significant role in driving global economic growth in the coming years, with an average growth rate of 4.4% between 2020 and 2025. It is also anticipated that construction production will continue to expand at an annual rate of approximately 3.5% between 2020 and 2030, establishing its position as a crucial driver of the global economy (Oxford Economics, 2022).

According to Haseeb et al (2011), the construction industry in Pakistan acts as an engine for the country's progress by creating employment opportunities, attracting foreign investment, providing housing facilities, utilizing raw materials from other industries, and fostering internal monetary circulation. Therefore, Pakistan's construction industry has the utmost importance, which contributes 2.3% to the country's GDP and makes up a sizeable section of the economy (Haseeb et al, 2011). Pakistan's construction industry is made up of several industries that supply materials for construction projects but, this business also produces a wide variety of material waste and is responsible for environmental damage (Arshad et al., 2018).

1.2 Construction Industry and Sustainability:

Urbanization, economic expansion, and exponential population growth have increased the need for infrastructure and services, resulting in a significant stockpile of construction and demolition (C&D) waste (Bose, 2022). The existing typical linear economy "take-make-consume-dispose" paradigm of production and consumption produces a lot of waste and is not environmentally sustainable. The cradle-to-grave method of manufacturing and consumption is the foundation of this concept, which suggests that things are made to be thrown away after use rather than repurposed or recycled. Such a strategy is incompatible with sustainable systems, which attempt to reduce waste and increase resource efficiency (Alonso-Muñoz et al., 2021).

Figure removed from digital version due to copyright.

Figure 1Linear and Circular Economy – Ref; (Macdonald, 2022).

Sustainable construction approaches are becoming increasingly vital as society places a greater emphasis on waste reduction and natural resource conservation. One such alternative is to employ recycled materials in construction and deconstruction, which has the potential to significantly reduce the environmental impact of the construction industry. Furthermore, the design of buildings and infrastructure may prioritize ease of deconstruction and material reuse, needing greater precision during construction. Simple building approaches can also help with deconstruction, increasing material reuse. By using these strategies, the construction industry

may be able to significantly increase the number of recovered materials that are reused, so contributing to a more sustainable future (Oxford Economics, 2022).

With the rising population of Pakistan and the lack of expertise and awareness within the construction industry, there is a significant issue of unsustainable resource usage. The country also faces challenges related to energy, water, and climate change. To address these challenges, the construction industry must prioritise the adaptation of sustainable approaches. To ensure the success of these initiatives, it is crucial to engage various stakeholders including researchers, architects, traders, engineers, and contractors. Furthermore, research focusing on construction and deconstruction management plays a pivotal role in promoting sustainability. It can provide valuable insights and offer a model for the key stakeholders in the industry to divert waste from landfills by identifying its economic value and exploring alternative applications (Amin et al., 2020).

1.3 The circular economy:

The definition provided by Ellen MacArthur Foundation explains that a circular economy is a strategic approach that promotes activities that prioritise durability, reuse, remanufacturing, and recycling to protect the value of energy, labour, and materials. This strategy promises that goods, components, and materials stay in the economy for periods, minimising waste and increasing resource efficiency (Ellen MacArthur Foundation, 2019). When shifting towards sustainable construction practices, the integration of circular economy principles extends the lifespan of construction materials, promotes their reuse, and minimises construction-related waste. By efficiently reusing materials repeatedly, further value is created.

The concept of circular economy emerged during the 1990s to tackle environmental change and address the global need for an ecological economy, however, the circular economy concept gained attention in 2002 when industry calls for the shift from a “cradle to grave” model to a “cradle to cradle” model to provide sustainable benefits to society through eliminating waste, efficient use of available resources and reuse wherever possible (Mrad & Frölén Ribeiro, 2022). Therefore, a circular economy is gaining popularity as a way of decreasing waste and supporting sustainable behaviours. This paradigm maximises resource use while minimising waste through reuse, recycling, and regeneration (Macdonald, 2022).

Manufactured from rich and diverse natural resources, clay bricks are a sustainable and long-lasting construction material. Bricks are capable of withstanding use for up to 150 years when created, engineered, and built with longevity in mind. Also, because of their versatility, they may be employed in a variety of projects to satisfy the varying demands of various customers, from facade renovations to extension projects. Using a circular economy strategy is essential nowadays to maximize the potential of resources. By reusing clay bricks for multiple generations instead of disposing of them after their initial use, waste is reduced, and sustainable practices are supported. This can be achieved through proper installation techniques and flexible building designs (Brick Sustainability Report, 2016).

1.4 Bricks Sector of Pakistan:

Whether it is a great wall of China, Turkey's famous Hagia Sofia, Poland's classic medieval Malbork castle, India's Taj Mahal, or New York's Chrysler skyscraper, all these icons have one thing in common, "Brick". In the 21st century, bricks have become an important construction element and builders preferred their usage in their infrastructure development (Fiala et al., 2019).

Pakistan's brick industry has a long history dating back to the early 1900s during the British colonial era. Following India's split in 1947, the industry enjoyed substantial expansion as Pakistan needed to rebuild its infrastructure and dwellings. The increased demand for new buildings and the necessity to repair old following the partition, increased output and growth of the brick kiln sector. As a result, the industry has played an important part in the country's economic growth and in meeting Pakistan's housing and infrastructure demands (Zahid, 2023). Bricks sector in Pakistan has a substantial brick kiln sector, with over 18,000 working kilns spread across the country. The investment in this industry amounted to USD 2 billion, resulting in an annual production output of up to 82.5 billion bricks, catering to the needs of the construction and related sectors. Moreover, this figure indicates that the brick kiln sector employs over 1.3 million people in Pakistan, according to the data that has been provided. 77% of these employees are men, with 23% being women, making up the majority therefore, a

sizable portion of Pakistan's population still relies on the business as a vital source of income (ICIMOD, 2018).

Pakistan is making efforts to achieve eco-friendly construction for all new buildings by 2025, with initiatives such as the Pakistan Green Building Code and the National Action Plan on Sustainable Consumption and Production. In Pakistan's ambitious effort to achieve eco-friendly construction for all new buildings by 2025, retrofits and renovations intended to modernize brick masonry structures can play a crucial role. Another way to advance Pakistan's sustainable development goals is to promote the use of locally sourced and environmentally friendly materials in the construction of new brick masonry structures. Moreover, by promoting sustainable design and planning, the production of carbon-neutral or negative materials, emerging construction technologies, and lower greenhouse gas emissions, the Green Building Code (GBC) supports Pakistan's commitment to reducing its carbon emissions and achieving the Sustainable Development Goals (SDGs) outlined in the UN 2030 Agenda. This goal is in line with SDGs 11, 12, and 13 and supports the National Action Plan on Sustainability (Khan et al., 2016).

1.5 Reclaimed bricks:

According to the Oxford Dictionary, the term "reclaim" refers to the process of obtaining materials from waste products or materials, enabling them to be reused (Oxford Dictionaries). In a similar context, reclaim or reclaimed brick is classified as something that has been used before but after obtaining from the deconstructed site it will be repurposed for another project for instance; a house, building, bridge, or any other civil infrastructure that employs bricks in its construction design. According to McMahon (2023), bricks sourced primarily from renovated or demolished buildings provide a sustainable choice for construction projects. Construction workers manually save the bricks for possible reuse rather than discarding them, however, such bricks may also be saved for future projects with the use of proper demolition methods. The reclaimed bricks can be sold to traders or businesses that specialize in buying and reselling such construction materials. Subsequently, these materials can be made available to builders or the public, offering affordable options for construction projects. These bricks are a practical choice for ecologically aware construction methods since they may decrease construction waste and improve sustainability (McMahon, 2023).

1.6 Problem discussion

1.6.1 Construction-related emission:

The construction industry is confronted with challenges such as low productivity growth rates and environmental impact. However, it also has a critical role to play in achieving the Sustainable Development Goals (SDGs) set forth by the United Nations in 2015. However, the built environment is responsible for 40% of worldwide CO2 emissions. Building activities account for 27% of these yearly emissions, with the remaining 13% generated by materials and construction methods used in building and infrastructure development, also known as embedded carbon (IEA, 2022). Therefore, the construction industry has a significant impact on the environment.

Three key materials - concrete, steel, and aluminium - are accountable for 23% of the total global emissions, with a significant portion being utilized in the built environment. This highlights a significant opportunity for reducing embodied carbon in these high-impact materials through various means such as policy implementation, thoughtful design practices, careful material selection, and meticulous specification. Compared to these materials, reclaimed brick generally has lower carbon dioxide (Co2) emissions. Concrete production is known to be a significant contributor to Co2 emissions due to the energy-intensive process of cement production and the release of Co2 during its manufacturing. On the other hand, reclaimed brick involves reusing existing materials, which reduces the need for new products and therefore lowers the associated Co2 emissions, (IEA, 2022).

In the case of South Asia, including countries such as Pakistan, India, Bangladesh, and Sri Lanka, the construction industry also makes a substantial contribution to CO2 emissions. South Asia's brick industry, which accounts for more than a quarter of all bricks manufactured globally, emits more than 130 million tons of CO2 into the atmosphere each year. The region's primary traditional kiln methods, fixed chimney bulls' trench and zigzag kilns have been proven to be inefficient, burning huge amounts of low-quality coal while generating fewer bricks. These difficulties highlight the need for more eco-friendly and sustainable brick production processes to improve economic and environmental sustainability in Pakistan and other developing nations facing similar challenges (Lodi et al., 2013).

1.6.2 Brick kilns emission in Pakistan:

Brick masonry building is the most common construction style in Pakistan, accounting for 62.38% of the total built environment. The approach ranges from traditional one-story infrastructure seen in rural regions to modern three-story buildings found in cities. For more than a century, brick masonry has been the primary construction technology in Pakistan, and it is still frequently used for new building construction throughout the nation. This type of construction is common in rural, suburban, and urban regions, and it accounts for a sizable share of total construction activity in Pakistan (Lodi et al., 2013).

Pakistan is one of the emerging countries facing considerable issues in the brick sector's sustainability. Pakistan, the world's third-largest brick manufacturer after China and India, produces approximately 70 billion bricks per year, accounting for 3% of worldwide brick output. The sector has about 16,000 operating units that employ over 500,000 people and generate annual sales of more than $6 billion US dollars. Unfortunately, over 99% of Pakistan's brick facilities and kilns are about a century old and use inefficient and antiquated methods thus the Co2 emissions are high during the manufacturing process, with single facilities emitting between 5,700 to 14,000 Co2 emissions tons per year (Rauf et al., 2022).

Despite such environmental impacts, bricks are a prominent building material with a thriving market in Pakistan. But conventional brick manufacturing processes produce huge quantities of waste, surplus clay, broken or deformed bricks and unusable or extra bricks that are examples of this waste. Another, primary reason for brick waste in Pakistan is a lack of effective environmental rules and enforcement, brick kilns operate illegally and are rarely held accountable for waste management policies. As a result, brick waste is disposed of indiscriminately, contributing to environmental degradation and health risks for local people.

Several countries utilize conventional brick production methods that are outdated and inefficient, resulting in the release of short-lived chemical pollutants such as black carbon, undermining the accomplishment of many of the United Nations' Sustainable Development Goals (SDGs) by 2030. In Pakistan, the brick kiln industry consumes about half of the country's coal production. The lack of a reliable emission inventory, along with an ongoing rise in these emissions, exacerbates the problem. Furthermore, because of the decentralized system of this business, it is critical to create sustainable solutions to address the environmental and health-

related concerns that it presents. These issues are urgent and require quick responses from stakeholders to reduce the detrimental impact on human health and the environment (Rauf et al., 2022).

1.6.3 Bricks waste in Pakistan:

According to the study's findings, waste generation rates for various building materials, including bricks (2%–12%), wood (2%–15%), and PCC (1%–10%), vary significantly. The variation in Construction related waste creation can be partly related to variations in technology and building methods employed by different contractors. According to the research, bricks waste more than any other material on average (6.82%), followed by tiles (6.68%) and plaster made from mortar (6.63%). The least wasteful materials, however, are diesel (2.34%), water-proofers (2.61%), and anti-termites (2.92%). These results, which were published by Arshad et al. (2018), highlight the significance of comprehending the variables that influence waste output in the construction industry. These characteristics may be used to guide methods to reduce material waste and improve resource efficiency in building projects, resulting in economic and environmental advantages. (Arshad et al., 2018).

Materials	% Waste	Rank	Materials	% Waste	Rank
Bricks	6.82	1	Aluminium	4.74	14
Tiles	6.68	2	Plain cement concrete	4.39	15
Plaster from mortar	6.63	3	Marble	4.37	16
Wood	6.41	4	Ceiling boards	4.32	17
Paints	6.00	5	Bitumen	4.29	18
Ceramics	5.51	6	Natural Rocks	4.14	19
Wires and cables	5.34	7	Steel railings	4.00	20
Reinforced cement concrete	5.16	8	Metals	3.61	21
Thermopore sheets	5.16	9	Mild steel GI pipes	3.57	22
Plastic pipes	4.95	10	Mild steel sections	3.41	23
Glass	4.92	11	Anti-termites	2.92	24
Polythene sheets	4.89	12	Water proofers	2.61	25
Steel rebars	4.76	13	Diesel	2.34	26

Figure 2 Results for material wastage and ranking on Pakistani sites - (Arshad et al., 2018).

According to Arshad et al. (2018), bricks, paints, plaster made of mortar, and tiles are the four main building materials that are used in most construction projects. The results of a comparative analysis of these top construction materials depending on building kinds are shown in the below figure. The findings highlight the need for a more sustainable approach to building material utilization, which has substantial consequences for the construction industry. Industry experts may create strategies to decrease waste creation, reduce resource consumption, and improve economic and environmental sustainability by knowing the relative wastefulness of various construction materials (Arshad et al., 2018).

Figure removed from digital version due to copyright.

Figure 3 Materials with High-Valued Wastage on Pakistani Sites - (Arshad et al., 2018)

According to findings of Danish SME, Gamle Mursten in its REBRICK project, in comparison to new bricks, each reused brick saves 0.5 kilos of Co2 emissions. As an example, a one-family house requires 16,000 bricks, saving around 8 tonnes of Co2 (Mursten, 2014). To sum up, this problem statement aimed to highlight the environmental impact of brick manufacturing and brick waste due to factors including carbon emissions, resource consumption, landfills, and excessive energy use.

1.6.4 Urbanization:

Urban migration has become a prevalent phenomenon in both developed countries as individuals seek improved access to essential amenities such as quality of life, healthcare,

education, employment, and more. Urban migration also brings several challenges with it for instance: overcrowding, housing shortage, limited resources, and competition for job opportunities. According to UNDP, Pakistan has the highest pace of urbanization in South Asia, with 36.4% of its population living in cities and by 2025, about half of the country's population will relocate to urban areas (Artaza, 2019). Thus, such urbanization has become a major challenge in Pakistan as a developing nation where fulfilling basic social needs is a serious issue (Khan & Majeed, 2022). Urbanization has boosted the demand for resources or construction materials, which has driven industrial development (Bronitsky & Wallace, 1974).

1.6.5 Housing:

With the significant rise in global housing demand in recent years, there has been rising worry about the global housing problem. A lack of available homes concerning the strong demand indicates the status of the housing sector and it is predicted that. by the end of the twenty-first century, two billion homes must be constructed to satisfy the world's housing needs. Housing affordability is another concern which is still increasing due to the limited land availability, resources scarcity and high construction costs (Kedir & Hall, 2021). Similarly, rapid urbanization has resulted in a rise in construction activity and waste generation, leading to the build-up of anthropogenic resources in metropolitan regions of Pakistan. This is a dilemma for Pakistan's metropolitan centres, where there is a significant housing scarcity owing to population expansion, urbanization, and degradation of existing homes. The housing gap in Punjab province, the most populated province, was predicted to be approximately 2.3 million units in 2017 and is expected to climb to 11.3 million units by 2047. (Zaheer et al., 2022). Overall, with a need for 500,000 new housing units per year but only 200,000 available this results in a yearly 300,000 units shortage on top of the existing deficit of 10 million housing units (Khan et al., 2016).

The predicted growth of the housing shortage is to grow over the next decade, the available alternative housing options are often of low quality, and overcrowding is common in "Katchi Abadis," or informal communities. (UN Habitat, Pakistan, 2018). The cost of housing in Pakistan has risen significantly due to the economic crisis, inflationary trends in material costs, government taxation measures and the country's reliance on imported construction supplies (UN-Habitat, Pakistan, 2018). The housing industry, including its institutions, rules, and regulations, has a significant impact on every aspect of a country's economy and interacts with

almost every sector of social development. People who live in proper housing have better health and more opportunities to improve their skills and make use of urban services. Simultaneously, a strong housing sector works as a development catalyst, improving associated businesses, promoting economic growth, creating jobs, improving service delivery, and eventually lowering poverty levels (UN-Habitat, 2018). The process of urbanization in Pakistan has led to a scarcity of affordable housing and economic challenges that have had a detrimental effect on the social sustainability of the country. It has made it difficult for people and communities to attain resources. Therefore, this needs to be addressed through a sustainable approach in the construction industry.

1.6.6 Labour challenges in brick kilns:

Factors such as large population, limited job opportunities, and inadequate access to economic aid, contribute to poverty, which is a serious issue in many nations. In Pakistan, unskilled workers are frequently underpaid and overworked without receiving supplemental compensation (Awan, 2019). Employers take advantage of the high unemployment rate and lack of economic streams to exploit workers. The brick industry is an important source of income for many families, particularly for child labour who often work in hazardous environments, resulting in workers living in unfavoured circumstances. The lack of fundamental necessities can have a negative influence on people's ability to perform successfully in life, thus affecting functioning within society. Brick kiln workers often live in poverty and thus remain trapped in bonded labour, despite working with their distinctive traditions, values, and ambitions. Such workers receive minimal pay and are controlled by those who provide their essential needs. Consequently, kiln workers and their families are isolated from mainstream Pakistani society (Niaz et al., 2017).

1.7 Research background:

As outlined in the problem statement, the manufacturing of bricks in Pakistan faces several challenges. These include the generation of a substantial amount of brick waste, and high CO2 emissions, with the brick sector alone accounting for over 130 million tons of CO2 emissions annually, largely attributed to coal usage. Urbanization presents additional challenges, with an anticipated migration of approximately half of Pakistan's population to major cities by 2025, resulting in a significant housing shortage and substandard housing in informal settlements or

slums. Furthermore, the rising cost of construction materials due to inflationary trends and economic challenges has led to labour exploitation. To address these challenges, the primary objective of this study is to investigate alternative construction materials as a sustainable solution to the issues associated with brick manufacturing. By doing so, it aims to promote overall sustainability in the construction industry. The focus is on the reuse of existing brick inventory within the built environment, which can create job opportunities, ensure safe working conditions for workers, and provide a cost-efficient construction resource to meet the housing demand driven by urbanization. This study specifically investigates the use of reclaimed bricks as sustainable construction material considering its environmental, social, and economic aspects.

1.8 Research Objectives:

- Assessing the environmental, social, and economic significance of reclaimed bricks in sustainable construction practices.
- Exploring the potential of reclaimed bricks as sustainable and resource-efficient material within the circular construction industry.

1.9 Research Questions:

The theoretical framework and the research questions of the study are interconnected in the thesis. The research problems and the theoretical framework of the study are interconnected and mutually supportive. This synergy expands the overall framework of the study. The key concepts within the theoretical framework must align with the primary research question and any supplementary research questions, as emphasized by Grant and Osanloo, (2014). Keeping this in mind, the following research questions were generated by considering the theoretical background. RQ1 emerged from the Triple Bottom Line (TBL) theory and RQ2 emerged from the resource efficiency concept:

- **RQ1:** How does the use of reclaimed bricks in construction projects promote environmental, social, and economic sustainability?
- **RQ2:** In what ways can reclaimed bricks be a sustainable and resource-efficient material for the circular construction industry?

1.10 Conceptual framework of the study:

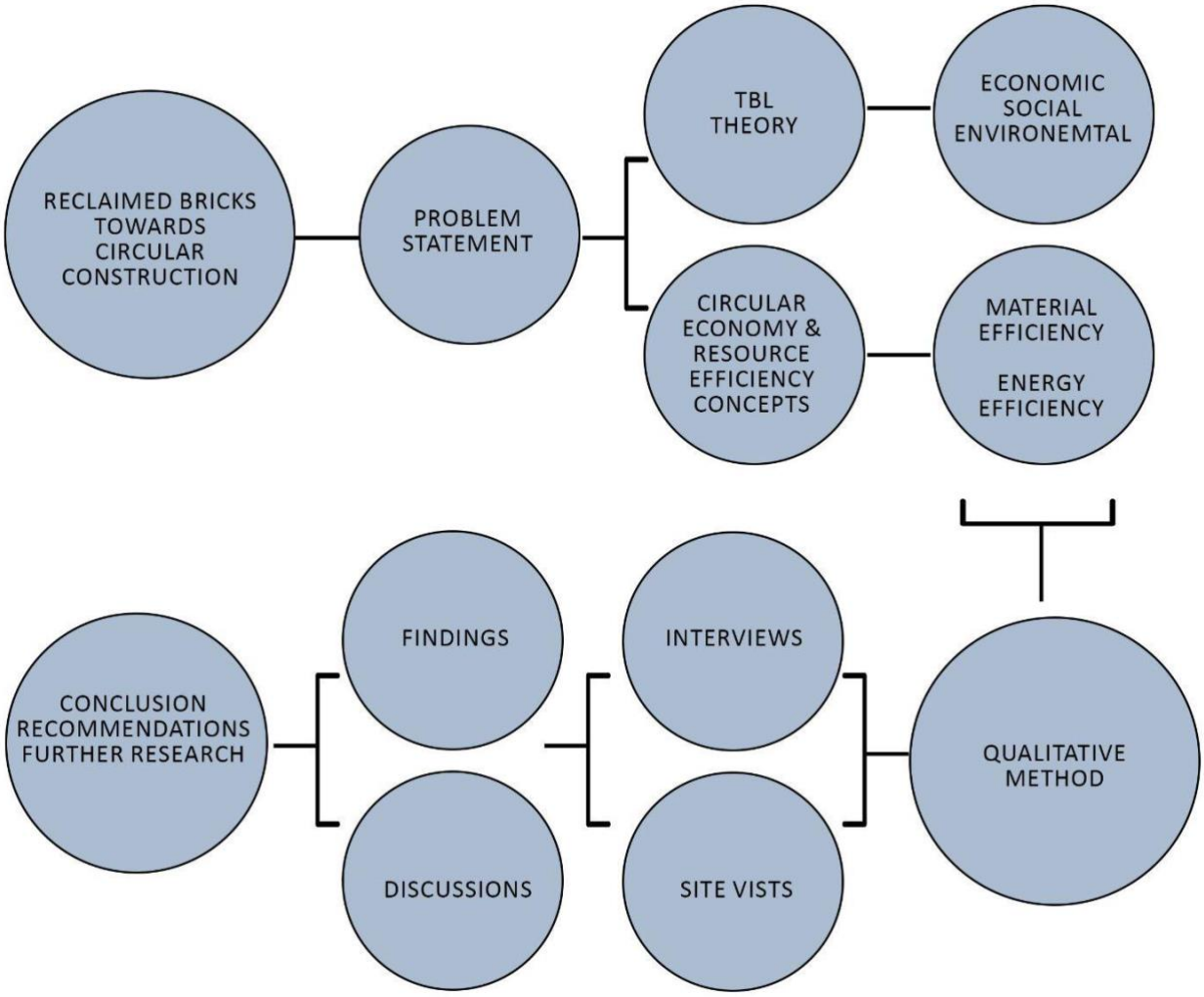

Figure 4 Conceptual framework – Ref; Author

The study's conceptual framework considers the problem statement, the Triple Bottom Line (TBL) theory, the Circular Economy and Resource Efficiency model, and the concepts of material and energy efficiency. It explores the utilization of reclaimed bricks to promote a circular economy (CE) in Pakistan's construction industry. The problem statement emphasizes the need to address resource depletion and waste generation in construction. The TBL theory is incorporated into the framework to incorporate the significance of social, environmental, and economic factors in pursuing sustainability objectives.

The framework's primary element, the Circular Economy and Resource Efficiency model

emphasizes the transition to a more sustainable and regenerative approach to resource management. This model emphasizes the need to optimize resource utilization and lower waste generation in the construction sector by especially relating it to material efficiency and energy efficiency. The framework also includes the qualitative research approach used for the study, which included site visits and interviews to gather data. This technique assisted in the collection of first-hand information and insights about the use of reclaimed materials and their contribution to circular economy activities.

The findings and discussion gained from primary data gathering are included in the framework, offering a deeper understanding of the constraints and opportunities associated with the use of reclaimed bricks in the context of Pakistan's building sector. The structure also contains a conclusion, which summarizes the study's significant results and conclusions. Recommendations are presented to assist stakeholders in efficiently embracing circular economy principles and taking advantage of reclaimed bricks. Finally, the framework proposes subjects for future study to further knowledge and understanding of circular economy techniques and their implementation in the construction sector.

Chapter 2
Theoretical Background

The primary objective of this study is to explore the potential utilization of reclaimed bricks to promote the principles of circular economy (CE) in Pakistan. To understand the role of reclaimed bricks as a sustainable construction resource, it is crucial to develop a theoretical background that provides a holistic understanding of the brick sector within the construction industry. Goh et al., (2020) conducted a study on the trends and current state of the "Triple Bottom Line" (TBL) theory and found that the adoption of sustainable construction practices was little in developing nations. Integrating sustainability into consideration faces various challenges. The research highlighted that there is a knowledge gap in defining sustainability, leading to uncertainty, and hindering implementation (Goh et al., 2020).

This study integrates the Triple Bottom Line (TBL) theory further to bridge the knowledge gap and develop a comprehensive understanding of sustainable construction by utilizing reclaimed bricks and their potential. It aims to create a theoretical framework that can effectively organize literature, collect data, present the findings, and discuss in a structured manner.

2.1 Triple Bottom Line (TBL) theory:

The United Nations (UN) is addressing sustainability through the Sustainable Development Goals (SDGs) which include, environmental, economic, and social aspects of sustainability (Schützenhofer et al., 2022). An industry that meets the present economic, social, and environmental requirements without causing harm to future generations is more likely to attract investors and consumers, thereby contributing to the company's overall success. There are global drivers and compelling motivations for the adoption of sustainable business practices, yet the full potential for creating long-term value through sustainability is not being realized (Høgevold et al., 2015).

In the mid-1990s, the management think-tank 'AccountAbility' developed the idea of the Triple Bottom Line (TBL). The TBL framework emphasises that organizational success and well-being should be assessed based on its impact on social and ethical concerns as well as the environment, in addition to its economic performance. In other words, the TBL paradigm acknowledges the significance of considering not just economic gains but also social and environmental considerations when evaluating a company's total success (Norman & MacDonald, 2004). The goal of sustainable construction is to achieve a balance between social,

environmental, and economic sustainability. The goal of environmental sustainability is to reduce the negative impact of construction on the environment. While economic sustainability is concerned with profits for stakeholders involved in the project and social sustainability analyses societal growth. The Triple Bottom Line (TBL) theory can help the construction industry to achieve its sustainability objectives by setting guided principles (Goh et al., 2020). Concerning reclaimed bricks, the Triple Bottom Line (TBL) theory provides an understanding of their utilization by emphasizing the environmental and social impact of such construction projects, in addition to economic benefits.

Figure removed from digital version due to copyright.

Figure 5 Triple Bottom Line (TBL) theory - Ref; (Lodi et al., 2013).

2.2 The Economic Perspective:

The economic pillar of sustainability relates to a company's ability to make profits, ensure its existence, and contribute to the local and global economies. Simply put, this aspect of sustainability refers to how businesses maintain their existence in the economic sector (Høgevold et al., 2015). The construction industry is vital to the economy, integrated economic factor refers to considering total expenses and balancing the demands of sustainability during

construction processes. For long-term cost-effectiveness, it is critical to examine the balance of all three pillars of sustainability when evaluating the economic worth of construction projects. The advantages of building projects are extended beyond completion and profit by using this integrated strategy, reaching society, and helping the people who utilize them (Goh et al., 2020). If the construction materials are less expensive, the cost of the overall construction project could be reduced. This can provide benefits to builders, consumers and those who face housing affordability challenges due to the rising cost and inflationary trends. Additionally, reusing construction materials can make the construction industry more economically feasible, opening new business opportunities, creating jobs, and supporting the economic growth of the local community.

The economic component of the TBL theory overall focuses on the financial aspects of an organization's operations. It involves assessing the organization's profitability, revenue generation, cost management, and overall economic impact. The goal is to ensure that the organization is economically viable and contributes to sustainable economic development. The economic perspective of the TBL theory has been explained in the theoretical framework through the following components involved in the construction:

- Entrepreneurial alertness
- Sustainable business model
- Job opportunities
- Transportation economic

2.2.1 Entrepreneurial alertness:

An entrepreneurial focus is essential in spotting opportunities even when they are not actively explored. Entrepreneurs with sophisticated and flexible thinking and high mental capacities have been discovered to have a substantial effect on industrial and social environments. A growing trend in sustainable entrepreneurship stresses thinking about sustainability in terms other than personal economic benefit. Sustainable entrepreneurs may have a different emphasis on their surroundings than those that are purely motivated by commercial motives. However, prior knowledge is important in identifying opportunities and determining how they are acknowledged, as having more entrepreneurial expertise increases the likelihood of discovering possibilities. Furthermore, entrepreneurs are more likely to discover important possibilities that can have a good influence on the environment when they analyse the

economic, environmental, and social components of their immediate environment (Piispanen et al., 2022).

2.2.2 Sustainable Business Model:

The main objective of incorporating a circular business model (CBM) is to produce and capture value while also attempting to reuse the resources as efficiently as possible. However, the conventional business model is based on making a profit via the sale of products through the flow of resources, materials, and products across time, but CBM emphasises including existing resources, recycled and reused products in that flow of resources, materials, and products as well (Lahti et al., 2018). The significance of evaluating the potential of sustainability in circular business models could be based on four stages for instance: identifying potential sustainability advantages, examining the economic viability, evaluating the environmental effect, and analysing the social consequences (Averina et al., (2021).

Transitioning to a circular economy (CE) requires significant changes in the underlying value-generating mechanism as well as the current linear business models used by both large and small businesses. Circular business methods play a vital role in facilitating the shift from a linear economy to a circular economy by harnessing the economic value remaining in products after their initial use to create new offerings. These models integrate essential elements of a circular economy into business operations and encourage the adoption of circular practices such as designing for reuse, resilience, reliance on renewable energy sources, adopting systems thinking approaches, fostering shared economies, and promoting industrial symbiosis (Guerra et al., 2021). Lahti et al., (2018) argued that companies that practise circular business models to solve sustainability problems suffer a great deal of uncertainty since customer behaviours and wants are still unknown, and there is no defined value chain or delivery system. Therefore, if companies can navigate this uncertainty, they stand a good chance of establishing themselves in the market and becoming profitable in the long run. However, overcoming the challenges of this uncertain environment may necessitate a significant amount of experimentation and research.

The early adopters who are establishing the way for circularity are promoting the acceptance of Circular Economy (CE) concepts in the construction industry. The most viable parts of CE implementation are waste as a resource, resource recovery, and circular supplies. These circular

business models are straightforward to grasp, allowing the construction industry to quickly embrace them. However, opportunities for early adopters remain in regions where CE is still in its infancy, such as South America, Asia, Africa, and Australia. While larger enterprises usually employ their resources and flexibility to seek new prospects through parallel operations, smaller and younger businesses are more likely to adopt CE principles (Guerra et al., 2021).

2.2.3 Job opportunities:

In regions with significant unemployment and vacancy rates, building deconstruction can have a good social, economic, and environmental impact. A local storehouse for salvaged building materials can maximise these advantages by assessing market potential, determining supply and demand, and functioning as a hub for salvaged objects, home repair instruction, and social contact.

Structural demolition offers employment opportunities in production, warehousing, and transportation. This strategy provides a practical technique that develops employment opportunities for people who are having difficulty finding work, such as those with limited work experience, disabilities, or criminal records. Furthermore, the financial benefits of deconstruction are enhanced by the sale of building components and products with value-added qualities. This strategy helps to waste elimination and neighbourhood transformation by providing opportunities for workforce development collaborations, training for builders and employees, and the use of locally recycled materials in historic building repairs and upkeep. Because of these advantages, deconstruction is a morally sound and practical alternative for underprivileged communities (Delta Institute, 2018).

With the context of circular economy:

The Circular Economy aims to enhance economic value through improved resource efficiency and increased labour, thereby offering the potential for creating new job opportunities while mitigating structural unemployment. This could be accomplished by developing the remanufacturing and repair sector, particularly in high-unemployment areas. Workers displaced from conventional manufacturing may find other employment opportunities in these fields. The overall, increasing emphasis on reuse, repair and recycling in a circular economy can contribute to employment creation and more sustainable economic practices. The

development of a circular economy across Europe especially has the potential to open a variety of work possibilities in various nations and areas such as in South Asia. It's important to measure the economic advantages of a more circular economy using several measures to fully misuse this potential. However, it could be inaccurate to represent the economic benefits of a more circular economy by concentrating primarily on indices of labour productivity and disregarding indications of material resource productivity. Therefore, it's important to appreciate the probability of diverse circular business models to support economic growth, employment, and social well-being by considering material productivity measures in addition to other indicators (Drakulevski & Boshkov, 2019).

It would be feasible for circular construction to utilize alternative demolition practices for end-of-life buildings such as selective demolitions which would be less automated and more human therefore, it would create job opportunities for the people, Shashi et al. (2023). In summary, the deconstruction of buildings and circular economy strategies might lead to the creation of new jobs while also supporting waste reduction and environmental protection. Utilizing bricks from de-constructed structures is a great example of a circular economy strategy that could increase sustainability and job prospects in nations with higher unemployment and poverty rates like Pakistan. This manual deconstruction procedure not only creates employment prospects for individuals with little formal education or work experience, but also makes supervisory, sales, and transportation positions available to those with the qualifications. Additionally, the less expensive cost of reclaimed bricks might boost demand and create additional employment possibilities in the industry. In general, building deconstruction and circular economy activities could provide a path towards environmentally responsible economic and social growth (Shashi et al, 2023).

2.2.4 Transportation Economics:

Transportation is an important component of construction logistics, accounting for more than half of overall logistics expenditures. While transportation expenses can account for up to two-thirds of total expenditures, this does not always imply that it is the most responsible for negative consequences. However, because building supplies are often low-cost and high-volume in comparison to other sectors, transportation may account for more than half of total construction logistics expenses. Materials generally account for 30-50% of the entire cost of a construction project, with transportation expenses accounting for 39-58% of total logistics

costs and 4-10% of the selling price of the structure. Another estimate says that transportation expenses might account for 10% to 20% of total building costs (Dhawan et al., 2022).

2.3 The Environmental Perspective:

Businesses have developed environmental management systems (EMSs), which are globally renowned and have received industry certification, to handle the assessment of their environmental performance within the context of the Triple Bottom Line (TBL). The development, implementation, and communication of environmental policies, the setting of goals and targets for minimizing environmental consequences, and the tracking of progress toward these goals are all made easier by these systems (Høgevold et al., 2015). Conventional bricks are burned using either the clamp technique or the furnace method. In clamp burning, a pile of green blocks and fuel is covered with clay and gently heated to a high temperature. Modern permanent constructions with numerous compartments are employed in kiln burning. The compartments are used to arrange the moulded clay as it is gently dried, burned, and chilled. The procedure, which is carried out sporadically in discontinuous kilns or cyclically in continuous kilns, can take up to two weeks (Padhi, 2015). However, brick kilns are the primary contributors to pollution and harmful gas pollutants in the brick-making industry, one of the sectors with the quickest rate of growth in the world. The use of heavy oils or coal as fuel in machines and furnaces contributes significantly to direct emissions of CO2, CO, CL2, NH3, SO2, NO, HCN, and fluorine are released when bricks are fired. These pollutants differ based on the type of kiln, firing duration, technology, and fuel (Dabaieh et al., 2020).

According to the Brick development association, (2023) report on the circular economy on material, carbon emissions connected with the product lifespan of a half-brick-thick cavity wall may be divided into phases and quantified in kilos of CO2 per tonne. Reuse and recycling result in 16.0 kg of CO2 emissions per tonne, a 7% decrease. This suggests that utilizing reused and recycled products can greatly reduce one's carbon footprint. The end-of-life stage, which includes deconstruction and processing, accounts for 2% of emissions, or 4.5 kg CO2 per tonne. Moreover, carbon emissions exceed 5% during the construction phase, which includes mortar consumption and waste, equating to 11.5 kg of CO2 per tonne. Distribution contributes 3% of total emissions, resulting in 8.0 kg of CO2 per tonne. However, the raw materials and production stage is the major contributor to carbon emissions, accounting for 90% of total

emissions. This step alone produces 213.0 kg of CO2 per tonne of product (Brick development association, 2023).

Figure removed from digital version due to copyright.

Figure 6 Carbon Emission over product lifecycle – Ref; (Brick development association, 2023).

These statistics from prior studies give an overview of the carbon emissions related to each step of the product lifecycle for a cavity wall that is half a brick thick. It emphasises how crucial it is to consider recycling and reusing techniques to reduce emissions and advance sustainability in the construction industry. The entire environmental footprint of construction components may be significantly reduced by making efforts to limit carbon emissions at the raw material and manufacturing stages.

2.3.1 Construction transportation:

The construction industry exhibits slow productivity growth and negative environmental impacts, necessitating its active involvement in achieving the Sustainable Development Goals (SDGs) set by the United Nations in 2015. Construction logistics present valuable opportunities to enhance both productivity and sustainability within the industry. At a construction site, three primary streams of incoming resources are observed: materials, equipment, and labour.

Simultaneously, two streams of outgoing resources can be identified: waste and excavated materials. The movement of these resources is facilitated by various transport vehicles, forming the transportation pattern of the site. Analysing construction transport involves considering various project types and materials, as different projects utilize distinct materials and require specific vehicles and load carriers. Nevertheless, irrespective of the project type, most housebuilding projects exhibit a consistent pattern of material flow that aligns with different project phases. If not properly managed, logistics activities associated with construction can lead to significant environmental damage. The impact of transportation in construction is substantial, with Guerlain et al. (2019) stating that it contributes to at least 30% of urban goods transport. However, there is ongoing debate regarding the specific figures concerning projects. Seo et al. (2016) suggest that construction transport is responsible for 2.4%–5.5% of CO2 emissions, whereas Chang and Kendall (2011) argue that materials transport alone accounts for 16% of total project emissions.

A study based on the Western Desert region explored that during brick manufacturing operations raw material transportation has a substantial influence on carbon emissions. Transporting raw goods and services in necessitates a significant amount of energy and transportation of labourers to and from brick kiln sites consumes a significant amount of energy, ranging from 10 to 80% (Dabaieh et al., 2020). However, to properly address these environmental concerns, it is critical to understand the complexities of construction, which involves several parties with varying goals (Fredriksson & Huge-Brodin, 2022).

In the context of sustainable transportation, "greening" refers to efforts that try to minimize vehicle emissions while also enhancing technology. It extends beyond technology, though, and includes rethinking systems to use less energy and resources while emitting fewer pollutants, all while increasing general well-being. Greening techniques for freight transportation involve increasing energy efficiency through technical, operational, and behavioural factors. Switching to cleaner fuels like electricity or alternative fuels, as well as resolving traffic congestion by modifying supply schedules and improving transportation planning, may all help to reduce fuel use and emissions. Another consideration is maintaining the ideal capacity and usage of freight transport vehicles, preventing both under- and over-loading, both of which can influence fuel economy and pollution levels. Finally, energy efficiency, which is determined by the distance travelled about the amount of energy spent, is affected by vehicle attributes, driving style, and

traffic circumstances. Greening freight transportation in general tries to make it more environmentally friendly and sustainable (Dhawan et al., 2022).

Furthermore, the establishment of sustainable logistics systems plays a crucial role in realizing the goals of the Circular Economy (CE). One of the key objectives of the CE is to achieve a closed loop in material and resource flows throughout the life cycles of products. This concept aligns closely with the commonly used term "closed loop," emphasizing the importance of minimizing waste and maximizing resource efficiency. According to Sassi (2008), the ideal scenario would be for materials to be extracted from structures and reused or repurposed in construction or other industries, with no waste generated. For materials, this is known as the closed-loop cycle (Sassi, 2008).

2.4 The Social Perspective:

The social pillar of sustainability is less well-defined and involves a variety of factors such as society, culture, and community. The dynamics of social relationships, behavioural patterns, and individual beliefs are crucial to social sustainability. The term corporate social responsibility (CSR) originated to describe an organization's social actions, although its meaning varies depending on whom you ask. Measuring an organization's social performance could involve actions such as contributions or safety precautions, as well as wider ideas such as “strategic philanthropy or corporate citizenship” (Høgevold et al., 2015).

Social sustainability considerations are extremely important in sustainable construction projects. Several elements serve as reference points for addressing sustainability challenges and meeting the demands of diverse stakeholders for instance, Health issues include providing clean water, sufficient sanitation, and a safe atmosphere (Kamaruddin et al., 2020).

Brick making is physically hard and hazardous to their health. Exposure to burning fuel and furnace gases is widespread, resulting in burns, back injuries, and respiratory problems. Chimney filters are seldom employed in the area's companies, which not only destroys the environment but also threatens the health of workers and communities nearby. Worker deaths have also been recorded because of workers losing their balance owing to heat stress and falling into fire pits or ovens in blazing furnaces (Dabaieh et al., 2020). Furthermore, social sustainability is centred around upholding human rights, which entails ensuring a safe working

environment, fair wages, and eradicating child labour. Educational initiatives are also implemented to enhance workers' understanding and awareness of innovative construction practices. Security measures prioritize the safety of workers and the surrounding community. The preservation of culture and traditions is valued, while integrity is upheld through adherence to anti-corruption regulations. Accessibility efforts aim to make construction sites more easily reachable. Stakeholder participation is encouraged to foster effective communication and collaboration throughout the construction process. By considering these social sustainability considerations, construction projects may solve social challenges, increase community well-being, and achieve long-term sustainability (Kamaruddin et al., 2020).

2.5 Construction resources and efficiency:

Global demand for resources and raw materials has increased in recent years, with projections showing that demand will double by 2060. This spike in demand has generated worries about limited resources and led studies to determine the criticality of certain resources (Yavor et al., 2021). The construction industry, in particular, contributes significantly to this resource consumption, accounting for about 30% of natural resource extraction and 25% of worldwide solid waste creation (Fritz Benachio, Freitas, & Tavares, 2020; Kedir & Hall, 2021).

The construction sector consumes a significant percentage of these resources, with data stating that the industry accounts for 40% of worldwide consumption of raw stones, gravel, and sand, as well as 25% of yearly virgin wood usage (Worldwatch Institute, as quoted in Kedir & Hall, 2021). While resource consumption has decreased over time, the environmental effect remains considerable with the sector using more than 40% of resources in the 1990s and today standing at around 32% (Rees, 1999; Yeheyis et al., 2013). The construction industry generates a quarter of worldwide solid waste, and in developing nations like Brazil, waste levels from the construction industry can surpass 60% (ABRELPE, 2018). Construction and demolition (C&D) waste is generated throughout the life cycle of a structure, with most of the waste generated near the end of its life accounting for 50% of total waste (Kibert, 2008). This waste is generally the result of the disposal of building materials that cannot be reused (Akanbi et al., 2018). The industry's linear business paradigm of "take, make, dispose of" complicates the problem by discouraging deconstruction and resulting in materials being disposed of in landfills or incinerated (Esa et al., 2016; Mangialardo & Micelli, 2018).

Concrete, sand, gravel, crushed rock, metals, and bricks are significantly used in the building industry, accounting for a large portion of worldwide material use. Concrete, bulk materials, and bricks account for 90% of the weight of all materials used in the building sector (Hopkinson et al., 2019). This considerable material use, however, comes with a substantial environmental cost. The construction industry accounts for roughly 50% of carbon emissions, 20-50% of natural resource use, and 50% of total solid waste, indicating its enormous environmental impact (Vasilca et al., 2021). The accumulation of anthropogenic materials in metropolitan areas because of mining and construction operations must be recognised. Humans have exploited and collected more than 80% of the world's natural resources above ground in just three centuries, highlighting the critical need for sustainable resource management techniques (Aldebei & Dombi, 2021). Global priorities, as stressed by the fourth United Nations Environment Assembly in 2019, including decreasing the environmental impacts of soil and mining activities and transforming the construction industry to a more sustainable and resource-efficient circular economy (Torres et al., 2021).

Overall, the construction industry's resource consumption, waste generation, and environmental effect pose substantial concerns. To address these difficulties and ensure equitable and balanced utilization of resources for current and future generations, it is critical to embrace sustainable practices, enhance resource efficiency, and shift to a circular economy.

2.6 Resource efficiency:

Resource efficiency concept can be defined by using several indicators, every indicator has a specific meaning that comprises certain aspects of the issues. Energy efficiency in constructions and products has gained substantial attention in recent years, leading to notable advances. However, there is currently an increasing interest in addressing other areas of material efficiency as well, including raw material supply and consumption, waste management, and reuse. These concerns are linked and should be tackled holistically, considering the complete life cycle of products and buildings (Ruuska & Häkkinen, 2014). The following formula was suggested by Mathieux, (2016) to holistically evaluate the resource efficiency of a product or industry:

(Energy - Efficiency + Material - Efficiency) = Resource - Efficiency

Energy efficiency assists the state by conserving resources, increasing industrial output, and strengthening competitiveness. It also helps to protect the environment by lowering greenhouse gas emissions, and it saves the population money. Any attempt produced to lower the quantity of energy utilized without jeopardizing its original function is referred to as energy saving. Energy efficiency, on the other hand, entails utilising energy resources wisely and optimally. Energy efficiency in construction refers to utilizing less energy to provide the same amount of energy supply for structures or manufacturing operations (Gabitov et al., 2020). On the other hand, the importance of material efficiency and the requirement for its improvement may be considered from a variety of perspectives. An insufficient supply or shortage of resources can cause economic threats, while the manufacturing processes required to get materials might have a significant impact on the environment and the industry for instance; extraction of raw materials and production of finished goods can also be resource-and labour-demanding, resulting in high expenses (Ruuska & Häkkinen, 2014).

2.7 Resource-efficient construction:

Improving resource efficiency in the construction industry is essential to achieving a balance between the growing demand for new infrastructure and sustainability-related needs. Reducing the use of raw materials and non-renewable resources, producing durable products with minimal waste, and preserving product value over the long term are all aspects of resource efficiency (Kedir & Hall, 2021).

Resource efficiency is critical across the full lifespan of constructed assets, including product manufacturing, design, building, operation, refurbishment, and disposal. The objective of resource-efficient construction is to optimize the effective usage of resources, water, and energy while reducing both embodied and operational consequences. The operational impacts of a product are the environmental consequences that result from its usage, whereas embodied impacts include the impacts connected with its production, building, and disposal phases, as well as the intrinsic features of the material itself. Energy, water, and garbage are especially essential resources with operational and embodied implications. Carbon reduction is a top concern in resource-efficient building, and it may be accomplished in a variety of ways. These include reducing material consumption and waste, increasing the use of reused and recycled materials, utilizing resources and products with low embodied carbon and water content,

ensuring the optimum longevity and durability of assets, reducing the amount of energy and water used during construction, and improving energy and water efficiency during the operational phase. The construction industry can effectively promote resource optimization, reduce environmental impacts, and advance sustainable practices by implementing these methods (Sfakianaki, 2015).

The WASCON conference was successful in making clear that the construction industry is an ideal opportunity for utilizing waste, industrial by-products, and recycled materials as "secondary raw materials." It is critical to manage this sector's environmental effect because it not only consumes a lot of resources but also produces a lot of waste. Environmental demands are felt throughout the whole life cycle of a structure, from product manufacture through actual building construction to building usage, recovery, and waste management. Construction materials additionally have a significant impact on how effectively buildings operate in terms of energy efficiency, environmental sustainability, safety, and health (Vandecasteele et al., 2017). It is vital for buildings to minimize energy consumption during the usage phase and maximize the utilization of renewable energy sources. Additionally, during the construction process, it is also crucial to use materials that require less energy and, if possible, contribute to carbon storage. The choice of building methods and materials significantly influences overall design and resource efficiency (Krause & Hafner, 2022).

2.8 Circular Economy and resource efficiency:

The circular economy and resource efficiency are established concepts that promote decreasing raw material usage, boosting material circulation, and minimizing losses. These ideas similarly strive to enhance prosperity and well-being while keeping the natural environment's boundaries in check. By embracing the circular economy and implementing resource-efficient techniques, communities can pursue goals for sustainable development while balancing economic growth and environmental preservation (Ewijk, 2018).

Figure removed from digital version due to copyright.

Figure 7 Resource efficiency and circular economy - Ref; (Ewijk, 2018).

The figure demonstrates the connection between resource efficiency and the circular economy. At its core, the illustration represents the life cycle of a product, wherein raw materials transform to become goods that contribute to societal progress and enhance overall welfare. The graphic includes six basic parts that are crucial to both notions (resource efficiency and the circular economy). These aspects include raw inputs, wealth or well-being, environmental consequences, the finite natural environment, inefficiencies or losses, and feedback loops between inputs and outputs. The circular economy and resource efficiency share the objective of lowering raw material use, encouraging material circulation, and limiting waste formation. They attempt to optimize economic advantages and societal well-being while considering the natural environment's limits. Different interpretations of these notions may highlight certain components, such as the effects on wealth while ignoring environmental restrictions. Overall, the picture may be used to visualize the interconnection and fundamental components of resource efficiency and the circular economy (Ewijk, 2018).

Moreover, the Ellen MacArthur Foundation has been actively promoting the concept and opportunities of the Circular Economy through various reports, aligning with the above graphic's depiction. It defines the Circular Economy as a regenerative system that aims to maintain materials in a closed loop, maximizing their value (EMF, 2015).

In the Circular Economy models, end-of-life building materials are reused, and their components and parts are deconstructed to serve as material banks for new construction, ensuring a closed loop for components and materials (Hopkinson et al., 2019). This concept

aligns with the broader concept of the Circular Economy proposed by the Ellen MacArthur Foundation. However, the widespread adoption of this idea requires further development of knowledge and tools, particularly in the Construction Industry, where the implementation of innovation takes longer (BIS, 2013). Construction projects are often unique, involving complex supply chains, which adds to the challenges involved in implementing circular practices (Pomponi and Moncaster, 2017).

An example provided by the Brick development association of the UK:

CLAY BRICK - Building for a sustainable future in the UK:

Figure removed from digital version due to copyright.

Figure 8 Building for a sustainable future in the UK – Ref; (Brick Development association, 2023).

Manufacture: Responsible land and water management strives to increase natural capital. The industry is striving hard to achieve net-zero CO2 emissions by 2050. Natural raw resources like clay and water are used in the manufacturing process. Construction: The sector works on minimising environmental effects by lowering packing waste and guaranteeing shorter delivery routes. Furthermore, efforts in skill development and assistance for the next generation of bricklayers are undertaken. It is worth noting that the CO2 emissions produced by 1 m2 of brickwork are comparable to driving a car for 150 kilometres. In use, clay bricks provide comfort, safety, and durability. They help with energy efficiency due to their large thermal

mass and acoustic insulation. Furthermore, they are non-combustible and have a lifespan of at least 150 years. Brick keeps its aesthetic appeal and value throughout time. End-of-life: Clay bricks have simple reuse and recycling alternatives, facilitating the move to a circular economy. This guarantees that the resources may be recycled, and that waste is minimized. Additionally, Bricks have been the favoured material for UK home construction for centuries because of their appealing aesthetic, low cost, and high-quality performance. The sector understands the critical need to address climate change and has pledged to help the UK achieve net-zero CO2 emissions by 2050. Clay brick homes that are resilient, long-lasting, and pleasant will play an important part in ensuring a sustainable future for future generations (Brick development association, 2023).

Conclusion:

The focus of this study was to investigate the use of reclaimed bricks to promote the principles of circular economy in Pakistan's construction sector. The research developed a theoretical framework based on the Triple Bottom Line theory by considering economic, social, and environmental issues. The study also looked at transportation economics in construction logistics to reduce the environmental impact of transportation activities. Moreover, the construction industry could reduce resource consumption, waste creation, and environmental consequences by implementing resource efficiency and circular economy principles. Transitioning to a circular economy necessitates stakeholder participation as well as the implementation of innovative technologies and guidelines.

Chapter 3

Production of Reclaimed bricks

Pakistan has a high number of brick masonry buildings and clay bricks are abundant in the country. Brick masonry is a traditional construction technique that has been used for generations in Pakistan, resulting in a significant number of existing brick buildings (Khan et al., 2016). The practice of demolishing buildings made of bricks also has a long history In Pakistan. Building demolition is typically done manually by workers using conventional equipment and techniques. These reclaimed bricks are cleaned and sorted before they are recovered from old structures, demolished structures, or construction sites. They are then reused to construct new structures or for other purposes. However, the local brick reclamation practice in Pakistan has not been extensively studied and relevant literature is limited to explore.

On the other hand, conventional bricks were one of the first man-made materials to be used for construction, a simple procedure of combining clay and water facilitates their manufacture. The numerous examples found worldwide that have survived centuries of difficult climatic conditions and battles speak to their resilience to wear and longevity. Hardening procedures for clay bricks have evolved throughout time, from sun drying to industrial furnaces, resulting in increased strength and longevity. However, the use of burned clay brick as a basic construction material has been around since ancient times, due to the increasing need for building bricks, reserves of muddy soils suitable for brickmaking are constantly depleting and to ensure strong growth, the brick-making process requires high moulding pressure and autoclaving. This whole manufacturing of clay bricks consumes a significant amount of energy and because of the high demand for construction bricks and the scarcity of suitable soil, there has been a recognized need to study alternate solutions and energy-efficient brick production processes (Fernandes, 2019).

3.1 Lifecycle of reclaimed bricks:

A circular illustration below demonstrating each phase of the cycle has been produced to increase awareness and knowledge of the brick reclamation process. Each stage of the cycle has been greatly investigated, utilizing a combination of relevant research and personal insights. The figure below illustrates the path of bricks from the deconstruction of the building to extracting construction material, sorting, trade, transporting and utilization at the new site emphasizing the significance of sustainable building construction with potential advantages of reclamation.

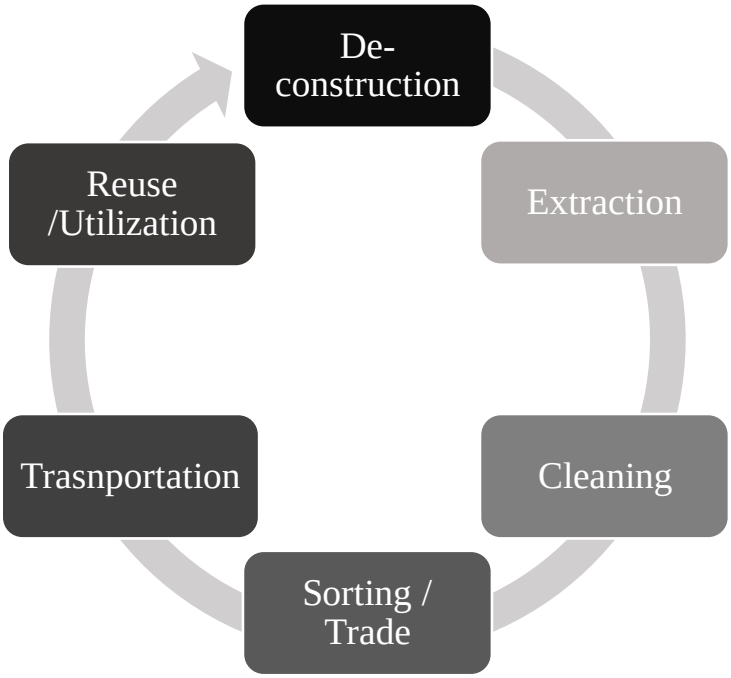

Figure 9 Bricks reclamation cycle – Ref, Author

3.1.1 Deconstruction:

The first step of reclaiming bricks is the deconstruction of the building therefore, brick-based constructions require careful de-construction to recover the bricks for use in future construction projects. According to (Sassi, 2002), brick building deconstruction requires a scientific procedure of deconstructing the structure and recovering the bricks for reuse. The procedure normally entails the use of specialized tools and equipment to delicately remove bricks from the structure without causing damage to them (Sassi, 2002).

Figure removed from digital version due to copyright.

Figure 10 Deconstruction of infrastructure - Reference, Google images

Why Deconstruction?

The low rates of recycling and reuse in construction are due to a variety of factors, including architectural materials that were not planned for deconstruction and the consequent time requirements, which make deconstruction prohibitively expensive. Some construction systems, on the other hand, have been constructed for flexibility and simplicity of deconstruction, allowing for reuse and recycling. To reduce waste concerns, several manufacturers are including recycling in the life cycle of their goods. Although most construction methods are designed for long-term use, some materials and features can nevertheless be recovered. Deconstruction can take two to ten times longer than demolition, making it economically unfriendly. Despite these obstacles, attempts are being made to improve the building industry's sustainability through creative design and material selection (Sassi, 2002).

To promote circularity in structures, the idea of "deconstruction" has become increasingly important. Instead of using the conventional, haphazard demolition method that produces a substantial quantity of waste, this process entails tearing down a structured piece by piece to reuse its components in various projects. New techniques for building requalification that support environmental preservation and healthy development have been made possible by

technological developments. One such technique is known as "Building Information Modeling" (BIM), which integrates lifecycle data and links all stakeholders across the supply chain to maximize building planning, construction, and administration. Moreover, another approach is called "Design for Deconstruction" (DfD), which entails creating structures to permit future modifications and the deconstruction of parts and materials with allowances for reuse and recycling. Buildings are seen by DfD as a storehouse of resources that, at the end of their useful lives, should be recycled or used again. To guarantee that deconstruction operations are effective through suitable construction procedures, a "deconstruction plan" is required (Bertino et al., 2021).

Building Information Modeling (BIM):

Building Information Modeling (BIM) usage has resulted in improved project quality, precise scheduling, accurate quantity predictions, and cost savings. BIM enables the selection of ideal building orientation, the evaluation of various facade alternatives, and the performance of daylight studies during the design process, all of which improve sustainability. As sustainability trends turn toward net-zero energy buildings and reduced carbon emissions, designers are being challenged to examine the building as a fully integrated and dynamic design and construction process (Bynum et al., 2013).

Design for Disassembly:

The purposeful design of structures to ease future alterations and eventual dismantlement, allowing for the recovery of systems, components, and materials is referred to as design for disassembly (DfD). This design strategy entails the creation of assemblies, components, materials, building processes, and information and management systems to aid with disassembly and resource recovery. The primary goal is to increase economic value while minimizing environmental consequences by encouraging material reuse, repair, remanufacture, and recycling. Energy recovery from materials and safe disposal is only considered as a last resort. DfD incorporates the notion of whole-building addition and subtraction, allowing for flexibility and adaptation throughout the life of the structure (Guy & Ciarimboli, 2008).

3.1.2 Extraction and Cleaning:

The next step after deconstructed sites is the extraction of bricks from the deconstructed site. However, this process requires a comprehensive search to find a suitable location within the actual site where bricks may be securely gathered while extracting from a destroyed structure.

Figure 11 Extraction and storing of reclaimed brick – Ref; Author.

After extracting the bricks from the deconstruction building, it's necessary to do the Cleaning of bricks which will separate the mortar keeping the bricks in place once they have been recognized as needing to be removed. The brick building is generally built of bricks that are bound together using mortar, which can be lime-based or standard Portland cement (OPC). Lime-based mortar is commonly employed in old masonry buildings, although it deteriorates with time, resulting in decreased bond strength. As a result, after a while, separating bricks with lime-based mortar becomes quite simple. The majority of brick reuse research focuses on the recovery and reuse of heritage bricks using lime-based mortar, with around 85% of such bricks detachable without harm. The remaining bricks are declared defective and may only be recycled as a substitute for natural gravel. According to the Institution of Civil Engineers' Demolition Protocol, bricks have a 10% recovery potential, which can go to 100% in specific buildings. The Brick Development Association underlines that used bricks remain usable as long as their characteristics are considered and related brick property testing is necessary. However, its high price is a result of both demand and reclamation expenses. Most methods for removing lime-based mortar require physical labour, which takes time but is theoretically

possible. Examples include utilizing a heavy/brick hammer and a wide cold chisel or bolster demolition hammer or brick cleaning equipment. (Hopkinson et al., 2019)

Figure removed from digital version due to copyright.

Figure 12 Removing plaster from brick wall – Ref; (UNITEC, 2023).

High-quality lime mortar forms a strong connection with the bricks. Using a strong hammer and broad cold chisel for bigger chunks and a brick hammer (ideally one with a replaceable hardened claw steelhead) for smaller bits, remove the mortar with care and effort. It is critical to continue with utmost caution and to follow all health and safety requirements, which include the use of a "Chisel Hand Guard" and other required personal protective equipment (PPE). There are multiple methods to remove plaster from a brick wall, depending on the type of plaster, the state of the wall, and the intended result. One of the most popular techniques is gently chipping away at the plaster with a long-reach scraper tool or chisel and hammer so as not to harm the underlying masonry (Brick development association, 2023).

Figure removed from digital version due to copyright.

Figure 13 Removing mortar from brick, Ref; (Hajrudin Hodzic, 2022)

Using a hammer and chisel to manually clean brick mortar is an old-fashioned technique that has been used for a long time. To remove the previously applied cement and leave a brick's surface clean, this method entails physically chipping away at the hardened mortar on the surface of the brick with a hammer and chisel (Hajrudin Hodzic, 2022).

A substantial problem is presented by the removal of bricks from cement-based mortar as well as the testing and certification of their quality for reuse. This problem is further complicated by the absence of regulated procedures or rules of behaviour for testing and performance assessments of recycled bricks. As a result, unless they go through extensive testing in accredited laboratories, load-bearing components that are considered reusable are frequently restricted to non-structural applications. The quality assurance of recovered bricks may be significantly improved by utilizing existing deconstruction technology, putting into practice standardized procedures, and providing enough personnel training. However, these difficulties might be linked to the lack of research and innovation in the reclamation and reuse of bricks from cement-based mortars, notably from masonry blocks (Zhou et al., 2020).

3.1.3 Transportation / Logistics:

Trucks are often used in the construction industry to transport the material and corporations may outsource this duty to third-party logistics providers (3PLs) in some situations. The size of the vehicles is decided by factors such as the project scale, waste creation rate, waste volume, and site accessibility. Road width also matters, as narrower roads necessitate smaller trucks. The truck capacity varies based on the exact project limits, and diesel fuel is commonly utilized in these vehicles (Lockrey et al., 2016). When assessing the reclaimed bricks' sustainability, it's vital to take the transportation element into account. Bricks are frequently sent across great distances to end users since brick kilns are typically situated outside of metropolitan cities. Reclaimed bricks, on the other hand, are often obtained from metropolitan regions or cities, resulting in a shorter transportation route, and perhaps lowering the embodied carbon dioxide (CO2) related to the transportation of construction materials (Thormark, 2000).

Overall, transportation and logistics management are essential to the development of a circular economy within the construction industry. For closed-loop material and resource flows and a reduction in transportation's negative environmental effects, sustainable logistics solutions are essential. Reclaimed bricks are frequently sourced from urban areas, which reduces

transportation distances and related CO2 emissions. This is an illustration of how logistics can support a circular economy. However, a reverse logistics approach to the reclaimed construction material could produce economic and environmental outcomes, including cost savings and a decrease in harmful emissions. To contribute to a circular economy and a more sustainable future, it is necessary to take logistics into account while developing sustainable construction methods, including the reuse of building materials like reclaimed bricks.

3.1.4 Reusing / Utilization:

Utilization of Brick masonry is often carried out by local masons and workers, who rely on their knowledge. The foundations are often constructed with brick masonry and cement sand mortar, and they are broader than the walls. Both mud mortar and cement sand mortar are used to build the walls, beginning at the plinth level. Utilizing different roofing materials, they rest directly and unconnected on the walls. Such a house is built in a methodical, progressive manner. It is significant to remember that, at the earliest phases of development, large buildings are frequently not initially built for their full scale (Lodi et al., 2013). Normally in Asian countries, the quantity of bricks is determined by the size of the available brick. The dimensions of modular bricks in Asia are 19 cm x 9 cm x 9 cm. Bricks that are non-modular come in a variety of sizes. The location influences the size decision as well. Asian nations vary in their use of sizes from one another. The non-modular bricks that are most frequently used in Asia are 230 mm × 110 mm x 70 mm. In several Asian nations, the thickness of the beam is typically maintained at 230 mm. A brick with a length of 230 mm is therefore often used. You can always determine the total number of bricks needed for 1 m3 of brick masonry, regardless of the size of the brick (Joseph & Negi, 2022). In Pakistan, bricks account for a significant portion of construction, approximately 62.38% of the total built environment (Lodi et al., 2013).

Chapter 4
Methodology

In this fourth chapter, a comprehensive overview of the research philosophy, research design, and methodology will be presented. This will encompass the adoption of a qualitative approach, the utilization of semi-structured interviews as the primary method for data collection, the identification of the target audience, the determination of the sample size of participants, specification of the geographical location, incorporation of field visits to gather thematic data and considerations of ethical aspects.

4.1 Research philosophy:

The term "research philosophy" describes a set of presumptions and viewpoints towards the development of knowledge. The ultimate objective of conducting research is to develop knowledge in a certain topic, even though it could first appear complicated. Conducting research essentially contributes to the growth of knowledge in a particular field while being guided by a set of ideas and presumptions referred to as research philosophy. Among these presumptions and beliefs are epistemological ones (concerning human understanding), ontological ones (concerning the facts discovered during the study), and axiological ones (concerning the researcher's values). These presumptions influence how to formulate and comprehend the research questions, the techniques the author picks, and the way to analyse your results. It is crucial to be aware of these assumptions since they have a substantial influence on both the research process and findings. The study nevertheless enhances the knowledge even if it concentrates on a small-scale issue inside a particular business or sector (Saunders, Lewis & Thornhill, 2009).

A philosophical perspective known as interpretivism emphasizes the subjective and significant character of human experiences as well as their involvement in social and cultural elements of existence. This perspective asserts that research methodologies should address the social construction of people's knowledge and perception of reality. Natural science techniques are therefore unsuitable for interpretative research. To obtain contextual depth and investigate the uniqueness of certain circumstances, interpretivism focuses on qualitative data (Chowdhury, 2014). In other words, the objective of interpretive research is to produce fresh and comprehensive perceptions and analyses of social contexts. This involves looking into organisations from the viewpoints of diverse groups in the context of business and management. Moreover, the interpretive approach is ideal for doing research in this area due

to the complex and sometimes unique character of business circumstances (Saunders, Lewis & Thornhill, 2009).

4.2 Research Design:

This study on reclaimed bricks as a sustainable construction resource takes a comprehensive approach to understanding their potential and future possibilities for promoting sustainability in the construction industry. However, it is guided by a research philosophy that includes assumptions and ideas that shape knowledge discovery.

This study utilizes an "interpretive research" approach to get a thorough understanding of reclaimed bricks as a resource for sustainable construction. According to this philosophy, research must consider how society shapes people's knowledge and understanding of the world. It also highlights the subjective and meaningful aspects of human experiences. Moreover, this research uses a qualitative methodology, observatory insights, and points of view, including stakeholder interaction on the environmental and social developments of using reclaimed bricks in construction as well as a lifecycle evaluation of the production, use, and economic opportunities of reclaimed bricks such as the influence on local jobs and the affordability and accessibility of construction materials. Thus, the interpretive method was most appropriate for this study given the distinctive characteristics of sustainable construction.

Moreover, my academic background in project management and experience in the construction industry have provided valuable insights and expertise to develop a methodology to study reclaimed bricks. The combination of the theoretical framework and practical experience shaped the research methodology used in this study.

4.3 Secondary data:

To develop comprehensive theoretical knowledge or framework, existing research on the reuse of construction material and the role of circular economy in construction was thoroughly examined with a particular focus on reclaimed bricks. This examination includes relevant past studies including publications, blogs, journals, reports, websites, and books.

4.4 Primary data:

To gather primary data, this study utilized qualitative research methods to explore the practical aspects of reclaimed bricks within the construction industry and their potential to promote sustainable construction initiatives. Interviews were conducted with contractors, workers and engineers who have been actively involved in the reclaimed construction material operations for several years. These interviews carefully examined the environmental, economic, and social aspects associated with the reclaimed bricks and relevant primary data was collected to address the research questions effectively.

Additionally, site visits provided valuable qualitative data through direct observation. The observations were focused on the extraction and cleaning of bricks during the cold storage deconstruction project. Moreover, reclaimed materials such as bricks, roof panels, iron girders, and timber supports were observed besides the reclaimed bricks during the animal farm project. These visits further enhanced the understanding of the projects and evaluated findings on sustainability and material reuse.

4.5 Snowball Sampling:

Snowball sampling is a strategy used to identify and collect data from individuals who possess attributes that are difficult to locate. This approach involves requesting research participants to recommend prospective future study participants from their network. This strategy, commonly referred to as the "chain method," may be an efficient and cost-effective way to contact elusive people (Naderifar et al., 2017). Qualitative data for this study were collected by using a snowball sampling approach. In Pakistan, contractors often work informally and especially deconstruction operations are not easily accessible. Therefore, the Snowball sampling method proved to be an effective strategy to identify deconstruction sites and participants to collect data. To initiate this process, a well-known professional associated with the construction industry was approached to acquire a lead towards a competent contractor. Once the first participant was identified and interviewed, the referral chain was established. Through this chain, other deconstruction sites were recommended, and the remaining participants were interviewed accordingly.

4.6 Semi-structured interviews:

A semi-structured interview is a conversational research method that combines closed and open-ended inquiries with follow-up why or how questions. This approach is distinguished by its flexibility in allowing the conversation to divert off-topic rather than strictly following a predetermined survey script. As a result, it works well for examining unforeseen problems and going further into the subtleties of a certain subject. Semi-structured interviews differ from more conventional survey techniques because it encourages the value of open communication and enhances cooperation between the researcher and respondents. Overall, the semi-structured interview is a useful instrument for delving further into the viewpoints of persons involved in complicated issues (Adams, 2015).

To allow respondents to freely express their perspectives without feeling restricted a flexible frame was developed for the semi-structured interviews. I ensured that the interviewees understood the aim or purpose of the session, and how the information would be gathered and used for the research project. The creation of a friendly, judgement-free environment that promotes open dialogue was my first aim. Participants were able to give detailed comments since the interview questions were open-ended.

4.7 Target Audience:

The sample size of this study was smaller but focused on in-depth understanding. However, in total 8 used brick traders/contractors, subject matter experts and workers were identified through the snowballing method and approached personally during site visits. The physical location of the qualitative research was Multan and Lahore, Pakistan.

4.8 Overcoming Language Barrier:

Due to the language barrier within the construction industry in Pakistan, interview questionnaires were translated from English into the local language. Being a native Punjabi and Saraiki language speaker, I asked questions in the local language and understood the responses clearly as well. Moreover, due to the excessive noise at the construction site interview voice recording was not possible therefore, data was transcribed into handwritten notes during the interactive sessions. It was a simple and practical decision to develop handwritten notes, and essential for the analysis and comprehension of the data acquired from

the study participants. However, responses were recorded in the form of shorthand-written notes and later carefully translated into English by me.

4.9 Thematic Analysis:

Firstly, once interview data has been transcribed in the written format and get familiarised with the gathered information to conduct thematic analysis, the next thing is to generate initial codes which enable to identify of data as “semantic content” so that raw data could be assessed in a meaningful manner regarding the phenomenon. Then the thematic analysis would recognize any emerging themes or patterns in the data. To do this, relevant codes are gathered, and differences and similarities among the data are sought after therefore it gives a good idea of an overall story about the data. The themes and sub-themes will be finalised in the fifth phase of selecting and naming themes and giving them labels that suitably reflect their significance. Lastly, the thematic analysis the report will be produced, results of the thematic analysis are presented in a report (Braun & Clarke, 2006).

Following the above instructions provided by Braun & Clarke, (2006) notes that were written were put together using the information obtained from the interviews, which made it easier to understand the data. The data were analysed using thematic analysis. Identifying the semantic meaning of the raw data, required creating initial codes. The next stage of thematic analysis consisted of obtaining relevant codes and identifying patterns and themes by comparing them. This provided an in-depth understanding of the data and made it possible to identify important insights related to the study's goals. The themes and sub-themes were then finished, and labels indicating their importance were provided. Eventually, a report that described the data, the themes that emerged from the data, and how the themes relate to the study questions or objectives was created. The use of theme analysis allowed for a greater understanding of the information gathered from the interviews and gave important insights into how using reclaimed bricks in construction could help promote sustainability and a circular economy in the construction industry.

4.10 Ethical consideration:

Each participant was informed in the local language about the purpose of the interviews and the study which solely aims to gather knowledge and learn from their expertise. Participants

were informed that their names and geographical location will be published in the report however if they do not like any information so it could be removed from the final report. Also, before, during and at the end of the interview participants will be given a free hand to ask a question if anything appeared unclear and share final thoughts. However, the interviews ended in a friendly manner and both sides enjoyed the conversation.

4.11 My role as a researcher:

The goal of qualitative research is for the researcher to gain insight into the opinions and experiences of study participants, which may be a difficult process because it may require discussing sensitive themes. Participants may have recently faced the issue under consideration, or they may be unable to recall previous encounters. Regardless of the technique used to gather data, the researcher is responsible for protecting the participants and their data (Sutton & Austin, 2015). Therefore, it was my duty to encourage open contact with the research participants since they were construction labourers or workers who unfortunately were living below the poverty line and their standard of living had been negatively affected by Pakistan's current inflation rate, along with the lives of everyone else in the country. To avoid participants from feeling that the research was somehow intended to expose their poverty or challenges, I intentionally created a non-judgmental environment. Overall, I acted as a respectful and responsible researcher. I gathered and analysed data that could enhance the understanding of the social, economic, and environmental implications of using reclaimed bricks.

Chapter 5

Findings

5.1 Background of findings:

The interpretive research approach was employed to analyse the qualitative findings of the study, which focused on addressing the research questions. The results were categorized into three primary participant groups, consisting of four (4) Contractors and four (4) construction workers who were interviewed during on-site visits. Additionally, two (2) civil engineers were interviewed via phone calls. Additionally, two (2) site visit findings are also presented in this chapter, which provided valuable observatory data and site visuals to enrich the understanding of the projects and contribute to the findings on sustainability.

Engaging in discussions with contractors and engineers who were involved in the production process and utilization of reclaimed bricks and other reclaimed construction materials provided valuable insights into various aspects of deconstruction practices and business prospects. The aim was to understand their expertise in the deconstruction process, explore their perspectives on issues within the brick industry, and identify the challenges faced by the construction industry in Pakistan.

Moreover, the potential of reclaimed bricks as a resource-efficient material to achieve circular economy objectives within the construction industry was examined. Furthermore, conversations were held with construction labourers and workers who were actively involved in teams practising reclaimed bricks and other reclaimed construction materials. This allowed for a comprehensive assessment of the working conditions, including factors such as job stability, long-term opportunities, and financial situations amid high inflation. The challenges faced by these workers were also examined.

Through the interpretive research approach, a deeper understanding of the participants' experiences, perspectives, and the broader context of the construction industry in Pakistan was gained. This approach facilitated a qualitative analysis that focused on uncovering the meanings and interpretations of the participants' experiences and perspectives within the specific research context.

The table below will represent their demographics:

Code	Participant Name	Type of work	Experience (Years)	Location (Pakistan)
Workers				
(P1-W)	Raheem Khan	Manual Deconstruction	5	Multan
(P2-W)	Asif Ali	Bricks cleaning and sorting	4 – 5	Lahore
(P3-W)	Shakeel Khalid	Bricks cleaning and sorting	3	Multan
(P4-W)	Asif Iqbal	Mix work	3	Multan
Engineers				
(P1- Engr)	Ali Khan	Civil Engineer - Senior Project manager (Bahira town)	10	Karachi
(P2- Engr)	Suleman Zafar	Civil Engineer - Private builder	5	Lahore
Contractors				
(P1-C)	Zafar Iqbal	Contractor	5	Multan
(P2-C)	Shaukat Ali	Contractor	9	Lahore
(P3-C)	Tanveer Khan	Contractor	10	Multan
(P4-C)	Naveed Danish	Contractor	12	Multan

5.2 Interview findings:

The interpretive research framework that was employed to analyse and understand the sustainability of construction, encompasses three interconnected pillars: environmental, economic, and social. This approach emphasizes the need to consider all three pillars collectively when evaluating the sustainability of construction projects or buildings. By adopting a balanced approach, the aim is to prevent any one pillar from dominating the others, ensuring a holistic perspective (Eklova, 2020).

Within this interpretive research framework, the research findings were categorized into three primary dimensions: economic, social, and environmental. Each dimension was further divided into main themes and sub-themes that emerged from the analysis of interview transcripts. This methodological approach facilitated the development of meaningful segments and organized themes, which in turn facilitated a clear and concise presentation of the research findings. By employing an interpretive research perspective, the aim was to delve into the underlying meanings and interpretations of the participants' experiences and perspectives within the context of sustainability in construction.

Themes and Sub-themes are listed below in the three main categories:

Economic:

1. **Motivating factor and business potential of Reclaimed construction material:**

- Urban shift and business opportunities.
- Profitability with a higher margin.
- Prior Experience and Industry knowledge.

2. **Economic Crisis Impact on The Construction Industry of Pakistan:**

- Higher Cost and Supply Shortage Impact.
- Shortage of Brick Supply and Demand for Reclaimed Brick.
- Economic impact on Pakistan's construction market.
- Reclaimed bricks as an economical alternative.
- The cost difference between new and reclaimed bricks.
- Transportation and its cost into consideration.

3. **Demand-driven opportunity for contractors and workers:**

- Challenges of employment and stability in the construction industry.
- Training and skills for the new entrants in the reclaimed construction material sector.

4. **Challenges of employment and stability in the construction industry:**

- Freelance work and financial struggles.
- Role of contractors in job stability.
- Training and skills for the new entrants in the reclaimed construction material sector.

Social:

5. **Mindset towards reclaimed construction material:**

- Promotion and mindset shift.
- Barrier towards sustainable construction practices.

Environmental:

6. **Brick Kilns and Deconstruction: Impact on the Environment in Pakistan:**

- Environmental impact of Smog.
- Degradation of agricultural land.
- Deconstruction of the environment.

7. **Improper construction disposal and waste management practices:**
8. **Transportation of reclaimed bricks:**

- Conventional Tractor-trolley method.
- Environmental impact of brick transportation.

.

Additional themes emerged:

- **Deconstruction-related challenges:**
- Challenges but untrained for new technology.
- Deconstruction plans or guidelines.
- Issued instructions from the government.

9. **Promoting sustainability through reclaimed bricks:**

Economic:

In developed countries, the construction industry generates approximately 9.9% of GDP, but in Pakistan, it contributes around 2.4%. Additionally, a sizable fraction of the labour force is employed by the global construction industry however, any changes whether positive or negative, within the industry affects the entire economy. Considering this, promoting sustainability becomes critical in satisfying the expectations, requirements, and future needs of both present and future generations. Therefore, it is crucial to recognise and evaluate the various facets of economic sustainability (Hanif and Khattak, 2017). This economic aspect presents the findings related to the deconstruction process, reclaimed bricks, business opportunities for contractors, and job opportunities in Pakistan. The aim is to assess the economic benefits and issues linked with the utilisation of reclaimed bricks in Pakistan's construction industry.

1. Motivating Factor and Business Potential of Reclaimed Construction Material:

Individuals with a proactive entrepreneurial mindset are more inclined to move from problem-solving to identifying sustainable opportunities, such two main factors of being aware of the potential problem and having an entrepreneurial attitude provide the required inspiration and guidance in the process of recognizing and seizing sustainable opportunities (Eller et al., 2020).

Urban Shift and Business Opportunities:

The finding reveals a significant shift in urban development in Pakistan leading to business opportunities for contracts in the sector of deconstruction and construction material reuse: new colonies and small towns are emerging in the city outskirts, people shift from dense-populated areas to new developments,

"Higher demand of deconstruction work, less competition, led to starting to contract of deconstructing infrastructure, extract material and resell it to those who would like to utilize for their new projects(P1-C).

The preference of clients to utilize used construction material in their project proved to be a business opportunity for the participant.

"Clients frequently expressed interest in utilizing reclaimed construction material such as bricks, iron and a concrete slab in their projects. Instead of purchasing such material from other suppliers, I recognized the potential to establish my own business" (P2-C).

Profitability with Higher Margin:

The profit margin in the reclaimed construction material business was significant, and it was the main reason for participants to seize the opportunity.

"Acquired an offer to purchase non-demolished / intact infrastructure at a lower cost, after deconstruction and reselling its material, it gave me much more earnings than I expected. That's how I started this business formally" (P2-C).

Prior Experience and Industry Knowledge:

Three participants mentioned that their past experiences in the construction industry played an important role in identifying the reclaimed construction material business as a feasible opportunity. They believed that their past experiences would contribute to effective business management and increase the possibility of success.

Utilizing my 15 years of experience as a professional mason, identified an opportunity within the construction industry, P4 (C). Used to work for a contractor in this deconstruction field, and after many years of working, created their team and established his business, P3 (C). Masonry background has proven invaluable, as it enables me to understand construction patterns and manage the deconstruction process, (P2-C).

Overall, the urbanization of Pakistan has offered commercial possibilities in the deconstruction and reuse of construction materials. Participants identified the increased demand for deconstruction work as well as clients' desire to reuse construction materials. Profitability and a bigger profit margin in this firm encouraged players to take advantage of the chance. Their previous building experience and industry understanding were critical in developing profitable companies.

2. Economic Crisis Impact on The Construction Industry of Pakistan:

The global financial crisis substantially influenced the construction industry, resulting in an economic downturn. This economic downturn impacted many stakeholders involved in construction operations, including employees, managers, partners, consumers, suppliers, subcontractors, and society (Fadhil & Burhan, 2021).

Bricks Higher Cost and Supply Shortage Impact

Participants believe that because of the economic crisis in Pakistan, construction material cost has increased, resulting in higher demand for reclaimed construction supplies.

"Economic crisis, the demand for used bricks and other used construction material is increasing day-by-day", P2 (C)" Expensive construction material has made it difficult to construct homes and other infrastructure", (P1-C).

Another participant stated that the high cost of construction supplies has made it difficult to build infrastructure and resulting in unemployment.

"Projects are on hold or cancelled, as a result, made thousands of construction workers unemployed", (P2-Engr).

Participants further added the high cost of construction materials presents a significant challenge for the construction business, as it hampers the ability to generate profit.

"Expensive construction material is a major challenge, Real-estate builders are unable to generate profits due to the devaluation of rupee (local currency)", (P2-Engr).

To summarise, the participants expressed their belief that the economic crisis in Pakistan has led to a surge in the prices of building materials, consequently increasing the demand for reclaimed construction supplies. This surge in costs has posed significant challenges for individuals seeking to construct homes and other infrastructure, making it financially burdensome. As a result, projects have faced delays or cancellations, leading to job losses among construction workers. Additionally, participants highlighted the struggles faced by construction businesses, as they find it difficult to generate profits due to the elevated building material costs and the devaluation of the local currency. Overall, the economic crisis and the escalating prices of building materials have had a substantial impact on Pakistan's construction industry.

Shortage of brick supply and demand for reclaimed bricks

Brick kilns were forced to shut down because of a sharp rise in the raw material prices: "Both participants stated the cost of new bricks have doubled this year, bricks kilns are being forced to close operations due to less market demand and high production cost".

Additionally, the closure of brick kilns has resulted in a shortage of supply:

"Closure of brick kilns creating brick supply shortage, the demand of reclaimed bricks is rising in Pakistan to meet that supply shortage" (P3-C & P4-C).

Furthermore, another participant responded in a similar context:

"Due to the added expense and shortage of raw material, brick kilns are delaying brick supplies causing delays in projects and forcing project owners to bear extra costs", (P2-Engr).

Overall, the substantial rise in raw material prices has resulted in the shutdown of brick kilns in Pakistan. Participants acknowledged that the price of new bricks has more than doubled, resulting in lower market demand and high production expenses for brick kilns. This shutdown has resulted in a brick supply shortfall in the market. As a result, to compensate for the supply constraint, demand for reclaimed bricks has increased. The shutdown of brick kilns, followed by a shortage of brick supply, has caused delays in construction projects and added expenses to project owners. The entire situation demonstrates the building industry's concerns in terms of growing costs and supply constraints.

Reclaimed bricks as an economical alternative:

Participants highlighted bricks are the critical component in Pakistan for construction projects when compared to other construction materials. The dependence on bricks as a primary component, plays a vital role in the project cost.

"Cement, sand, and a specific amount of iron are required to build infrastructure; however, bricks are consumed in larger quantities. Due to lesser quantity cement, sand, and iron are affordable but bricks being as the main component this adds substantial project cost", P3 (C).

Participants indicated that reclaimed bricks serve as an alternate option to new bricks and facilities to resume stalled projects with its affordability factor.

"Reclaimed construction material including bricks, contributing towards providing cost-efficient construction supplies, also helping people to complete or initiate their pending construction projects in Pakistan" (P1-C).

Another participant was also convinced that reclaimed bricks are a cost-efficient alternative in Pakistan to new bricks for construction projects.

"Reclaimed bricks are cheaper and readily available, so it's a win-win situation for both client and builder", (P2-Engr).

Overall, participants stressed the vital importance of bricks in Pakistani construction projects and the significant impact that they have on project costs. Bricks contribute significantly to the entire project cost due to the greater amount required when compared to other materials such as cement, sand, and iron. Reclaimed bricks were promoted as an economical alternative to new bricks, offering cost-effective construction materials. The cost of reclaimed bricks allows people in Pakistan to complete or begin delayed construction projects. Participants agreed that reclaimed bricks are a less expensive and more easily available solution that benefits both clients and builders. Overall, reused bricks are viewed as a cost-effective choice for construction projects in Pakistan.

The cost difference between new and reclaimed bricks:

To explore the cost efficiency further, I asked every participant about the cost of reclaimed bricks, and the average cost of each reclaimed brick was PKR 12 (Pakistani rupees). However, later I inquired about the price of new bricks from a nearby brick kiln and found out that each new brick cost PKR 17 (Pakistani rupees). **Hence, it was found that the cost of a reclaimed brick is approximately 30% lower compared to new bricks.**

Transportation and its cost into consideration:

All participants stated similar responses regarding the use of smaller types of modes of transportation (Motorcycle rickshaws, carts, etc.) in shifting reclaimed bricks from deconstructed site to another location.

In the context of the cost of reclaimed bricks, participants emphasized the significant influence of logistics costs.

"While reclaimed bricks are normally less expensive, transportation costs should also be considered. New sites with extraordinary distance, the extra cost could reduce the price margin between new and old bricks significantly", P3 (C).

Another participant highlighted the significance of shorter distances related to cost:

"Shorter distances are favourable and cost-efficient, often clients insist on a free delivery of reclaimed bricks for shorter distances for further financial benefit" (P1-C)

A similar response was received from another participant as well:

"The use of smaller vehicles for transporting reclaimed bricks is cost-efficient and easier to manage within cities. However, the mode of transportation can vary depending on the quantity of bricks being transported", (P4-C).

Overall, participants agreed that smaller forms of transportation, such as motorbike rickshaws and carts, are frequently utilized to transfer recovered bricks from dismantled sites to other areas. They highlighted the importance of transportation costs when calculating the overall cost of reclaimed bricks, fewer distances are more cost-effective and advantageous, according to participants, and some clients even insist on free delivery for lesser distances to reap financial benefits. Smaller cars for transportation are viewed as more cost-effective and easier to maintain in urban contexts. However, depending on the number of bricks being transported, the means of transportation may vary. Overall, transportation costs influence the pricing and logistics of reclaimed bricks.

3. Demand-driven opportunity for contractors and workers:

Participants were further questioned to assess the current market condition of reclaimed bricks or other materials in Pakistan, despite the ongoing economic crisis. One of the participants indicates that:

"*Clients are seeking professionals to demolish infrastructure efficiently, to extract construction material and reuse in their new project", P2 (C).*

Two participants stated that reclaimed material demand is high,

"It's common to get booking from builders, and brokers or middlemen in the market who resell our extracted material on profit after showcasing at their warehouse, (P2-C & P4-C).

Another aspect that emerged during the discussion was that clients often reuse the extracted material for their future projects. The contractor's role is primarily limited to the deconstruction of the infrastructure and handing over the extracted bricks to the client.

"Site owners often keep the extracted bricks and other materials. Both parties negotiate and finalise not to sell extracted material to other clients, especially, bricks. They are the first thing required for the new project, thus reclaimed bricks is a budget-friendly choice", P4 (C).

Overall, despite Pakistan's continuous economic crisis, the market for reclaimed bricks and other materials is said to be positive. Clients are actively looking for expertise to dismantle infrastructure and remove construction components for reuse in new projects. Reclaimed materials are in high demand, with builders making early reservations and brokers or intermediaries reselling the removed components for a profit. Furthermore, clients frequently prefer to reuse the retrieved materials, particularly bricks, for future projects. The contractor's primary responsibility is to dismantle the structure and deliver the extracted components to the customer. Overall, the market for reclaimed materials is growing, providing a cost-effective option for construction projects.

4. Challenges of employment and stability in the construction industry:

Unemployment and lack of construction projects:

As we have seen earlier in the findings, Pakistan's construction industry is facing severe problems, mostly due to economic issues and high construction material costs.

Participant indicates that fewer construction projects are operational currently, resulting in unemployment within the industry.

"*Due to economic issues and expensive construction materials, not many projects are operational nowadays therefore masons and construction workers are unable to find work", (P1-C).*

Freelance work and financial struggles:

When asked workers about their current employment in the deconstruction sector, they said:

"Work is better than standing on the Ada platform of free labourers" and waiting for clients". Their earnings: "Receive eidi Festive bonus from the contractor and financial help

when we complete the project, with overall pay he can afford necessities for a family with these earnings. (P1-W)

Other Similar Responses:

"Working as a freelance construction worker, picking up jobs here and there. It's luck that someone will call you to work for them otherwise you have to return home without any money", (P2-W).

Regarding their earnings:

"Getting our Bihari "daily wage" according to the current market rate must be spent very carefully". Overall, it's not sufficient, so I need to work on Friday "holiday" or at night-time to earn extra (P2-W).

Role of contractors in job stability:

The other two participants describe it's their contractor who manages the job stability aspect for them now. Overall, the response unveiled that the deconstruction line of work has provided him with stable job opportunities.

"Thekay-dar (contractor) is responsible for finding new opportunities and managing the construction team". (P3-W). "Work is stable, and I have been working with my contractor for the last 4 years now". (P4 W)

Regarding the earnings:

Have been working with the same contractor for a long time, and in any serious financial problem can get advance money from the contractor. Overall, they are stable and comfortable with this income P3-(W) & P4-(W).

To conclude, the construction industry in Pakistan is now suffering economic challenges and high materials costs, resulting in fewer active projects and increased unemployment within the industry. Workers in the deconstruction sector have stated that, while labour gives some security compared to being unemployed, the pay can be insufficient. Freelance workers emphasized the difficulty in getting employment and the necessity to work extra hours to increase their income. On the other side, other workers stated that their job stability is controlled by contractors, giving them a more predictable and comfortable salary. Overall, the

deconstruction industry provides varied amounts of employment stability and pay depending on the employees' conditions.

Training and skills for the new entrants in the reclaimed construction material sector:
Upon discovering the size of the de-construction team, all four different participants varied. (P1-C) & (P3-C) team consisted of 10 workers, while the (P2-C) team was based on 12 workers and **the (**P4-C) team consisting of 9 full-time and 2 part-timers were only used for transportation purposes. On average 10.5 workers were employed on each de-construction project.

Two participants shared a response, that since bricks are delicate and basic construction knowledge is required to join reclaimed bricks line for work as a worker.

"Ideal to hire someone with basic construction experience, bricks are delicate and without basic knowledge using a chisel and hammer could damage bricks while the cleaning process", (P1-C & P4-C).

Participants also disclosed that training is simple, any new worker can be easily trained in a short period.

"Not extensive training is required, anyone can be trained for this line of work easily", (P1-C). Training is easy if any special deconstruction equipment is not used…Bigger projects require more workforce, they call new workers an hour before a project starts, they learn work in a few hours and perform a duty, (P2-C).

Another similar response:

"No experience or extensive training is required as their line of work is manual and just required basic sense" (P3-C).

Interesting discovery:

"*One of the most skilled team members was a drug addict when he joined the team, but he has fully recovered since started working with them (P3-C).*

Overall, the Participant's findings show that deconstruction and brick-cleaning operations could be attainable to new entrants with basic training. Prior considerable experience is not

required, and people from different backgrounds of society could swiftly learn the essential abilities. The examples provided also show that this area could provide an opportunity for personal development and a fresh start.

Social

To effectively include the social component in sustainable building processes, it is critical to promote awareness among all stakeholders. This involves developing a sense of responsibility in society, as the rate of development in achieving social sustainability is dependent on individuals' understanding and awareness, which is influenced by their actions (Kamaruddin et al., 2020). This social aspect presents the findings related to the sense of responsibility towards the utilization of reclaimed bricks and other reclaimed construction materials in Pakistan.

5. Mindset towards reclaimed construction material

Traditional thinking and socio-cultural elements, such as attitudes, social status, perceptions, and behaviours, frequently impact reuse practices. Negative associations from the past, such as those that associate reuse with poorer quality, unappealing aesthetics, and restricted usefulness, could hinder reuse adoption (Knoth et al., 2022).

An important theme emerged related to the perception of Pakistan's mindset; the participant stated that the common mindset in Pakistani society discourages the use of reclaimed material for construction.

Participants stated that a mentality is preventing the shift towards sustainable construction in Pakistan.

*"Reclaimed construction material is surely beneficial in terms of availability, quality, and cost; however, people have the mindset: "Why would they utilize used construction material in their new construction project"**,** (P1-Engr).*

Promotion and mindset shift:

The lack of coordination and communication among the people concerned is an important obstacle. Additionally, individual attitudes might differ and there is an insufficient understanding of comprehensive techniques for effective waste management (Jin et al., 2017).

Cooperation and communication were stressed by one of the subject matter experts. One of the participants stated that.

"The need for awareness initiatives to change this belief and promote an understanding of the benefits that used materials may provide for both people and the environment" (P1-Engr).

Participants raised a question and suggested that:

Electronic or print media of Pakistan, only advertise companies that manufacture new construction materials, they should initiate a promotion campaign about the utilization of used construction materials…this will create a sense within the community, (P1-Engr).

Overall, the participants emphasized the importance of changing mindsets and increasing knowledge of the benefits of reused materials for both people and the environment. They also proposed that the media in Pakistan launch promotional efforts to promote the usage of old building materials, which would assist in raising community awareness. Overall, these initiatives are critical for encouraging sustainable practices and accomplishing the goals of the construction industry's circular economy.

Environment:

Construction activities create a significant amount of material waste, which includes, bricks, concrete pieces, demolition waste, and scrap steel, among other things. This leads to negative environmental consequences (Nagapan et al., 2012). This environmental aspect presents the findings of the environmental impact associated with brick kilns, the deconstruction process, reclaimed bricks, and transportation in Pakistan.

6. Brick Kilns and Deconstruction: The Environment of Pakistan:

Significant health, environmental, and financial problems are being driven due to brick kilns, which emit harmful gases. In Pakistan, both people and animals struggle with illnesses of the skin and respiratory system. Brick kilns are considered one of the major causes of these environmental and health issues by experts and professionals (Khan et al., 2019).

Environmental Impact of Smog:

Pakistan faces an environmental emergency due to Smog and the closure of schools every year:

"Smog is the most prominent environmental issue with the brick sector being a major contributor to this issue in Pakistan", (P1-Engr).

Participants believed that the main reason behind this is brick kilns:

"Brick Kilns Owners Association Pakistan" is an influential association in Pakistan with strong political affiliation, breaking SOPs and burning rubber, and bad or dirty petroleum products to manufacture bricks (P1-Engr).

Another participant shared that,

"*Brick kilns, also known as "Bhattas" are normally located near cities and emit heavy smoke that blankets the sky and surrounding area," P1 (C).*

In summary, Pakistan is currently facing an environmental crisis due to emissions, and brick kilns play a substantial role in exacerbating the situation. These kilns, often located near urban areas, emit dense smoke that blankets the sky and surrounding regions. Unfortunately, the Brick Kilns Owners Association Pakistan, which holds influential political connections, frequently disregards standard operating procedures (SOPs) and employs hazardous materials in the brick manufacturing process.

Degradation of Agricultural land:

Participant highlighted the issue of brick production using clay obtained from agricultural land:

Bricks are made of clay which is known as the "Chekni Mitti" type of clay, especially obtained from agricultural land. This practice is destroying our agricultural lands, P1 (C).

Another participant shared concern related to selling clay to brick kilns for brick manufacturing:

"Landlords sell (Mitti) clay to brick kilns operators for easy money, this destroys their agricultural lands and leads to food shortage in the country" (P1-Engr).

In conclusion, clay extraction from agricultural land for brickmaking hurts soil composition and fertility, threatening future agricultural output. This approach not only reduces agricultural productivity overall but also increases the likelihood of food shortages. As a result, a country's reliance on imported food to satisfy its needs grows.

Deconstruction and The Environment:

Construction, renovation, and demolition operations generate significant waste, it is critical to observe and reduce waste to achieve sustainability. However, concerning traditional demolition methods, deconstruction has developed as a more ecologically friendly strategy and demands considerable changes in how the construction industry plans, produces, and operates structures (Allam & Nik-Bakht, 2023).

Upon asking a question regarding the role of deconstruction for the environment, all participants shared a similar response,

"Deconstruction of infrastructure or their line of work is positively contributing towards environmental sustainability and utilizing reclaimed construction material helping in cleaning the cities and reducing construction waste" P2 (C).

One of the participants further added, as the contractor,

"I make promises to clients and have the main aim to deconstruct infrastructure and clean everything, ensuring no construction waste is discarded on streets or in any empty places", P3 (C).

Another participant stated that,

"Although deconstruction generates significant construction waste, it is properly managed and disposed of professionally, the team ensures that nothing is left behind anything or wasted during the deconstruction process infrastructure. This is because we recognize that every element of the building has monetary value in the market therefore, leaving anything behind or wasting is a financial loss for us P4 (C).

Overall, Participants believed that deconstruction benefits environmental sustainability by reclaiming construction materials and minimizing waste. During the deconstruction phase, contractors focus on cleaning cities and ensuring proper waste management. They understand

the monetary value of each component of the structure and strive to avoid financial losses by not leaving anything behind or wasting materials.

7. Improper construction disposal and waste management practices:

Improper waste disposal procedures harm the environment and pose substantial issues to communities across the world. Improper physical waste disposal contributes to global pollution and hurts the general population (Nagapan et al., 2012).

Participant highlighted the issue of improper disposal of construction waste in Pakistan:

"Currently, there are not many spaces left to dump construction waste in our spaces, so people often leave their construction waste wherever they can on streets, empty plots and even outside their house walls", (P4-C).

Another participant similarly stated that:

"*People often discard their bricks leftover or brick pieces also known as "Rora" outside their house. This practice attracts garbage throwers, resulting in a mixture of brick pieces with garbage. Consequently, street garbage piles are formed, creating an unhealthy environment for the whole area", (P1-C & P4-C).*

Another participant slightly contradicted the previous statement:

"Freelance brick collectors "Pheeri Walas" gather the left-over brick pieces and prevent them from going into the waste. These collected leftover bricks hold financial value and are high in demand because they are used to provide a strong foundation for marble or tile flooring when spread over the bare soil surface, (P2-C).

To conclude, due to the limited number of available waste dumps, improper disposal of building waste, particularly bricks, is a common problem. As a result, residents frequently discard their construction material in places like roadways, empty land, and the sidewalks in front of their homes, creating ugly conditions and attracting garbage throwers. But by gathering surplus bricks for reusing as flooring foundations, independent brick collectors help to reduce waste.

8. Transportation of bricks:

It is important to carefully assess how far reclaimed bricks may be carried. The feasible transportation distance depends on several factors, including the proximity to new brick manufacturers, the quality of new bricks, and the available transportation options (Thormark, 2000).

Participants shared their perspectives regarding the transportation-related challenges faced from one deconstruction site to another:

"Loading and unloading reclaimed bricks is time-consuming, the challenge arises when a client requires larger quantities of reclaimed bricks, especially from or within the densely populated areas, this requires larger vehicles which face difficulty reaching the site" (P2 C).

Another participant shared:

"Transporting smaller batches of reclaimed bricks is simpler, and larger batches are challenging if the deconstructed site is located in densely populated areas of the city", P3 (C).

To conclude, participants discussed the difficulties of moving reclaimed bricks from deconstructed sites to other areas. Larger amounts of reclaimed bricks were difficult to transport, particularly in densely populated regions, due to the need for larger vehicles that had trouble accessing the locations. Smaller quantities of reclaimed bricks, on the other hand, were thought to be easier to transport.

Conventional Tractor-trolley method

Vehicle characteristics, driver behaviour, traffic circumstances, and unloading planning all influence energy efficiency in construction logistics. Each of these aspects contributes to the overall energy efficiency of the logistics system (Fredriksson & Huge-Brodin, 2022).

The findings of two participants shed light on the challenges associated with the commonly used tractor trolleys for brick transportation across the country:

"*Drivers are often overloaded and their harsh driving causes accidents almost every other day. Moreover, there is a ban on tractor trolleys in many areas of the city because they create a lot of issues in the neighbourhood" (P1-C & P4-C).*

Another participant emphasized that:

"Tractor trolleys are mainly suitable for larger roads and are not suitable for inner-city roads. Their usage within inner-cities, causes traffic congestion and noise pollution" (P2-C).

Overall, the usage of tractor-trolleys for brick transportation presents issues since drivers are frequently overburdened and drive aggressively, resulting in frequent accidents. Tractor trolleys are also prohibited in several cities because of the problems they cause in communities. Furthermore, they are better suited to broad highways and contribute to traffic congestion and noise pollution when employed in urban areas.

Environmental impact of brick transportation:

Transport, a major component of construction logistics, has a considerable environmental impact, accounting for approximately 10% of CO2 emissions in house-building projects. Construction-related transportation not only has an environmental impact but also contributes to congestion in urban infrastructure built for ordinary traffic. In construction projects, coordinating flows across multiple roles and organizations can lead to lower environmental impact and costs. To overcome these issues, logistics services customized exclusively for construction projects have been developed (Fredriksson & Huge-Brodin, 2022).

In this context, the response received from participants was that:

"Tractor trolleys used for brick transportation are often old models and consume excessive diesel resulting the (smoke release) gas emission and leave a bad impact on the environment", (P3-C).

In comparison:

"When transporting reclaimed bricks and other used materials, it's safer, cannot be overloaded, and a quicker and smaller mode of transportation is allowed anywhere in the city" (P1-C & P4-C).

Participant highlighted the role of smaller vehicles in transportation:

"The smaller methods of transportation for reclaimed bricks reduce traffic congestion together with noise-related emissions", P2 (C).

Another participant added,

"Reclaimed bricks are transported on motorcycle rickshaws, and carts which consume less fuel, have better fuel efficiency, and less smoke emission" (P3-C).

Overall, participants emphasized that using outdated tractor-trolley models for brick delivery results in excessive fuel use and pollutants, significantly hurting the environment. Transportation of reclaimed bricks and other used materials using smaller modes of transportation such as motorcycle rickshaws and carts, on the other hand, offers benefits such as increased safety, avoidance of overloading, faster transportation, and reduced traffic congestion and noise-related emissions.

Additional themes:

Challenges but untrained for new technology:

New technologies aiming at increasing production, safety, and quality are frequently introduced to the construction industry, like other industries. The complexity of the industry, however, makes it difficult for these approaches to be widely adopted (Sepasgozar & Bernold, 2012).

The participants shared the challenges within the deconstruction work:

"It's manual work, not easy. Sometimes, we must dismantle hard walls with a hammer, which is a challenge", P1 (W). And *"It's challenging work" (P2-W). "Challenging and injuring myself several times", (P3-W).*

Another participant highlighted the need for the adaptation of innovative tools:

"It's hard work, especially with big projects, needs advanced tools to reduce manual hammer and chisel tasks" (P4-W).

However, the subject matter expert participant highlighted the reason behind not adopting such innovative tools:

"Builders are reluctant to adopt new technologies in the construction industry because the workforce is illiterate and not trained, a severe shortage of skills or skilled workers", (P2-Engr).

In conclusion, participants discussed the difficulties they encountered during the deconstruction process, such as the manual effort needed and the difficulty of destroying hard walls. Some participants acknowledged the need for improved equipment to eliminate manual duties, however, the construction industry's reluctance to accept new technology was cited because of an illiterate and unskilled workforce, as well as a scarcity of experienced personnel. These problems highlight the need of resolving talent shortages and encouraging construction industry training to improve efficiency and safety during deconstruction procedures.

Deconstruction plan or guidelines:

Understanding the building characteristics and deconstruction techniques is crucial for material reuse and establishes guidelines, which helps in understanding the features of future deconstruction projects (Carvalho Machado et al., 2018).

When asked about the status of official guidelines regarding the deconstruction in the county, both participants shared similar responses:

"No formal de-construction plans or guidelines are provided by Pakistan's government or any other responsible department" (P1-Engr & P2-Engr).

Since there are no formal deconstruction guidelines available, the question was asked from the subject matter experts to explore the capabilities of contractors in the deconstruction of infrastructure and reclaiming material. Below responses that were gathered:

Private contractors have been working in this line of work for a long time, they gained experience and are trained now.

"They see reselling value in every piece of brick or material, even without any formal deconstruction plans, they can extract material safely and efficiently", (P1-Engr).

Private contractors are the only option for the deconstruction of infrastructure in Pakistan:

Unfortunately, there are no small-scale innovative companies that can navigate in narrow streets of cities and deconstruct infrastructure manually, private contractors are capable of de-construction without formal plans or guidelines, (P2-Engr).

One of the participants shared, the client and contractor are involved during the deconstruction of infrastructure, and there is no involvement of local authorities:

"Normally, the (Thekay dar) Private Contractor manages and deconstructs infrastructure for their clients, local authorities have no role to play in this", (P2-Engr).

Participants also stated clients approach experts to get guidelines to improve the deconstruction process but it's rare:

"Sometimes clients themselves consult engineers or architects to get guidelines or special instructions about the deconstruction process. Regarding how infrastructure should be deconstructed, what way is more beneficial to recover construction material from the site", (P2-Engr).

In conclusion, participants in Pakistan recognized the lack of formal deconstruction plans or instructions supplied by the government or competent authorities. Private contractors have assumed the lead in infrastructure deconstruction, depending on their skills and training to retrieve materials safely and effectively. Local governments play a limited role in the deconstruction process, with private contractors overseeing and carrying out the work on behalf of customers. Clients may seek engineering or architectural advice to better the deconstruction process, although such discussions are uncommon. The lack of established rules emphasizes the importance of developing and implementing thorough deconstruction plans to ensure safe and effective infrastructure removal and material recovery processes.

Issued instructions from the government:

One of the participants mentioned the provided guideline:

"*Basic guidelines were issued by the government but not directly related to the deconstruction process: Waste management instructions were issued from the government, for instance; blocking roads or leaving anything outside where traffic finds it hard to pass by", (P1-Engr).*

9. Promoting sustainability through reclaimed bricks:

There are major environmental benefits to utilizing repurposed clay bricks instead of new ones. Reusing these materials is capable of significantly reducing the construction's overall impact on the environment (Thormark, 2000).

When asked about resource efficiency in the context of reclaimed bricks, participants shared similar thoughts:

"Bricks are the main construction material in Pakistan. I advise my team to utilise old/reclaimed bricks often. As a result, we save costs. Reclaimed bricks are resource-efficient solutions for the construction industry in Pakistan" (P2-Engr & P1-Engr).

Both participants agreed that achieving the circular economy objective within the construction in Pakistan is possible:

"Existing deconstruction and reselling model, it's a circular economy", (P1-Engr & P2-Engr).

Participants emphasised that further collaboration is required between stakeholders and the need to adopt the latest technologies within the construction industry:

"Strong collaboration is needed within the construction to enhance circular opportunities", (P1-Engr).

Participant expressed the limited extent of circular contractor activities:

"The current circular construction activities are only tied to contractors; further exploration is needed towards green technologies and innovative practices to achieve circular economy objectives. Currently not sufficient", (P2-Engr).

In conclusion, the participants stressed the advantages of employing reclaimed bricks in Pakistan's construction industry for cost savings and resource efficiency. They believed that the existing deconstruction and resale systems could be used to achieve the circular economy objective. However, they emphasised the importance of expanded collaboration, the adoption of new technology, and the development of green practices to fulfil the promise of a circular economy.

Conclusion:

The above findings on the potential of reclaimed bricks in the Pakistani construction industry can be related to an interpretive approach. The interpretive approach focuses on understanding and interpreting the meanings and social constructions associated with human behaviour and phenomena. In this case, the study examines the various factors related to the use of reclaimed bricks and interprets their significance in the context of economic, social, environmental, transportation, and deconstruction aspects.

From an interpretive perspective, the study acknowledges that the use of reclaimed bricks goes beyond its practical and tangible benefits. It recognizes that the decision to adopt reclaimed bricks is influenced by complex social and economic factors. The interpretation of the findings highlights the recognition of the Pakistani economic crisis and high building material prices as important obstacles in the construction business. The study understands the social context in which construction industry participants operate and how these economic challenges impact their decision-making processes.

Furthermore, the interpretive approach emphasises the understanding of the environmental implications and the social constructions associated with sustainable practices. The study interprets the environmental benefits of reclaimed bricks, such as decreased resource extraction and waste creation, as significant factors in promoting sustainable construction methods. It recognizes the importance of resource efficiency and interprets the findings in a way that emphasises the need to reduce the construction industry's impact on the environment.

Additionally, the interpretive approach allows for the exploration and interpretation of the social constructions related to transportation. The study acknowledges the participants' perspectives on the importance of transportation expenses and how they influence the overall cost of reclaimed bricks. By interpreting the significance of using smaller forms of transportation and sustainable mobility options, such as motorcycle rickshaws and carts, the study demonstrates an understanding of the social and environmental implications associated with transportation choices.

Overall, the interpretive approach provides a lens through which the findings of the study can be understood and interpreted in the broader social and cultural context. It highlights the interplay between economic, social, environmental, transportation, and deconstruction factors and offers a deeper understanding of the meanings and implications associated with the use of reclaimed bricks in the Pakistani construction industry.

5.3 Site visits findings:

Introduction:

This research study involved visiting two densely populated cities in Pakistan, namely Lahore and Multan, due to their significant urban migration and population growth, leading to a high demand for construction activities. The primary objective of these site visits was to explore the relevance of the reclaimed brick industry and its potential contribution to a circular economy. Lahore and Multan were selected as ideal locations to examine the relationship between urbanization, population growth, and the demand for construction materials. As cities expand and infrastructure development becomes increasingly crucial, the construction sector experiences a surge in the need for building materials. This trend presents a unique opportunity to investigate the role of the reclaimed brick industry in promoting sustainable practices and fostering a circular economy.

Figure removed from digital version due to copyright.

Figure 15 Built-up Lahore - Ref; (Iqbal et al., 2022)

Figure removed from digital version due to copyright.

Figure 14 Lahore urban migration 1850 – 2017 - Ref: (Nadeem et al., 2021).

Lahore, Pakistan's second-largest city, has seen tremendous population growth and urbanisation. With an average growth rate of 3%, the urban population has expanded from

861,279 in 1951 to 11.12 million in 2017. The expanding built-up area of Lahore City, which expanded from 220 km2 in 1995 to 665 km2 in 2017, reflects this expansion. The above figures show the city's growth pattern, which demonstrates a circular extension around the historic population centres outside the city wall. This fast urbanisation brings with it infrastructure and sustainability challenges (Nadeem et al., 2021, Iqbal et al., 2022).

Figure removed from digital version due to copyright.

Figure 16 Urban migration in Multan in 1997, 2007 and 2017 respectively. Ref; (Nadeem et al., 2022).

The figure shows a dramatic alteration in Multan city's built-up area over time. Figures illustrate the amount and percentage of land cover changes in Multan between 1987 and 2017. The statistics show a significant rise in built-up area, from 5795.64 hectares (16.01%) in 1987 to 22,790.20 hectares (62.96%) in 2017. Multan's rapid urbanization is being driven by causes including population increase and urban migration, leading to significant demand for construction (Nadeem et al., 2022).

Project 1 - Cold storage deconstruction

The project involved the deconstruction of an old-fashioned cold storage structure made of about 100,000 bricks. The project's location in Lahore, Pakistan, provided a great possibility for brick extraction and reuse. Practical and real-time observations were made during the site visit, offering useful insights for the research. Several images were taken on the spot to document and explain these observations. These photographs document the process of deconstruction and the condition of the bricks.

Extraction of bricks by using heavy-duty machinery:

The extraction of bricks typically involves the use of heavy-duty machinery, which helps streamline the process and increase efficiency. There are several common methods and machinery used in brick extraction, depending on the specific circumstances and location.

Figure 17 Extraction of bricks by using machinery. Reference, Author

The image above is from Thokar Niaz Baig in Lahore, Pakistan depicting the extraction of bricks using excavators. They are commonly used in brick pit operations where bricks are extracted from clay-rich soil. Excavators can handle large volumes of material and are often used to remove topsoil and overburden to access the brick-bearing layers.

Cleaning by using a chisel hammer:

Cleaning in the process:

Cleaning bricks using a chisel hammer can be a labour-intensive process but effective for removing stubborn dirt, mortar, or paint from the surface of the bricks. The image on the right depicts the bricks in the process of being cleaned.

The process involves placing the brick on a stable surface first and assessing its condition. The chisel hammer is used to gently tap the surface where there is dirt,

Figure 18 Cleaning bricks by using a chisel hammer - Ref: Author

mortar, or paint build-up, gradually increasing the force if necessary. The process is conducted systematically, starting from one corner, and moving across the surface. Loose debris is periodically brushed away, and the cleaned areas are rinsed or wiped. Stubborn spots are addressed by repeating the process, and the bricks are inspected for any remaining dirt.

After cleaning of bricks:

Figure 19 After cleaning of bricks – Ref; Author

After the bricks have been cleaned with chisels, the surface appears significantly cleaner and free from dirt, mortar, or paint build-up. The chiselling process helps remove stubborn debris, revealing the original appearance of the bricks. Depending on the extent of the cleaning and the condition of the bricks, they may require additional steps such as rinsing, wiping, or drying to ensure all residue is removed. Once the bricks are clean and dry, they can be used for various purposes such as construction, renovation, or aesthetic enhancements, depending on the specific project or application.

Sorted and ready to transport:

Figure 20 Sorted and ready to transport Reclaimed bricks – Ref, Author.

After cleaning the bricks, they are typically ready for transportation. Once the bricks have been thoroughly cleaned and any remaining debris or residue has been removed, they can be stacked or packed for transport. The cleaned bricks are usually sturdy and in suitable condition for handling and moving to their intended destination.

Project 2 - Animal farm

Project 2 featured the construction of a large-scale livestock farm made of 80,000 bricks in Multan, Pakistan. Because of the project's proximity to developing communities and active construction zones, made it highly suitable and practical to employ reclaimed bricks, aligning with the core principles of the circular economy. The site visits gave us useful information and chances to extract and repurpose other reclaimed materials too. The project exhibited rapid sales and served as a remarkable example of how circular approaches can be employed to advance sustainability.

Figure 21 Animal farm, before deconstruction - Ref; Author

Before the deconstruction:

The image shows the interior of a farm shed built of bricks for the walls, iron girders for the roof panels, and wooden supports. Materials that can potentially be utilized after deconstruction include bricks, iron girders, and timber supports. These components can be recovered and reused in other construction projects, furthering the ideals of sustainability and circular economy.

After the deconstruction process:

Figure 22 Reclaimed bricks after deconstruction process - Ref, Author.

These reclaimed bricks from the farm shed were cleaned and sorted after the deconstruction process. These bricks were then put up for sale on-site. The reclaimed bricks provided a cost-saving benefit since they were priced around 30% less than new bricks on the market. This highlights the economic viability and affordability of reclaimed materials, promoting sustainable construction practices, and supporting the circular economy principle.

Extracted reclaimed material besides bricks:

Figure 23 Extracted reclaimed material - Ref, Author.

In addition to the reclaimed bricks, the farm shed deconstruction provided additional valuable items with resale potential. Roof panels, iron girders, and wooden supports were included in these. These recovered materials from the deconstruction process were available on-site at a lesser cost compared to purchasing new supplies. By reselling these reused materials, the project not only promotes sustainability but also provided cost-effective solutions for several types of construction projects, following the circular economy principles.

Conclusion:

Site visits to the Lahore cold storage deconstruction project and the Multan animal farm project provided significant insights into the possibilities of recovered materials and their importance in supporting sustainable practices and the circular economy. The deconstruction of an old cold storage structure in Lahore revealed the viability of brick extraction and reuse. Heavy-duty machinery was used for efficient extraction, followed by cleaning with chisel hammers to remove dirt, mortar, and paint from the bricks. The cleaned bricks were sorted, ready for sale, and priced lower than the new bricks on the market. This emphasised the economic benefit of reclaimed materials as well as their potential contribution to sustainable construction

techniques.

Similarly, Multan's animal farm project demonstrated the large-scale utilisation of reclaimed bricks in a practical context. The proximity of the project to active construction sites, as well as the availability of other reclaimed materials like roof panels, iron girders, and timber supports, presented additional options for sustainable practices and cost-effective solutions. The successful resale of these materials highlighted their monetary worth as well as the benefits of incorporating circular economy principles into construction projects.

Overall, the importance of reclaiming and reusing materials as a realistic approach for reducing waste, preserving resources, and encouraging sustainable development was emphasized by both site visits. The results of these visits provide helpful models for upcoming projects, promoting the use of principles of circularity and promoting a more sustainable and environmentally friendly construction industry.

Chapter 6

Analysis and Discussions

6.1 Triple Bottom Line (TBL):

The Triple Bottom Line (TBL) offers the construction industry well-defined policies and action plans, contributing significantly to a more sustainable future. TBL's practical concepts are successfully aligned with the building industry's common environmental aims (Goh et al., 2020). The TBL framework is implemented to analyse and discuss the reclaimed brick sector in Pakistan and its sustainability performance. The TBL, incorporating economic, social, and environmental aspects, provided an extensive approach to assess the industry's influence on long-term development. This has helped to discuss in-depth insights into the role of the reclaimed brick industry in achieving economic sustainability, social well-being, and environmental sustainability by analysing the qualitative findings.

6.1.1 Social sustainability:

Sustainable construction is the use of sustainable development concepts across the whole construction life cycle, from planning and material extraction to waste management and demolition. The social sustainability objective is to maintain collaboration between the environment and the construction site. To achieve social sustainability objectives such elements as health, human rights, education, security, culture, accessibility, integrity, and stakeholder participation are crucially linked with construction activities (Kamaruddin et al., 2020).

The Triple Bottom Line (TBL) framework provides a complete way to evaluate sustainability performance, and the concept of sustainability has attracted substantial attention in the construction industry. The purpose of this discussion is to investigate the social component of sustainability in the context of Pakistan's reclaimed brick operations. With these discussions, it will give an insight into the social implications and limitations of sustainable construction techniques by examining qualitative data.

Human rights:

Construction-related activities offer safe working conditions, but it also involves preventing the employment of child labour, which can cause social unrest and harm the government's status (Kamaruddin et al., 2020). The findings reveal instances of human rights breaches in Pakistani brick kilns, including the use of child labour and forced labour. Such violations not only deteriorate societal norms but also harm businesses' reputations. Addressing these issues

is critical for promoting social sustainability in the building sector and ensuring human rights protection.

Health and Safety:

Sustainable construction aims to create a clean and healthy, pollution-free environment, this ensures the community's well-being (Kamaruddin et al., 2020). The findings, however, highlight environmental problems, such as pollution created by brick kilns, which causes school and business closures. This is a key barrier to accomplishing social sustainability goals. Exploring alternate transportation technologies and approaches, such as using smaller vehicles, can help to reduce these difficulties and enhance health and safety outcomes.

Accessibility:

The concept of accessibility is important in achieving social sustainability. It involves providing simple access for the community of the neighbourhood, involves providing simple transportation alternatives and ensuring smooth traffic patterns near the construction site, (Kamaruddin et al., 2020). Accessibility is an important feature of social sustainability in construction. The usage of tractor-trolleys for brick transportation presents difficulties, such as frequent accidents and traffic congestion in tight streets. Using more efficient transportation systems can improve accessibility, decrease negative neighbourhood impacts, and contribute to social sustainability.

Education and Development:

According to Kamaruddin et al., (2020) providing construction employees with training and development programs could be a critical role in reducing skills-related hurdles. The achievement of sustainable building goals might be hampered by insufficient skill training supplied by workers or contractors (Kamaruddin et al., 2020). Training and development programs for construction employees are critical for overcoming skill-related obstacles and reaching sustainable building goals. The findings emphasize the need for modern equipment and technology in the deconstruction industry, as well as contractors' reluctance to embrace them owing to a shortage of skilled staff. By assuring worker well-being and safety, training programs that promote a safe and clean workplace can improve social sustainability.

Integrity and Compliance is a critical aspect in construction-related activities, given the status of stakeholders' backgrounds, compliance with legislation and laws should be a top concern (Kamaruddin et al., 2020). Findings indicated that "Associations of Pakistan kilns owners" hold significant influence with strong political backing, often neglect SOPs and consume hazardous chemicals during brick production which causes serious environmental pollution. However, Integrity and legal compliance are critical for establishing social sustainability in construction. Noncompliance and the use of hazardous chemicals in brick manufacturing offer considerable issues. Strict adherence to rules and regulations is required to encourage sustainable building methods and safeguard stakeholders' well-being.

Stakeholders' Awareness and Involvement:

The findings reveal the significance of the perception, mindset, and awareness in promoting social sustainability in the construction industry of Pakistan. According to Kamaruddin et al. (2020), a construction project's social sustainability depends on the participation of all groups. It enables the integration of social cooperation and helps in striking a balance between development ideas and societal demands (Kamaruddin et al., 2020). It's crucial to develop an awareness among the local community of Pakistan to utilize reclaimed bricks and other materials in their project for their benefits and overall sustainability. Society understands the social implications and desires a change from existing construction procedures until there is awareness, (Kamaruddin et al., 2020). Goh et al., (2020), emphasized on involving stakeholders, in such a collaborative platform at the project level is seen as critical for successful stakeholder interaction (Goh et al., 2020). Therefore, stakeholder involvement from the start of a project increases the acceptability of reuse procedures and lessens scepticism from those who are new to the idea.

To sum up, Human rights, health and safety, accessibility, education and development, integrity, and stakeholder participation are all part of the social component of sustainability in Pakistan's reclaimed brick operations. Addressing the issues raised in this study is crucial for achieving social sustainability and the well-being of communities and stakeholders. The construction industry in Pakistan could move towards a more socially sustainable future by implementing sustainable construction techniques and actively incorporating stakeholders.

6.1.2 Economic sustainability:

In the construction industry, "economic sustainability" refers to the potential of specific projects to generate profits and benefit all project stakeholders, Goh et al., (2020). According to the study's findings, Pakistan's construction industry is suffering economic constraints and high material costs, resulting in fewer active projects and rising unemployment. The economic component of the Triple Bottom Line (TBL) concept focuses on financial sustainability and economic performance optimization. The findings have various economic consequences in the context of the deconstruction and reuse of construction materials:

Business opportunity:

It is essential to develop business models that not only promote reuse solutions but also offer significant overall impact while being economically feasible to achieve economic sustainability. (Nußholz & Whalen, 2019). The study's findings shed light on the considerable impact of growing raw material prices and the closure of brick kilns in Pakistan on the construction industry. The doubling of new brick prices has made construction projects more difficult, resulting in greater production costs for brick kilns and decreasing market demand. This has resulted in a brick supply shortage, leading development projects to be delayed and costlier. The sector is dealing with rising costs and supply constraints, forcing the investigation of alternative cost-effective alternatives.

The utilization of recovered construction materials, particularly reclaimed bricks, is one solution that came from the research. According to the study, reclaimed bricks are 30% cheaper than new bricks, demonstrating their economic viability as a cost-effective alternative. This conclusion is significant for developers looking for low-cost solutions to the economic crisis difficulties. The study also looked into the possibility of circular business models (CBMs) in the construction industry. Adopting a circular business model is in line with efficiently recycling resources and collecting value. CBMs stress the integration of existing resources and recycled products in the flow of resources, materials, and products, as opposed to the standard linear business model, which concentrates on the sale of products and the flow of resources in a linear way. This strategy increases sustainability and resource efficiency while also providing new economic prospects.

The study highlighted deconstruction activity and a desire for reused construction materials as

important drivers of reclaimed construction material business viability. Participants recognized the economic potential of capitalizing on recovered material demand and using their industry knowledge and building experience. Participants were able to create profitable businesses that contribute to resource efficiency and sustainability by embracing the ideas of a circular economy. Profit margins in the reclaimed construction material sector were discovered to be large, emphasizing the financial possibilities of implementing a circular business model. This discovery motivates entrepreneurs and contractors to take advantage of the opportunity and pursue long-term enterprises in the construction businesses. Businesses can address economic issues while also contributing to a more sustainable and environmentally friendly building sector by using CBMs and supporting material reuse.

Another study highlighted "the deconstruction of the Coca-Cola plant in Vienna, which is said to be Austria's first large-scale deconstruction project. The operation used ecologically friendly and non-destructive disassembly procedures, resulting in a €100,000 profit for the building's owners, a group of eight property developers. More than 5,000 roof panels were effectively repurposed as thermal insulation on-site, as were around 3,000 square meters of an enormous green roof (Schützenhofer et al., 2022).

Employment opportunity:

Considering the findings, it's essential for understanding the opportunities and challenges faced by the construction industry. First off, the construction labourers' financial struggles by the high unemployment rates and lack of employment prospects in the construction industry. Job instability and uncertainty are a result of economic crises and the high cost of construction supplies. However, the results also show individuals who involve in deconstruction labour have some financial security and career possibilities. This shows the potential economic advantages of working in the deconstruction and reclaimed resources sector, giving employees and their families a steady source of income, and enabling them to meet their basic needs.

Moreover, the deconstruction industry gives a chance for new entrants since extensive training is not often necessary. New workers may pick up the required skills quite quickly, especially if specialist deconstruction equipment is not involved. One participant told a remarkable tale of a team member who was a drug addict and when joined the industry and was able to effectively change their life via their job in deconstruction. These results highlighted the

fundamental value of construction and the simplicity with which new workers may enter the deconstruction sector.

Logistical management:

Optimizing the economic performance of reclaimed brick transportation requires effective logistics management. Participants in the study highlighted the importance of smaller modes of transportation, such as motorcycle rickshaws and carts, as cost-effective and convenient solutions for delivering bricks, particularly in metropolitan areas. Transportation expenses could be decreased by implementing effective logistics solutions, which contributes to greater economic sustainability.

Case example: The Urban Lakeside Aspern project is an actual illustration of the economic benefits that may be realized via proper transportation management. The project developers lowered transportation costs and prevented the need to acquire materials from outside sources by forming a logistics company and managing huge volumes of excavated materials on-site. This technique resulted in economic advantages and improved project financial sustainability (Schützenhofer et al., 2022).

In general, transportation economics in the context of reclaimed bricks involves considering financial implications into account, optimizing logistics, and drawing up principles from successful case studies. Stakeholders can ensure cost-effective transportation of reclaimed bricks and promote economic sustainability in the construction industry by addressing these issues within the TBL's economic component.

6.1.3 Environmental Sustainability:

TBL’s environmental measurements entail evaluating the condition of natural resources and the variables affecting their sustainability. These measurements consider indications such as energy usage, water and air quality, availability of natural resources, handling of solid and hazardous waste, and patterns of land use and cover (Slaper and Hall, 2011).

According to the study's results, brick kilns in Pakistan contribute considerably to an environmental emergency, because of the gases that they generate. These emissions, which are characterized by thick smoke that engulfs the sky and adjacent surroundings, constitute a

significant environmental threat. With strong governmental backing, the Brick Kilns Owners Association Pakistan frequently disregards standard operating procedures (SOPs) and uses hazardous compounds during brick manufacture, worsening environmental degradation.

The Triple Bottom Line (TBL) framework's environmental component highlights the necessity of limiting negative environmental consequences and supporting sustainable practices. The findings highlight many environmental issues and potential in the context of Pakistan's reclaimed brick sector:

Emissions and Air Pollution:

The study's findings show that brick kilns in Pakistan release considerable amounts of harmful emissions, resulting in poor air quality and health issues, which is consistent with the findings of Subhanullah et al. (2022). Despite the well-established link between air pollution and community health challenges, Pakistan has paid little attention to this issue. The contribution of brick kiln emissions to air pollution and haze in Pakistan emphasizes the need of tackling this issue not only for the local environment but also for public health. To enhance the industry's environmental sustainability, it is critical to focus on lowering emissions and incorporating cleaner technologies or alternative materials into the brick-making process. By doing so, the negative impact on air quality and related health risks may be reduced, resulting in a healthier and more sustainable environment.

Soil Degradation and Agriculture:

The findings of the research about the negative effects of clay extraction for brick manufacture on soil composition and fertility are consistent with the need of implementing sustainable land use practices and researching alternate raw material sources, as identified by Rutherford and Luby (2018). The negative effects of soil removal, as stated by farmers in terms of decreased crop yield and revenue, highlight the serious implications for agricultural productivity and food security.

Both studies highlight the need of addressing these issues and promoting environmental sustainability in the context of brick manufacture. Implementing sustainable land use techniques can help prevent negative consequences on soil composition and fertility, assuring agricultural land preservation for future production. Furthermore, investigating alternate raw

material sources for brick manufacture can lessen reliance on clay extraction from agricultural land, hence reducing environmental and agricultural hazards. Considering Rutherford and Luby (2018)'s insights and the early result of this study indicate that establishing sustainable land use practices and investigating alternative raw material sources are critical steps toward achieving environmental sustainability in the brick production industry. These activities not only assist in reducing both the short- and long-term impacts on crop production and food security, but they also help to save resources and promote a more resilient and environmentally friendly agricultural system.

Waste Management:

In the construction industry, proper waste management is critical, including the treatment and disposal of building debris, particularly bricks. Inadequate trash disposal techniques, such as dumping building materials in unsuitable areas, lead to hideous circumstances and encourage further trash dumping. Encouragement of reclaimed brick reuse and recycling may significantly decrease waste and lessen the environmental impact.

Transportation Challenges:

The transportation constraints of transporting reclaimed bricks, as well as the idea of green distribution, are consistent with the concepts mentioned in the study by (Benmamoun, Zoubida, and Hachimi, 2017). The logistical challenges of transporting reclaimed bricks, particularly in densely populated areas, underscore the importance of efficient transportation infrastructure. The research emphasizes transportation operations optimization by shortening travel routes, eliminating trips and empty returns, and assessing the transportation network. These solutions are consistent to increase the environmental efficiency of brick transportation.

Furthermore, the problem of traffic congestion produced by the usage of tractor trolleys for brick distribution is consistent with the study's emphasis on reducing negative environmental consequences. The research emphasizes the significance of investigating alternate transportation solutions to meet present car restrictions, particularly in metropolitan locations. Businesses may reduce road congestion, noise pollution, and other negative environmental consequences connected with brick transportation by adopting sustainable transportation choices and utilizing green distribution methods.

In conclusion, the study's findings highlight various environmental challenges and potential in Pakistan's reclaimed brick business. Addressing these difficulties by the TBL paradigm demands a focus on decreasing emissions, encouraging sustainable land use practices, improving waste management, optimizing transportation logistics, and limiting traffic congestion and noise pollution. The building industry may help Pakistan achieve a more sustainable future by incorporating environmental sustainability into the industry.

construction materials. Furthermore, the deconstruction and reuse of building materials. The study included successful deconstruction initiatives example the "Coca-Cola plant in Vienna, have resulted in significant profits for real estate developers".

Finally, focus on the environmental sustainability aspect. In several regions, the environmental effect of brick kilns, particularly emissions and air pollution, is a considerable concern. Reclaimed bricks are a more sustainable option since they reduce pollutants and improve air quality. The building sector may reduce the negative impact on air quality and public health by using cleaner technology and alternative materials in the brick-making process. Environmental sustainability is further supported by sustainable land use practices and the investigation of alternate raw material sources. Soil damage and agricultural issues result from clay extraction for brick manufacturing. Implementing sustainable land use strategies and exploring alternative raw material sources helps in the preservation of soil fertility, the protection of agricultural land, and the promotion of a more resilient agricultural system. Effective waste management, including the reuse and recycling of reclaimed bricks, decreases waste and has a low environmental effect. Furthermore, improving transportation logistics and implementing sustainable mobility options help to reduce road congestion, noise pollution, and carbon emissions connected with brick transportation.

Ultimately, the utilization of reclaimed bricks in construction projects enhances environmental, social, and economic sustainability. Socially, it guarantees safe working conditions, respects human rights, improves health and safety results, increases accessibility, promotes education and development, and encourages stakeholder engagement. Economically, it provides reducing cost options, increases business expansion, generates job opportunities, and optimizes logistical management. Environmentally, it minimizes emissions and air pollution, solves soil

degradation and agricultural difficulties, improves waste management, optimizes transportation logistics, and reduces traffic congestion and noise pollution. Therefore, Reclaimed bricks have the potential to improve environmental, social, and economic sustainability.

6.2 Resource efficiency:

According to the United Nations, resource efficiency means reducing the environmental effect of product use and production over their full life cycles by supporting sustainable practices. As well as. resource efficiency promotes greater well-being while utilising fewer materials, therefore respecting the Earth's natural constraints. Apart from protecting natural resources, a resource-efficient circular economy promotes economic activity by using materials more effectively, businesses can lower manufacturing costs which leads towards seamless transition and prospects for economic gain, (Ewijk, 2018).

The formula **"(Energy - Efficiency + Material - Efficiency) = Resource – Efficiency"** describes the relationship between energy efficiency and material efficiency and highlights the contribution to overall resource efficiency. The formula emphasises the significance of both energy and material when assessing the sustainability and resource efficiency of reclaimed bricks as a resource-efficient construction material for the industry.

6.2.1 Energy Efficiency:

A key component of sustainable building is energy efficiency, and utilizing reclaimed bricks offers an opportunity for reducing carbon emissions. According to Hussain and Arif Kamal (2015), the embodied energy of construction materials is the total amount of energy used throughout the course of a material's complete life cycle, including extraction, processing, transportation, and assembly.

Traditional brick production operations are known to emit considerable amounts of greenhouse gasses, mostly from manufacturing and transportation activities. With about 16,000 brick kilns functioning in Pakistan, the South Asian brick sector alone accounts for more than a fifth of world brick production, generating a concerning 5,700 tons of CO2 yearly (Rauf et al., 2022; Lodi et al., 2013). The manual manufacturing process of reclaimed bricks, on the other hand,

offers a resource-efficient option which could significantly decrease emissions. According to research, reclaimed bricks are becoming increasingly popular because of their affordability. This increasing demand reduces the use of traditional bricks, which are associated with higher carbon emissions.

The Resource Rows construction project in Denmark is a proven example of the environmental benefits of employing reclaimed bricks. The architects of Lendager Group worked on this project, which included the construction of 63 apartments and 29-row homes over a total area of nearly 9,000 square meters. The architects projected that utilizing reclaimed bricks prevented around 500g of CO2 emissions from being emitted into the environment. As a result, the carbon footprint of the Resource Rows project was around 12% lower than that of conventional new construction (Sub. Urbanist, 2020).

Furthermore, transportation is an important part of construction logistics in terms of energy efficiency. In Pakistan, traditional brick kilns frequently rely on outdated tractor trolleys for transporting bricks, resulting in high diesel consumption and smoke emissions. However, a study revealed an alternate method used by contractors transporting reused bricks. Instead of traditional tractor-trolleys, these contractors use smaller vehicles like motorbike rickshaws and carts, which are more fuel-efficient and emit less pollution (Fredriksson & Huge-Brodin, 2022). The construction industry may successfully cut transportation-related carbon emissions by using recycled bricks and smaller vehicles for transportation. This strategy not only cuts fossil fuel usage but also helps to reduce overall carbon emissions in the construction industry.

6.2.2 Material Efficiency:

Material efficiency is critical to achieving sustainability and resource conservation in the building sector. Site visits to the Lahore cold storage deconstruction project and the Multan animal farm project shed insight into the possibilities of recovered materials in attaining material efficiency and fostering a circular economy.

The extraction and reuse of bricks demonstrated the potential of material efficiency during the dismantling of the cold storage facility in Lahore. The use of heavy-duty equipment permitted fast extraction, while the cleaning procedure removed dirt and mortar from the bricks. The cleaned bricks were then sorted and made available for resale at a lesser price than fresh bricks.

This not only highlighted the economic benefits of employing reused materials but also their potential contribution to sustainable construction methods.

Similarly, the Multan animal farm project showcased the use of reclaimed bricks and other materials on a massive scale. The project's proximity to active construction zones allowed for the use of reclaimed materials such as roof panels, iron girders, and timber supports. This use of reclaimed supplies provided realistic choices for increasing material efficiency and developing cost-effective solutions. The successful resale of these materials demonstrated not just their monetary value, but also the advantages of incorporating circular economy ideas into construction projects. These site visit findings emphasized the necessity of reclaiming and reusing materials as an efficient technique for attaining material efficiency. The utilization of reclaimed bricks enables a cost-effective solution to fluctuate raw material costs, maintaining project stability and resolving affordability issues. It also decreases waste formation and the need for new brick manufacture, resulting in environmental benefits such as decreased landfill effect and resource conservation.

Construction projects that include material efficiency measures and reclaimed supplies can help to make the industry more sustainable and resource conscious. Adopting circular economy concepts enhances material efficiency, lowers waste, and encourages a more ecologically responsible approach to building. These findings give useful industry insights, supporting the wider adoption of material efficiency measures and creating a sustainable building sector.

Chapter 7

Conclusion, Recommendations, limitations, and further research:

RQ1 - How does the use of reclaimed bricks in a construction project promote environmental, social, and economic sustainability?

Let's get started by discussing social sustainability. Health, human rights, education, security, culture, accessibility, integrity, and stakeholder engagement are all aspects of social sustainability in construction. In a variety of ways, the utilization of reclaimed bricks can contribute to social sustainability. For example, the construction industry could maintain a safe and ethical working environment by addressing human rights concerns such as the use of child labour and forced labour at brick kilns. This not only respects cultural standards but also improves the reputation of construction-related businesses. Furthermore, sustainable construction approaches strive to produce a clean and healthy environment, encouraging community well-being. Accessibility is an important part of social sustainability, and the effective transportation of reused bricks may improve accessibility, decrease traffic congestion, and limit negative consequences on local communities. Furthermore, by offering construction workers training and development opportunities, the industry could remove skill-related barriers and promote social sustainability through workforce empowerment. Finally, integrity and regulatory compliance are critical for developing social sustainability, assuring stakeholder well-being, and preserving ethical practices in the construction business.

Moving on to economic sustainability, the utilization of reclaimed bricks opens several possibilities. One of the primary benefits is the lower cost as compared to new bricks. According to this study's findings, reclaimed bricks can be up to 30% less costly than new bricks, providing developers and builders with considerable cost-saving potential. This cost advantage presents an opportunity for contractors to supply the need for low-priced.

RQ2 - Can reclaimed bricks be a sustainable and resource-efficient material for the construction industry?

The results of the study suggest that reclaimed bricks will be a resource-efficient and sustainable construction material. The notion of resource efficiency, which involves reducing the environmental effect of product usage and manufacturing, encourages the use of recovered resources. Construction projects that employ reused bricks can minimize carbon emissions and reliance on typical brick production processes, which are known to generate considerable quantities of greenhouse gases.

The Resource Rows construction project in Denmark exemplifies the environmental advantages of employing reused bricks. The architects calculated that by using recycled bricks, they were able to avoid around 500g of CO2 emissions, resulting in a 12% smaller carbon footprint than traditional new buildings. Furthermore, transporting reclaimed bricks in smaller vehicles such as motorbike rickshaws and carts adds to energy efficiency and lowers carbon emissions in the construction sector. Another critical part of sustainability is material efficiency, and site visits to the Lahore cold storage deconstruction project and the Multan animal farm project revealed the possibilities of employing reused materials to achieve material efficiency. The extraction and reuse of bricks from the cold storage facility demonstrated the economic benefits and possibilities for sustainable construction using reclaimed materials. The Multan animal farm project also demonstrated the widespread use of reused materials like roof panels, iron girders, and timber supports, encouraging material efficiency and cost-effective solutions.

Overall, the utilization of reclaimed bricks in construction projects has various advantages. It helps to stabilize construction costs by avoiding new product price volatility, eliminates waste by reusing existing resources, and contributes to a circular economy approach. By adopting material efficiency methods and reused materials, the building industry may advance toward a more sustainable and resource-efficient future. These findings provided useful insights for the industry and contributed to the widespread implementation of material efficiency measures in construction.

7.1 Conclusion:

Reclaimed bricks have emerged as a topic of interest in the construction industry, prompting questions about their suitability as a sustainable and resource-efficient material for the circular construction approach. The research questions mentioned in Chapter 1 about the potential of reclaimed bricks to fulfil the requirements of circular construction practices. By examining their life cycle, durability, and adaptability, it becomes crucial to assess whether reclaimed bricks can effectively contribute to resource conservation and minimize waste generation. While the research for the second question delves into the broader impacts of using reclaimed bricks in construction projects. Exploring the environmental, social, and economic dimensions of sustainability, it was important to understand how the utilization of reclaimed bricks can

positively influence each of these aspects. This included evaluating their potential to reduce carbon emissions, conserve natural resources, promote social equity, and create economic opportunities through job creation and cost savings.

The study in this dissertation investigated the potential adoption of circular economy methods in the construction industry, especially with the utilization of reclaimed bricks to answer the research questions. The research has shown that reclaimed bricks are a sustainable and resource-efficient solution for the construction industry, adhering to resource efficiency and circular economy concepts. The findings of this study support the idea that utilizing reclaimed bricks in the construction industry could help to achieve sustainability goals. The construction industry may help to create a more resource-efficient and resilient built environment in Pakistan as well as around the world by reducing environmental impact, preserving resources, and supporting circular economy principles. Moreover, the inclusion of theoretical frameworks such as the Resource Efficiency theory and the Triple Bottom Line (TBL) approach offered valuable insights into the possible advantages and limitations of using reclaimed bricks in construction. However, it’s important to recognize the limits of this study, though. The study's conclusions might not be immediately relevant to other areas or environments because it was done specifically within the context of Pakistan's construction industry. Additional research will be needed to investigate the long-term effects and scalability of using reclaimed bricks in substantial construction projects.

In conclusion, utilizing reclaimed bricks in construction offers an attractive approach toward environmentally friendly construction by enhancing resource efficiency, reducing waste, and promoting circular economy principles. This study emphasizes how crucial it is for the construction industry to adopt sustainable solutions to achieve a built environment that is socially inclusive, environmentally conscious, and economically feasible. The construction industry may significantly contribute to the development of a more sustainable future by recognizing the potential of reclaimed bricks and embracing circular economy concepts.

7.2 Limitations of the research:

Due to a lack of literature, developing a more solid theoretical framework was also difficult. Researchers might strengthen the theoretical foundation by incorporating larger sustainability frameworks or ideas. Finally, broadening the study to other nations and involving different

stakeholders will offer a more complete picture. Future studies can help to a better understanding of recycled bricks' potential in promoting sustainability in the construction industry by overcoming these constraints. The study had some limitations that provided the potential for improvement. For starters, the dearth of literature explicitly focused on recycled bricks in buildings hampered the study's grasp of their potential advantages. To solve this, future studies might perform a more extensive literature analysis, examining related themes such as sustainable construction and the circular economy. Second, the difficulties in presenting the research goal and sustainability principles to illiterate construction workers hampered data gathering. Visual aids, simpler language, and participatory ways can help to overcome this. Furthermore, the dearth of research on recovered bricks in the context of the circular economy limited the scope of the study. Future studies can go deeper into the circular economy notion, considering other building materials as well.

7.3 Recommendation:

The following key recommendations are derived from the findings of this research focused on sustainable construction practices in Pakistan. The study, based on qualitative research and expert insights, highlights critical areas that require attention and improvement to promote sustainable development and ensure worker safety within the construction industry. By implementing these recommendations, Pakistan's reclaimed brick industry can promote sustainable development, improve the quality of reclaimed materials, and ensure safer working conditions for construction workers.

7.3.1 Stakeholder’s Engagement and Social Awareness:

One common recommendation found while exploring the literature of this study is that it is the responsibility of the local government to introduce policies to encourage their citizens towards sustainable development. However, in developing countries such as Pakistan, where political instability and uncertainties are always high, announced sustainability objectives are often nothing more than a political tool used to gain votes in elections. Therefore, based on research findings, it is recommended that the local government should not be solely responsible for providing an effective strategy or policy towards sustainable construction practices. Instead, the application of stakeholder theory is recommended in this regard, wherein collective efforts can be employed to create a sense of sustainable construction within the community.

According to Bal et al., (2013) engaging with stakeholders is crucial in achieving effective outcomes as building projects grow more globally diversified. Although some stakeholders, such as the client and primary contractor, are frequently seen as essential, there are others whose value may be disregarded, making it difficult to address sustainability problems. As a result, it's crucial to use an organized strategy when engaging with stakeholders that have a significant impact on sustainability (Bal et al., 2013).

Furthermore, the qualitative findings of engineers reveal that citizens' perception or mindset regarding the use of extracted material from deconstructed sites in their construction projects is an obstacle towards achieving sustainable construction objectives in Pakistan. Research participants suggest that it's important to raise awareness among the community that the utilization of reclaimed construction material can provide economic, social and environmental benefits not only for individuals but for the whole community in Pakistan. Therefore, adopting the stakeholder theory can help identify relevant local media platforms, influencers, and notable personalities, connect them with the sustainability target and put the target into action, for instance, creating awareness of sustainable construction in Pakistan by utilization of reclaimed construction material e.g., reclaimed brick.

In conclusion, while local governments are surely responsible for implementing policies for sustainable development, political instability in developing countries such as Pakistan makes it impossible to rely completely on them. Thus, stakeholder theory practice is recommended to help in identifying key individuals in the community and encouraging a collaborative effort toward sustainable construction methods.

7.3.2 Optimising Quality Assurance of Reclaimed Bricks in Pakistani Construction:

Findings from a qualitative study involving subject matter experts (engineers) highlight the need for establishing a formal or technical mechanism to enhance the quality of reclaimed bricks in new construction projects in Pakistan. Although contractors possess the skills and capabilities to deconstruct infrastructure without formal plans or instructions, it is crucial to implement such mechanisms to ensure quality standards. According to Gu et al. (2023), the effectiveness of green building objectives is directly impacted by contractors, who play a significant role in putting green construction methods into effect. Green construction

management and technologies are demanding more from contractors than traditional building methods; however, contractors still have limited access to these resources (Gu et al., 2023).

A strong recommendation is made to implement a technical mechanism for reclaimed materials, aiming to enhance contractor capabilities and facilitate the adoption of sustainable construction practices on a larger scale in Pakistan. To achieve this, it is suggested that contractors receive appropriate training and educational campaigns focusing on the deconstruction process and quality testing of reclaimed bricks. The involvement of subject matter experts and relevant institutions would further contribute to strengthening the capabilities of contractors in Pakistan.

7.3.3 Health and Safety:

Since the deconstruction process is mainly based on manual work and requires physical Laboure. The qualitative findings that workers find it challenging when it's required to dismantle strong walls with a hammer and chisel and Injuries also take place. However, findings also revealed that workers may find deconstruction of the field financially sufficient in which they can fulfil their basic needs and maintain a steady life however, work, despite the fact they are unable to save much to address health-related emergencies or any other situation. Referring to the preceding study, it is evident that monitoring and implementing agencies have expressed frustration and dissatisfaction with the absence of a construction regulatory authority in Pakistan. This regulatory body would be responsible for overseeing health, safety, and environmental standards on construction sites, like regulatory bodies such as OSHA in the United States or Safe Works in Australia. Practical steps have not yet been implemented, despite the Pakistan Engineering Council's (PEC) efforts to address this issue by organizing meetings and awareness seminars at the municipal and academic levels. Construction health and safety law was introduced by the Ministry of Planning Commission in 2017, but it failed to make it to the parliament for discussion, ratification, or implementation. As a result, when accidents occur, no penalties are applied, and the industry finds it difficult to follow the internationally accepted safety requirements (Azeem et al., 2020).

To address this issue, it is recommended that all stakeholders, including the government, contractors, and clients, collaborate to ensure construction worker safety in Pakistan during the processing of reclaimed materials. The establishment of health and safety regulations, which

currently lack in Pakistan, and their strict enforcement is strongly recommended. To effectively monitor and enforce compliance with safety requirements, it is crucial to establish a regulatory organization. Additionally, there is a pressing need to enhance the knowledge and training of workers and contractors in construction health and safety. Encouraging the construction industry in Pakistan to voluntarily adopt safety regulations and standards aligned with international best practices can promote self-regulation. Implementing these recommendations would result in the promotion of safer working conditions for construction workers and the adoption of environmentally friendly deconstruction practices in the construction industry of Pakistan.

7.4 Further research:

Further research could integrate masonry aspects and evaluate the impact of reclaimed bricks after their utilization in construction projects in Pakistan. For instance, a comparative study should be conducted between new bricks and reclaimed bricks. The research should thoroughly investigate and evaluate the outcome of both projects considering the three pillars of sustainability: Environment, Social, and Economic. The proposed strategy would offer a thorough evaluation of the advantages and disadvantages of utilizing reclaimed bricks as compared to new bricks. It would provide a better understanding of the effects on the environment, including energy use, carbon emissions, and waste reduction, as well as the social elements, including stakeholder views, community involvement, and local job prospects. In addition, it is important to carefully consider all the economic factors, such as cost analysis, material savings, and long-term financial significance. The research will offer useful insights into Pakistan's construction industry by considering these three sustainability pillars while carrying out a comparative assessment. When making decisions, it would be helpful to consider the environmental effect, impact on society, and financial sustainability of using reclaimed bricks.

8. References:

8.1 Journals:

Abbasi Kamardi, A. et al. (2022) "Developing sustainable competitive advantages from the lens of resource-based view: Evidence from it sector of an emerging economy," Journal of Strategic Marketing, pp. 1–23. Available at: https://doi.org/10.1080/0965254x.2022.2160485.
ABRELPE, 2018. Panorama dos resíduos solidos no Brasil 2017. Available at: http:// abrelpe.org.br/panorama/

Adams, W.C. (2015) "Conducting semi-structured interviews," Handbook of Practical Program Evaluation, pp. 492–505. Available at: https://doi.org/10.1002/9781119171386.ch19.

Afzal, M., Maqsood, S. and Yousaf, S. (2017) "Performance Evaluation of Cost Saving Towards Sustainability in Traditional Construction Using Prefabrication Technique," International Journal of Research in Engineering and Science (IJRES), 5(5).

Akanbi, L.A., Oyedele, L.O., Akinade, O.O., et al., 2018. Salvaging building materials in a circular economy: a BIM-based whole-life performance estimator. Resour. Conserv. Recycl. 129, 175e186. https://doi.org/10.1016/j.resconrec.2017.10.026

Aldebei, F. and Dombi, M. (2021) "Mining the built environment: Telling the story of Urban Mining," Buildings, 11(9), p. 388. Available at: https://doi.org/10.3390/buildings11090388.

Allam, A.S. and Nik-Bakht, M. (2023) 'From demolition to the deconstruction of the built environment: A synthesis of the literature', Journal of Building Engineering, 64, p. 105679. doi 10.1016/j.jobe.2022.105679.

Almssad, A., Almusaed, A. and Homod, R.Z. (2022) "Masonry in the context of sustainable buildings: A review of the brick role in architecture," Sustainability, 14(22), p. 14734. Available at: https://doi.org/10.3390/su142214734.

Alonso-Muñoz, S. et al. (2021) "Building exploitation routines in the circular supply chain to obtain radical innovations," Resources, 10(3), p. 22. Available at: https://doi.org/10.3390/resources10030022.

Amin, F., Muhammad , A.M. and Alam, F.-e- (2020) "Sustainable construction and demolishing waste management: A Case Study in Pakistan," 2nd Conference on Sustainability in Civil Engineering (CSCE'20) [Preprint].

Aniyikaiye, T.E. et al. (2021) "Traditional brick making, environmental and socio-economic impacts: A case study of Vhembe District, South Africa," Sustainability, 13(19), p. 10659. Available at: https://doi.org/10.3390/su131910659.

Arora, M. et al. (2021) "Urban mining in buildings for a circular economy: Planning, process and feasibility prospects," Resources, Conservation and Recycling, 174, p. 105754. Available at: https://doi.org/10.1016/j.resconrec.2021.105754.

Arshad, H. et al. (2018) "Quantification of material wastage in the construction industry of Pakistan: An analytical relationship between building types and waste generation," Journal of Construction in Developing Countries, 22(2), pp. 19–34. Available at: https://doi.org/10.21315/jcdc2017.22.2.2.

Averina, E., Frishammar, J. and Parida, V. (2021) "Assessing sustainability opportunities for circular business models," Business Strategy and the Environment, 31(4), pp. 1464–1487. Available at: https://doi.org/10.1002/bse.2964.

Awan, A.G. (2019) "IMPACT OF MINIMUM WAGE POLICIES ON POVERTY ALLEVIATION IN PAKISTAN," Global Journal of Management, Social Sciences and Humanities, 5(2). Available at: https://doi.org/https://orcid.org/0000-0001-5767-6229.

Azeem, M. et al. (2020) 'Competitiveness in the construction industry: A contractor's perspective on barriers to improving the construction industry performance', Journal of Construction Engineering, Management & Innovation, 3(3), pp. 193–219. doi:10.31462/jcemi.2020.03193219.

Bal, M. et al. (2013) 'Stakeholder engagement: Achieving sustainability in the construction sector', Sustainability, 5(2), pp. 695–710. doi:10.3390/su5020695.

Bertino, G. et al. (2021) "Fundamentals of building deconstruction as a circular economy strategy for the reuse of construction materials," Applied Sciences, 11(3), p. 939. Available at: https://doi.org/10.3390/app11030939.

Biswas, D., Gurley, E. S., Rutherford, S., & Luby, S. P. (2018). The Drivers and Impacts of Selling Soil for Brick Making in Bangladesh. Environmental management, 62(4), 792–802. https://doi.org/10.1007/s00267-018-1072-z

Bose, B.P. (2022) "State-of-the-art on Recycling of Construction and Demolition Waste in a Circular Economy: An Approach Towards Sustainable Development," International Journal of Earth Sciences Knowledge and Applications [Preprint]. Available at: https://dergipark.org.tr/en/download/article-file/2864431 (Accessed: February 23, 2023).

Braun, V. and Clarke, V. (2006) "Using thematic analysis in psychology," Qualitative Research in Psychology, 3(2), pp. 77–101. Available at: https://doi.org/10.1191/1478088706qp063oa.

Brennan, J. et al. (2014) "A closed-loop system of construction and Demolition Waste Recycling," Proceedings of the International Symposium on Automation and Robotics in Construction (IAARC) [Preprint]. Available at: https://doi.org/10.22260/isarc2014/0066.

Bronitsky, L. and Wallace, W.A. (1974) "The economic impact of urbanization on the Mineral Aggregate Industry," Economic Geography, 50(2), p. 130. Available at: https://doi.org/10.2307/142960.

Bynum, P., Issa, R.R. and Olbina, S. (2013) 'Building information modelling in support of sustainable design and construction', Journal of Construction Engineering and Management, 139(1), pp. 24–34. doi:10.1061/(asce)co.1943-7862.0000560.

Chen, C.-W. (2020) "Improving circular economy business models: Opportunities for Business and Innovation : A new framework for businesses to create a truly circular economy," Johnson Matthey Technology Review, 64(1), pp. 48–58. Available at: https://doi.org/10.1595/205651320x15710564137538.

Chileshe, N., Rameezdeen, R. and Hosseini, M.R. (2016) 'Drivers for adopting reverse logistics in the construction industry: A qualitative study', Engineering, Construction and Architectural Management, 23(2), pp. 134–157. doi:10.1108/ecam-06-2014-0087.

Chowdhury, M.F. (2014) "Interpretivism in aiding our understanding of the contemporary social world," Open Journal of Philosophy, 04(03), pp. 432–438. Available at: https://doi.org/10.4236/ojpp.2014.43047.

Ciesielska, M., Boström, K.W. and Öhlander, M. (2018) "Observation Methods," Qualitative Methodologies in Organization Studies [Preprint]. Available at: https://doi.org/https://doi.org/10.1007/978-3-319-65442-3_2.

Dabaieh, M. et al. (2020) "A comparative study of life cycle carbon emissions and embodied energy between sun-dried bricks and fired clay bricks," Journal of Cleaner Production, 275, p. 122998. Available at: https://doi.org/10.1016/j.jclepro.2020.122998.

Dalkılıç, N. and Nabikoğlu, A. (2017) "Traditional manufacturing of clay brick used in the historical buildings of Diyarbakir (Turkey)," Frontiers of Architectural Research, 6(3), pp. 346–359. Available at: https://doi.org/10.1016/j.foar.2017.06.003.

Di Maio, F. et al. (2017) 'Measuring Resource Efficiency and Circular Economy: A Market Value Approach', Resources, Conservation and Recycling, 122, pp. 163–171. doi:10.1016/j.resconrec.2017.02.009.

Ding, L., Wang, T. and Chan, P.W. (2023) 'Forward and reverse logistics for circular economy in construction: A systematic literature review', Journal of Cleaner Production, 388, p. 135981. doi:10.1016/j.jclepro.2023.135981.

Dipl, P.S. (2002) Study of current building methods that enable the dismantling of building structures and their classifications according to their ability to be reused, recycled or downcycled., www.researchgate.net. School of the Built Environment, University of Nottingham, University Park.

Drakulevski, L. And Boshkov, T. (2019) "Circular Economy: Potential And Challenges," International Journal Of Information, Business And Management, Vol. 11.

Eberhardt, L.C., Birgisdottir, H. and Birkved, M. (2019) "Potential of circular economy in Sustainable Buildings," IOP Conference Series: Materials Science and Engineering, 471, p. 092051. Available at: https://doi.org/10.1088/1757-899x/471/9/092051.

Eklova, K. (2020) 'Sustainability of buildings: Environmental, economic and Social Pillars', Business & IT, X(2), pp. 2–11. doi:10.14311/bit.2020.03.01.

Eller, F.J. et al. (2020) 'Identifying business opportunities for sustainable development: Longitudinal and experimental evidence contributing to the field of sustainable entrepreneurship', Business Strategy and the Environment, 29(3), pp. 1387–1403. doi:10.1002/bse.2439.

Esa, M.R., Halog, A., Rigamonti, L., 2016. Developing strategies for managing construction and demolition wastes in Malaysia based on the concept of the circular economy. J. Mater. Cycles Waste Manag. 19 (3), 1144e1154. https://doi:10.1007/ s10163-016-0516-x.

Ewijk, S. van (2018) 'Resource efficiency and the circular economy: Concepts, economic benefits, barriers, and policies', UCL Institute for Sustainable Resources.

Fadhil, G.A. and Burhan, A.M. (2021) 'Investigating the effects of the economic crisis on construction projects in Iraq', E3S Web of Conferences, 318, p. 02005. doi:10.1051/e3sconf/202131802005.
Fernandes, F.M. (2019) "Clay Bricks," Long-term Performance and Durability of Masonry Structures, pp. 3–19. Available at: https://doi.org/10.1016/b978-0-08-102110-1.00001-7.

Fredriksson, A. and Huge-Brodin, M. (2022) 'Green Construction Logistics – a multi-actor challenge', Research in Transportation Business & Management, 45, p. 100830. doi:10.1016/j.rtbm.2022.100830.

Gabitov, A.I. et al. (2020) 'Energy Efficient Technologies for the construction and Buildings Reconstruction', IOP Conference Series: Materials Science and Engineering, 753(2), p. 022086. doi:10.1088/1757-899x/753/2/022086.

Goh, C.S. et al. (2020) "Revisiting triple bottom line within the context of sustainable construction: A systematic review," Journal of Cleaner Production, 252, p. 119884. Available at: https://doi.org/10.1016/j.jclepro.2019.119884.

Grant, C. and Osanloo, A. (2014) "Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your 'house,'" Administrative Issues Journal Education Practice and Research, 4(2). Available at: https://doi.org/10.5929/2014.4.2.9.

Gu, J. et al. (2023) 'Green and Sustainable Construction Industry: A systematic literature review of the contractor's Green Construction Capability', Buildings, 13(2), p. 470. doi:10.3390/buildings13020470.

Guerra, B.C. et al. (2021) "Circular economy applications in the construction industry: A global scan of trends and opportunities," Journal of Cleaner Production, 324, p. 129125. Available at: https://doi.org/10.1016/j.jclepro.2021.129125.

Guy, B. and Ciarimboli, N. (2008) 'DfD : design for disassembly in the built environment : a guide to closed-loop design and building', in DFD: Design for disassembly in the built environment: A guide to closed-loop design and building. University Park, Penn.: Hamer Center.

Hanif, M. & Khattak, S. (2017). Assessment of Economic Factors for Sustainable Construction Industry.

Høgevold, N.M. et al. (2015) 'A triple bottom line construct and reasons for implementing sustainable business practices in companies and their business networks, Corporate Governance, 15(4), pp. 427–443. doi:10.1108/cg-11-2014-0134.

Hopkinson, P. et al. (2019) "Recovery and reuse of structural products from end-of-life buildings," Proceedings of the Institution of Civil Engineers - Engineering Sustainability, 172(3), pp. 119–128. Available at: https://doi.org/10.1680/jensu.18.00007.

Hosseini, M.R. et al. (2014) 'Reverse Logistics for the Construction Industry: Lessons from the Manufacturing Context', International Journal of Construction Engineering and Management, 3(3). doi: 10.5923/j.ijcem.20140303.01.

Hussain, A. and Arif Kamal, M. (2015) 'Energy Efficient Sustainable Building Materials: An overview', Key Engineering Materials, 650, pp. 38–50. doi:

10.4028/www.scientific.net/kem.650.38.

Jaafar, M. and Abdul-Aziz, A.-R. (2005) "Resource-based view and critical success factors: A study on small and Medium Sized Contracting Enterprises (SMEs) in Malaysia," International Journal of Construction Management, 5(2), pp. 61–77. Available at: https://doi.org/10.1080/15623599.2005.10773075.

Jin, R. et al. (2017) 'An empirical study of perceptions towards construction and demolition waste recycling and reuse in China', Resources, Conservation and Recycling, 126, pp. 86–98. doi:10.1016/j.resconrec.2017.07.034.

Kakkos, E. et al. (2020) "Towards urban mining—estimating the potential environmental benefits by applying an alternative construction practice. A case study from Switzerland," Sustainability, 12(12), p. 5041. Available at: https://doi.org/10.3390/su12125041.

Kamaruddin, T., Adul Hamid, R. and Abd Ghani, S. (2020) 'Social Aspect implementation in sustainable construction', IOP Conference Series: Materials Science and Engineering, 849(1), p. 012036. doi:10.1088/1757-899x/849/1/012036.

Kedir, F. and Hall, D.M. (2021) "Resource efficiency in industrialized housing construction – A systematic review of current performance and future opportunities," Journal of Cleaner Production, 286, p. 125443. Available at: https://doi.org/10.1016/j.jclepro.2020.125443.

Khan MW, Ali Y, De Felice F, Salman A, Petrillo A. (2019). Impact of brick kilns industry on the environment and human health in Pakistan. Sci Total Environ. 678:383-389. doi: 10.1016/j.scitotenv.2019.04.369

Khan, J.A., Jawed, Y., Zain, U., Aziz, F., Qayyum, A., Abedin, Z.U., Amin, A., Faiz-ul-Sibtain (2016). Pakistan's Vision 2030 on Sustainable Development: A Paradigm Shift Towards Eco-friendly Green Buildings. Retrieved from https://www.switch-asia.eu/site/assets/files/3366/pakistan_vision_2030_final.pdf.

Khan, S. and Majeed, M.T. (2022) "Toward economic growth without emissions growth: The role of Urbanization & Industrialization in Pakistan," Journal of Environmental Studies and Sciences, 13(1), pp. 43–58. Available at: https://doi.org/10.1007/s13412-022-00797-3.

Kibert, C.J., (2008) "Sustainable Construction: Green Building Design and Delivery. John Wiley & Sons, Inc., New Jersey, Estados Unidos.

Knoth, K., Fufa, S.M. and Seilskjær, E. (2022) 'Barriers, success factors, and perspectives for the reuse of construction products in Norway', Journal of Cleaner Production, 337, p. 130494. doi: 10.1016/j.jclepro.2022.130494.

Lahti, T., Wincent, J. and Parida, V. (2018) "A definition and theoretical review of the circular economy, value creation, and sustainable business models: Where are we now and where should research move in the future?" Sustainability, 10(8), p. 2799. Available at: https://doi.org/10.3390/su10082799.

Lemke, C. (2021) "Conceptual Framework of Sustainable Development," Sustainable Management, Wertschöpfung und Effizienz, pp. 9–39. Available at: https://doi.org/10.1007/978-3-658-33246-4_2.

Lubis, N.W. (2022) “Resource based view (RBV) in improving company strategic capacity,” Research Horizon, 2(6), pp. 587–596. Available at: https://doi.org/10.54518/rh.2.6.2022.587-596.

Mangialardo, A., Micelli, E., 2018. Rethinking the construction industry under the circular economy: principles and case studies. In: Proceedings of the International conference on Smart and Sustainable Planning for Cities and Regions, 1, pp. 333e344. https://doi.org/10.1007/978-3-319-75774-2_23.

Mansour, H. et al. (2022) “Resource-based view in Construction Project Management Research: A Meta-analysis,” IOP Conference Series: Earth and Environmental Science, 1067(1), p. 012057. Available at: https://doi.org/10.1088/1755-1315/1067/1/012057.

Muntari, M.Y. and Windapo, A.O. (2021) “Clay as a sustainable building material and its benefits for protection in the built environment,” IOP Conference Series: Materials Science and Engineering, 1144(1), p. 012044. Available at: https://doi.org/10.1088/1757-899x/1144/1/012044.

Murray, A., Skene, K. and Haynes, K. (2015) “The circular economy: An interdisciplinary exploration of the concept and application in a global context,” Journal of Business Ethics, 140(3), pp. 369–380. Available at: https://doi.org/10.1007/s10551-015-2693-2.

Nadeem, M. *et al.* (2021) ‘Scaling the potential of compact city development: The case of lahore, Pakistan’, *Sustainability*, 13(9), p. 5257. doi:10.3390/su13095257.

Nadeem, M. et al. (2022) ‘Exploring the urban form and compactness: A case study of multan, Pakistan’, Sustainability, 14(23), p. 16066. doi:10.3390/su142316066.

Naderifar, M., Goli, H. and Ghaljaie, F. (2017) “Snowball sampling: A purposeful method of sampling in qualitative research,” Strides in Development of Medical Education, 14(3). Available at: https://doi.org/10.5812/sdme.67670.

Nagapan, S. et al. (2012) ‘Issues on construction waste: The need for Sustainable Waste Management’, 2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER) [Preprint]. doi:10.1109/chuser.2012.6504333.

Niaz, U. et al. (2017) “Socio-Economic and Cultural Problems of Brick Kiln’s Working Families: (A Case Study of District Faisalabad),” Journal of Applied Environmental and Biological Sciences [Preprint].

Nogueira, E., Gomes, S. and Lopes, J.M. (2022) ‘The key to sustainable economic development: A triple bottom line approach’, Resources, 11(5), p. 46. doi:10.3390/resources11050046.

Norman, W. and MacDonald, C. (2004) “Getting to the bottom of ‘Triple bottom line,’” Business Ethics Quarterly, 14(2), pp. 243–262. Available at: https://doi.org/10.5840/beq200414211.

Nußholz, J.L. and Whalen, K. (2019) ‘Financial assessment of reusing materials in buildings: Comparing financial potential of wood, concrete, and glass reuse’, IOP Conference Series: Earth and Environmental Science, 225, p. 012042. doi:10.1088/1755-1315/225/1/012042.

Nußholz, J.L.K. and Milios, L. (2017) “Applying circular economy principles to building materials: Front-running companies’ business model innovation in the value chain for buildings.”

P.N., M.L. et al. (2018) ‘Energy efficient production of clay bricks using industrial waste’, Heliyon, 4(10). doi: 10.1016/j.heliyon. 2018.e00891.

Piispanen, V.-V. et al. (2022) ‘Sustainable circular economy in the wood construction industry: A business opportunity perspective’, South Asian Journal of Business and Management Cases, 11(1), pp. 27–34. doi:10.1177/22779779221080570.

Ramesh, T., Prakash, R. and Kumar Shukla, K. (2013) ‘Life Cycle Energy Analysis of a multifamily residential house: A case study in Indian context’, Open Journal of Energy Efficiency, 02(01), pp. 34–41. doi:10.4236/ojee.2013.21006.

Rauf, A. et al. (2022) “Prospects towards sustainability: A comparative study to evaluate the environmental performance of brick-making kilns in Pakistan,” Environmental Impact Assessment Review, 94, p. 106746. Available at: https://doi.org/10.1016/j.eiar.2022.106746.

Rees, W.E., 1999. The built environment and the ecosphere: a global perspective. Build. Res. Inf. 27 (4e5), 206e220, 1999.

Ruuska, A. and Häkkinen, T. (2014) ‘Material efficiency of building construction’, Buildings, 4(3), pp. 266–294. doi:10.3390/buildings4030266.

Sassi, P. (2008) ‘Defining closed-loop material cycle construction’, Building Research & Information, 36(5), pp. 509–519. doi:10.1080/09613210801994208.

Saunders, M., Lewis, P., & Thornhill, A. (2009). Understanding research philosophies and approaches. Research methods for business students, 4, 106-135.

Schützenhofer, S., Kovacic, I. and Rechberger, H. (2022) ‘Assessment of sustainable use of material resources in the architecture, engineering and construction industry - A conceptual framework proposal for Austria’, Journal of Sustainable Development of Energy, Water and Environment Systems, 10(4), pp. 1–21. doi: 10.13044/j.sdewes.d10.0417.

Sfakianaki, E. (2015) ‘Resource-efficient construction: Rethinking construction towards Sustainability’, World Journal of Science, Technology and Sustainable Development, 12(3), pp. 233–242. doi:10.1108/wjstsd-03-2015-0016.

Shashi et al. (2023) “What we learn is what we earn from sustainable and Circular Construction,” Journal of Cleaner Production, 382, p. 135183. Available at: https://doi.org/10.1016/j.jclepro.2022.135183.

Slaper, T., & Hall, T.J. (2011). The Triple Bottom Line: What is it and how does it work? Indiana Business Review. 86. 4-8.

Subhanullah, M. et al. (2022) ‘Assessment and impacts of air pollution from brick kilns on public health in Northern Pakistan’, Atmosphere, 13(8), p. 1231. doi:10.3390/atmos13081231.

Sutton, J. and Austin, Z. (2015) “Qualitative research: Data collection, analysis, and Management,” The Canadian Journal of Hospital Pharmacy, 68(3). Available at: https://doi.org/10.4212/cjhp.v68i3.1456.

Thormark, C. (2000) “Environmental analysis of a building with reused building materials,” International Journal of Low Energy & Sustainable Building, 1.

Torres, A. et al. (2021) “Sustainability of the global sand system in the Anthropocene,” One Earth, 4(5), pp. 639–650. Available at: https://doi.org/10.1016/j.oneear.2021.04.011.

Ucer, D. et al. (2018) “Analysis on the mechanical properties of historical brick masonry after machinery demolition,” Construction and Building Materials, 161, pp. 186–195. Available at: https://doi.org/10.1016/j.conbuildmat.2017.11.090.

Vandecasteele, C., Andres, A. and Coz, A. (2017) ‘Wascon 2015: Resource Efficiency in Construction’, Waste and Biomass Valorization, 8(5), pp. 1379–1380. doi:10.1007/s12649-017-9999-5.

Vasilca, I.-S. *et al.* (2021) ‘The management of environmental resources in the construction sector: An empirical model’, *Energies*, 14(9), p. 2489. doi:10.3390/en14092489.

Yang, X. et al. (2022) ‘Urban mining potential to reduce primary material use and carbon emissions in the Dutch residential building sector’, Resources, Conservation and Recycling, 180, p. 106215. doi: 10.1016/j.resconrec.2022.106215.

Yeheyis, M., Hewage, K., Alam, M.S., Eskicioglu, C., Sadiq, R., 2013. An overview of construction and demolition waste management in Canada: a life cycle analysis approach to sustainability. Clean Technol. Environ. Policy 15 (1), 81e91. https:// doi.org/10.1007/s10098-012-0481-6.

Zhou, K. et al. (2020) “Developing advanced techniques to reclaim existing end of service life (EoSL) bricks – an assessment of reuse technical viability,” Developments in the Built Environment, 2, p. 100006. Available at: https://doi.org/10.1016/j.dibe.2020.100006.

8.2 Websites and Reports:

(The Ministry of Economy and Employment Finland, 2014) 'Sustainable growth through material efficiency - Working group proposal for a national material efficiency programme', [Online]. Available at: https://tem.fi/documents/1410877/3323088/Sustainable_growth_through_material_efficiency/fd454ebd-49a7-4675-af0d-a897b5aec87a (Accessed: 24 May 2023).

Artaza, I. (2019) Urbanisation in Pakistan: United Nations Development Programme, UNDP. The Express Tribune. Available at: https://www.undp.org/pakistan/urbanisation-pakistan (Accessed: April 24, 2023).

Brick Sustainability Report (2016). Available at: https://www.brick.org.uk/admin/resources/brick-sustainability-report-2016-1.pdf (Accessed: March 6, 2023).

C, org. (2020) Training programme on inspection and monitoring of brick kilns, Centre for Science and Environment. Available at: https://www.cseindia.org/training-programme-on-inspection-and-monitoring-of-brick-kilns-9867 (Accessed: April 4, 2023).

Clarke, L. (2022) The benefits of using reclaimed bricks for your project, Reclaimed Brick Company. Reclaimed Brick Company. Available at: https://reclaimedbrickcompany.co.uk/blogs/yard-display/the-benefits-of-using-reclaimed-bricks-for-your-project (Accessed: April 9, 2023).

Economics, O. (2022) Future of construction, Oxford Economics. Available at: https://www.oxfordeconomics.com/resource/Future-of-Construction/ (Accessed: February 24, 2023).

EMF (Ellen MacArthur Foundation), 2015. Towards a Circular Economy: business rationale for an accelerated transition. Available at: https://www. ellenmacarthurfoundation.org/publications/towards-a-circular-economybusiness-rationale-for-an-accelerated-transition.
European Commission. (2014). Resource efficiency in the building sector [PDF]. Available at: https://ec.europa.eu/environment/eussd/pdf/Resource%20efficiency%20in%20the%20building%20sector.pdf (Accessed: 25 May 2023).

Foundation, E.M. (2019) Completing the picture - how the Circular Economy Tackles Climate Change, Completing the Picture - How The Circular Economy Tackles Climate Change | Shared by Comms. Available at: https://emf.thirdlight.com/link/2j2gtyion7ia-n3q5ey/@/preview/1?o (Accessed: 24 May 2023).

ICIMOD.org. (2018) Brick Kilns Performance Assessment - Climate & Clean Air Coalition. International Centre for Integrated Mountain Development. Available at: https://www.ccacoalition.org/sites/default/files/resources/Brick_Kilns_Performance_Assessment.pdf (Accessed: April 8, 2023).

Institute, D. (2018) Deconstruction & Building Material Reuse: A Tool For Local Governments & Economic Development Practitioners, Delta Institute. Available at: https://delta-institute.org/wp-content/uploads/2018/05/Deconstruction-Go-Guide-6-13-18-.pdf (Accessed: April 4, 2023).

Joseph, W. and Negi, S. (2022) Rate analysis of brickwork in 2022, Civilwala. Available at: https://civilwala.org/rate-analysis-of-brickwork/ (Accessed: 23 May 2023).

Lodi, S.H., Sangi, A.J. and Abdullah, A. (2013) "Brick masonry construction in Pakistan," HOUSING REPORT[Preprint]. Available at: https://www.world-housing.net/wp-content/uploads/2013/12/WHE-report173_letter.pdf (Accessed: February 28, 2023).

Macdonald, C. (2022) The shift from linear to circular economy is the road to sustainable digitalization, LinkedIn. Available at: https://www.linkedin.com/pulse/shift-from-linear-circular-economy-road-sustainable-caroline (Accessed: 11 June 2023).

Marc, J. (2021) Rebrick – reuse bricks to give them a new life, Zero Waste Europe. Available at: https://zerowasteeurope.eu/2014/01/rebrick-reuse-bricks-to-give-them-a-new-life/ (Accessed: April 10, 2023).

MATHIEUX, F. (2016) Resource efficiency = energy efficiency + material efficiency, E3P. Available at: https://e3p.jrc.ec.europa.eu/articles/resource-efficiency-energy-efficiency-material-efficiency (Accessed: 31 May 2023).

McMahon, M. (2023) What is reclaimed brick? Home Questions Answered. Available at: https://www.homequestionsanswered.com/what-is-reclaimed-brick.htm (Accessed: March 6, 2023).

Mursten, G. (2014) The rebrick project, Gamle mursten. Available at: http://www.gamlemursten.eu/ (Accessed: March 6, 2023).

Oxford, l. Dictionaries (2023) Reclaim, reclaim verb - Definition, pictures, pronunciation, and usage notes | Oxford Advanced Learner's Dictionary at OxfordLearnersDictionaries.com. Available at: https://www.oxfordlearnersdictionaries.com/definition/english/reclaim?q=reclaiming%2B (Accessed: April 13, 2023).

Padhi, S. (2015) 4 primary steps of brick manufacturing process, CivilBlog.Org. Available at: https://civilblog.org/2014/02/25/4-primary-steps-involves-in-brick-manufacturing/ (Accessed: March 19, 2023).

Pakistan, U.N.H. (2018) The state of Pakistani Cities 2018, UN-Habitat. Available at: https://unhabitat.org/the-state-of-pakistani-cities-2018 (Accessed: April 13, 2023).

Ritchie, H. (2020) Cars, planes, trains: Where do CO2 emissions from transport come from? Our World in Data. Available at: https://ourworldindata.org/co2-emissions-from-transport (Accessed: 23 May 2023).

UN-Habitat (2018) Goal 11: Make cities and human settlements inclusive, safe, resilient, and sustainable, Sustainable Development Goals - 17 Goals to Transform our World. Available at: https://sdg.data.gov/11-1-1/ (Accessed: 25 May 2023).

UNEP (2011) Decoupling natural resource use and environmental impacts from economic growth, A Report of the Working Group on Decoupling to the International Resource Panel. Fischer-Kowalski, M., Swilling, M., von Weizsäcker, E.U., Ren, Y., Moriguchi, Y., Crane, W., Krausmann, F., Eisenmenger, N., Giljum, S., Hennicke, P., Romero Lankao, P., Siriban Manalang, A., Sewerin, S

urbanist, S. (2020) Building with waste, Sub Urbanist Medium. Available at: https://sub-urbanist.medium.com/building-with-waste-fa6a12c93763 (Accessed: April 7, 2023).

Zaheer, N., Arshad, S. and Kwak, D. (2022) Managing supply and demand: The key to getting 'housing' right in Pakistan, World Bank Blogs. Available at: https://blogs.worldbank.org/endpovertyinsouthasia/managing-supply-and-demand-key-getting-housing-right-pakistan (Accessed: April 11, 2023).

Zahid, U. (2023) Overview of the brick kiln industry in Pakistan, Graana.com. Available at: https://www.graana.com/blog/overview-of-the-brick-kiln-industry-in-pakistan/ (Accessed: April 8, 2023).

1. **Appendix - Interview questionnaire:**

Interview questionnaire for Contractor / Trader / Engineer:

Economic:

1. Why did you start the use or deconstruction of the construction material business?
2. How do you find clients and what kind of requests do you get from clients?
3. Do you think that utilizing reclaimed bricks affected or can affect the cost of construction in Pakistan?
4. How can a business of reclaimed bricks and used construction materials benefit contractors and other builders in Pakistan?

Workers:

5. How many employees are working in your team? Throughout the process of (demolition, extraction, cleaning, re-selling, and transportation)?
6. Can you hire someone without experience or knowledge and easily train them?

Market:

7. What is the current market demand for old bricks and how was it before?
8. Is there any cost difference between new and old bricks nowadays?

Environment:

9. What are the current environmental issues that you see related to the brick industry in Pakistan?
10. Do you think that your line of work is contributing the environment sustainability? In terms of utilizing reclaimed construction materials could clean our cities and reduce construction waste?

Transportation of bricks:

11. How do you transport reclaimed bricks from the de-constructed site to the new site? Any challenge you face in transportation?
12. Is the smaller method of transportation for the reclaimed bricks better than typical tractor trolleys used for new bricks, and does it provide any economic or environmental benefits?

Questions for Engineers:

1. Is there any formal de-construction plan or guidelines have been provided by the government
2. or regulatory bodies and experts to local contractors who are involved in this industry?
3. Do you believe private contractors in Pakistan are fully trained to deconstruct infrastructure without any de-construction plans or guidelines?
4. What are the current issues that you see related to the existing brick industry in Pakistan?

5. What are the overall challenges currently faced by the construction industry in Pakistan?
6. Do you think that reclaimed bricks can be a potential resource-efficient material in Pakistan?
7. Do you believe that we can achieve the circular economy objective within the construction industry of Pakistan?

Interview questionnaire for employee/worker:

1. Are you working on daily wages or monthly (full-time)?
2. Due to inflation (increasing food prices, etc.), are you able to afford necessities and fully satisfied with the earning from this line of work?
3. Do you think this line of work is stable and will provide long-term job opportunities for you?
4. Do you face any challenges in this line of work? E.g. Safety related issues

Ending part of the interview:

Demographics (بنیادی معلومات**):**

Name (نام)_____ Experience in Industry **(**صنعت میں تجربہ**)** _____

Location (مقام)_____ Role / Expertise (کردار / مہارت) _____

Educational background **(**تعلیمی پس منظر**)**_____