CHAPTER 2

REVIEW OF RELATED LITERATURE AND FRAMEWORKS

The previous chapter provided a general introduction to the research, highlighting key aspects such as the study problem, the research gap, and the study objectives. This led to the second chapter, the literature review, which presents the existing body of knowledge on sustainable engineering practices to develop a framework for enhancing these practices in Zimbabwe's hospitality sector. The chapter offers an overview of engineering practices and the concept of sustainability. It also explores literature on the sustainable development of infrastructure, the life cycle engineering of infrastructure, and the challenges faced in advancing sustainable engineering practices in the sector. The chapter concludes by identifying the knowledge gap.

In basic terms, engineering refers to a scientific field and jobs involving taking our scientific understanding of the world to use it to come up with inventions, designs and build things such as infrastructure which solves various problems and attain certain set goals. Engineering as a practice, is therefore responsible for the designing and construction of essential infrastructure in the economy such as buildings and bridges. Other researchers have pointed out that engineering is the building of things to solve problems being faced in a sector or economy for instance the building of houses or buildings.

It is engineering that leads to the designing of the buildings seen around the country as well as bridges and road networks that help the economy to grow and be sustainable (Moore, 2020). Engineering has been essential in various sectors such as in hospitality where it plays a key role in designing attractive and strong infrastructure such as hotels as well as revitalizing them to ensure they are up to the ever-changing standards (Gould, 2021).

It is the job of the engineers to ensure that they constantly design, develop, and build infrastructure that helps to meet certain targets in the country and beyond such as economic growth. Engineering comes through various practices which are defined as the process of identifying problems relating to engineering therefore coming up with solutions to solve the problems through methods such as construction of models, science, and mathematics as well as technology (Cole, 2020).

Thus, engineering practices refer to the action that is taken to make sure that there is continuous improvement on building or infrastructure for instance continuous maintenance and checking of emanating problems (Gordon, 2019). With engineering practices, the major aim is to attain sustainability of building hence this means that the practices are used to ensure that there is immediate fixing of problems as soon as they are determined, and it is key in minimizing risks such as collapse of buildings (Moore, 2020).

One of the major or popular engineering practices is the continuous maintenance of infrastructure at regular intervals. Such a practice entails that the fitness of the building and infrastructure is continuously determined and checked to fix emanating problems before they grow or become a threat to the suitability of the business (Hughes, 2021).

Regular maintenance of infrastructure such as buildings and rooms in hotels or restaurants is key in modernising their looks and attracts key stakeholders to the business such as customers and investors. Engineers are essential in the regular maintenance of infrastructure through innovative design and implementation of certain designs on the infrastructure as well as fixing problems on the building such as rooms, elevators, stairs or escalators in buildings such as hotels and malls.
Other engineering practices include the adoption of technology in diagnosing and fixing engineering problems which has been adopted hugely in first world countries such as China, the USA, and Germany (Lee, 2018; Carter, 2020; Gomez, 2022). Through technology adoption, it is easier to discover engineering problems in infrastructure and enhance the easy design of innovations that engineers can use to revitalise or improve infrastructure for instance the use of Computer Aided Design (CAD) (Lee, 2018). Further, according to Carter (2020), the adoption of technology has helped to improve the standard of infrastructure and hotels for instance the use of air conditioners in rooms, and elevators. Gomez (2022) alludes that in most cases, technology is used as an engineering practice to diagnose defects in buildings and also design the best possible aspects that can help improve the situation at hand such as cracks in the buildings or weak trusses.

According to Law (2020), adoption of environmentally friendly equipment is key in enhancing sustainable engineering in infrastructural development. The researcher points out that sustainability now comes from undertaking practices that do not pollute the environment in any way but that ensures that there is the preservation of natural resources. These include the use of solar power instead of fossil fuels that emits carbon into the atmosphere.

According to Danubianu (2016), sustainability means the ability to survive or exist for a foreseeable future or even for eternity through various practices or implementation of certain strategies. In business, sustainability is the existence of the firms for a long period of time to serve different generations and in accounting terms, sustainability is known as being perpetual (Gomez, 2021). In other terms, sustainability is the ability to survive in the business environment for time immemorial and be able to serve generations and generations to come. Thus, sustainability entails a going concern and means something that exists or is done repeatedly to achieve certain set targets such as improving standards (Law, 2021).

Therefore, in engineering, sustainability has various meanings such as the ability for engineering projects such as hotels or bridges to exist for a long time to serve generations and generations to come. When designing projects, sustainability is critically considered by engineers as it helps to make sure that their work stays in existence for a very long time (Demsetz & Villalonga, 2017). In the same context, sustainability also entails having behaviors or practices that are done repeatedly to solve a certain problem or meet certain targets which is also common in engineering or the revitalization of infrastructure in the hospitality sector (Paulsen, 2021).

According to Keller (2018), the concept of sustainability is common in industry and commerce where it has been used to explain the need for businesses to be able to carry out business today and be able to survive to see tomorrow and this is usually as a result of good performance in all the performance indicators of the company such as finances and the products or service as well as the efficient allocation of resources. Nonetheless, Hugh, (2018) alludes that sustainability is also been adopted in other fields such as engineering in which various practices such as continuous repairs, refurbishment and revaluation of infrastructure has been adopted in building and on bridges.

Sustainable engineering hence means the never-ending engineering practices that are put in place by engineers to ensure that buildings have ever improving standards. According to Lee (2018), sustainable engineering is more common in infrastructure such as building in sectors which include hospitality in which the appearance of the buildings is of great importance regarding luring and retaining customers.

Several concepts of sustainable engineering have been developed across the globe in the last century and one of the well celebrated is Environmental Engineering (EE). In general, according to Moore (2021), EE has its focus on the adverse environmental effects of nature and human activities on natural resources that are essential to human survival such as fresh water supply and it also affects other key components such as waste management and sanitation amongst others (Davis & Cornwell, 2006).

Thus, EE comes along with ecosystems that are key in integrating human society with natural environment to achieve a mutual benefit (Mitsch, 2012). In all countries, they are used to carrying out tasks such as restoration of lakes, grassland and phytoremediation sites. According to Mitsch and Jorgensen (2013), EE has been used widely to design, construct, restore and manage ecosystems. The researchers point out that this is achieved mainly by the usage of 5 classes of EE design which are:

- Ecosystem utilisation to reduce pollution problems
- Ecosystem imitation to resolve a source problem which may be burning of fossil fuels,
- Ecosystem recovery for instance land restoration,
- Ecosystem ecological modification such as selective plant harvesting
- Balanced use of ecosystems, such as sustainable agricultural systems.

It is also pointed out by Weizsäcker *et al.* (2016) that EE is adopted in environments to reduce the pollution, and waste in organisations. It was developed by researchers, policy makers, and practitioners from many countries. On the other hand, there is also Industrial Ecology (IE) which is about shifting processes from open loop systems to the closed loop system. IE has its primary focus on imitation since natural systems do not produce waste so it works with "industrial metabolism" as well as life cycle planning and eco-industrial parks to imitate the natural systems (Mulder, 2020). It is key to note that both EI and EE are environmentally oriented, but lack the social component of sustainability.

The hierarchy of sustainability is key in showing the key components that enhance sustainable engineering in organizations and Figure 2.1 below provides a diagrammatical illustration of the hierarchy.

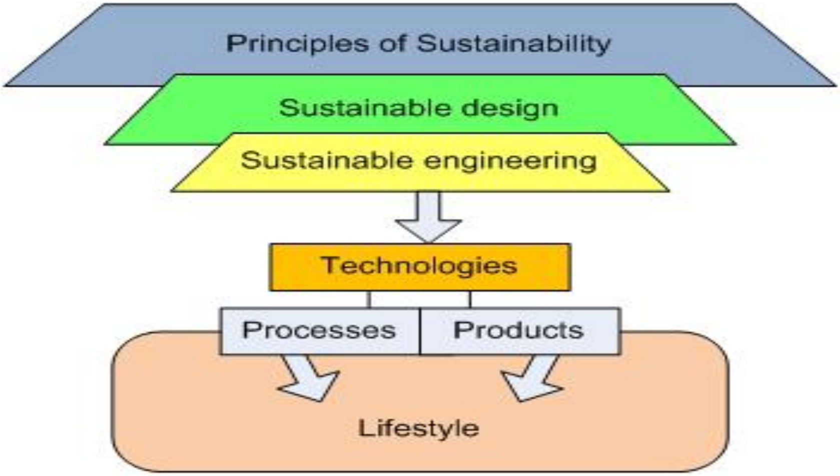

Figure 2.1: Hierarchy of sustainability.

As shown in Figure 2.1 above, the Principles of Sustainability are at the top of the hierarchy which shows that it is key to achieving sustainability in engineering. To achieve that, there is a need to have Sustainable Design, the process of thinking. The following stage, Sustainable Engineering deals with the technical implementation of ideas or innovations that are developed or designed by the engineers. The design and engineering stages therefore work hand in hand to influence the Technologies to be used for example in construction or in revitalising infrastructure, which provide the Processes and Products. It is a portal through which the established principles of sustainable design and engineering affect people's lifestyles creating changes in society. Because of people's strong dependence on multiple technologies, these become the factors that can facilitate change in society and can even become tools of manipulation and initiation of global trends (Eli, 2018).

As the world continues to evolve in many aspects day by day, engineers have developed many approaches to engineering systems development. Most of the modern design approaches have a number of similarities with a few differences that get rid of setbacks of the earlier ones and to put in novel knowledge and developments in the field (Gericke & Blessing, 2012). The following are some of the modern design approaches which are key in solving longstanding African infrastructure problems;

According to Hines (2020) Concurrent Engineering (CE) as an engineering management philosophy comes along with a set of operating principles guiding a product development process by means of quick successful completion. This means that it is an effective method used to manage the development of complex systems that are used in societies and organisations, but it requires a set of tools and procedures in order to operationalise its concepts. It promotes the integration of downstream concerns into the upstream phases of a development process (INCOSE, 2014).

According to INCOSE (2014), System Engineering is an interdisciplinary approach used in the realization of successful systems that aims at satisfying stakeholder's needs in a high quality, trustworthy, cost efficient, and schedule compliant manner throughout a system's entire life cycle. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem.

Lifecycle Engineering refers to the consideration of the entire lifecycle of a system right from the point of conception of the idea to the end-of-life management of the system. The necessity for Lifecycle Engineering of a system arose from the realisation that a new industrial culture has to be developed (Alting & Jorgensen, 2013). The new industrial culture must drastically reduce the amount of waste generated, reduce environmental damage and occupational health damages. Furthermore, the new industrial culture would need to increasingly.

A theory refers to the statements and facts that emerge from a study and are used to explain or predict a certain phenomenon (Kumar, 2014). Theories are key in showing that the study is not coming from nowhere but has a theoretical underpinning that guides it. Therefore, a theoretical framework in research refers to the adoption of a certain theory or theories that are closely related to the phenomenon understudy and help to explain the current study. In this study, Dissiter's Law of Fives Theory was adopted to provide the theoretical guidance to the study.

According to Dissiter's Law of Fives, neglecting maintenance and repairs when they are essential will generally equal five times the maintenance cost. Thus, when the organization forgoes maintenance of the building at regular intervals, it will end up repairing the building at a cost that is five times more than what it could have incurred if it had maintained the buildings on regular intervals through sustainable engineering practices (Moore, 2020).

The Law of Fives explains that it is cheaper to maintain infrastructure, for instance, in the hospitality sector if the maintenance is done on regular intervals to make sure that any damages are fixed before they get out of hand (Gordon, 2021). Fixing damages in the early stages or as soon as they are discovered is important in making sure that the repairs are done cheaper than when the damages have affected other parts of the infrastructure or the business which is costly and affects sustainability.

Further, it was pointed out that through Dissiter's Laws of Five, refurbishing or repairing infrastructure such as hotels and restaurants on regular intervals for instance annually helps the authorities to make sure the damages on the building or infrastructure does not worsen which is a threat to the perpetuity of the business (Borris, 2022). The theory helps to explain that lack of infrastructure repairment in the hospitality sector on regular intervals means that businesses such as hotels face a huge threat of high costs when they decide to improve the infrastructure and, in some cases, this affects the performance of the businesses in aspects such as profitability and market share.

The costs that come from failure to revitalize infrastructure in the hospitality sector on regular intervals do not just concern financial costs but also losing business as the standards of the hotel fall as compared to the competition. In that manner, research has also pointed out that getting or luring new customers is 3 times costly than retaining already existing customers (Kottler, 2017) hence, it is important to make sure that hotel standards are kept high through sustainable engineering that enhances sustainability in the performance of the hotels.

Therefore, Disitter's Law of Five theory plays a major role in this study in showing the consequences of not maintaining hotel infrastructure as it will cost more during repairs that are part of the refurbishing of the infrastructure. Further, it shows that the costs do not include money that is lost when fixing a greater problem but also the cost of losing and luring customers to the business through aggressive marketing strategies. These costs have a negative effect on the sustainability of the business as they eat through the profit and hinders investors from coming into the firm.

Life-cycle Engineering (LCE) is a decision-making methodology that considers environmental, performance and cost requirements in the entire duration of an infrastructure. It is centred on the design and production of products with minimal environmental impact during their entire life cycle (Stuart & Sommerville, 1998). Therefore, it has all its support on a more balanced view of investment considering construction, development, and revitalisation issues. Thus, LCE is crucial in infrastructural development because design decisions made early in the design process can have multiple impacts on life-cycle metrics for instance costs and time (Borg *et al.*, 2020). According to Asiedu and Gu (1998), decisions made by designers at the design phase influence between almost 80% of the total costs. Therefore, the interest in sustainable development has influenced various original equipment manufacturers to scrutinize the manner they deal with the cost and environmental issues (Glazebrook *et al.*, 2000). Some of the approaches state that there is need to reduce the adoption of non-renewable resources and toxic releases into the environment (Rivera-Becerra & Lin 1999).

The primary reason that maintenance is deferred is because there is unavailability of the money or funds to finance it. That is, if budget planning does not allocate enough money for maintenance of infrastructure then an increase in deferred maintenance is inevitable (Cole, 2020). Additionally, if allocated funding is the used for emergencies in the business and more visible projects then the risk of equipment failure and building deterioration increases. Inadequate funding of regular maintenance has also occurred in part because the segments redirected funds budgeted by the state for routine maintenance to other activities (AO, 2016).

Although some public systems of higher education and individual institutions have addressed this problem aggressively in recent years, many struggle with identifying their needs and presenting a persuasive as well as a credible argument for the financial support necessary to restore deteriorating or remedy unsafe conditions (Kaiser, 2004). The facilities manager must understand the corporate goals of an organization, the interaction and relative importance of the social, political, and economic forces that affect those goals.

Obvious examples of the consequences of this lack of understanding include expenditure on maintenance of buildings that are to be rendered obsolete in the strategic plan (Worthing, 2020). Another challenge faced in applying sustainable engineering practices is inadequate Projects Preparation and project planning

(LAO, 2016). It is key to be proactive and come up with the future in enhancing or implementing engineering practices such as continuous maintenance of infrastructure. It has been discovered in studies that some engineers are not future oriented and do not plan on their job or instill certain practices before the problem arises (Morris, 2020). This means that the engineers do not embrace innovation and therefore are not able to put in place practices such as technology adoption and also continuous maintenance of buildings or infrastructure. Engineers are builders and problem-solvers who play crucial roles in industry and society. As such, engineering education provides an excellent platform for imparting additional skills that can address contemporary challenges worldwide. Multi and interdisciplinary approaches are necessary to address these complex social, economic, and technological challenges.

These approaches can effectively complement the result-oriented analytical approach to problem solving that engineers receive as an integral part of their rigorous training. There also exists a clear trend toward multidisciplinary education in all fields of engineering; de Graaff and Ravesteijn (2001) describe the crucial need for the "complete engineer," an individual who not only has technical scientific skills, but also has an understanding of the interplay between technology and society, organisational and management skills, as well as social and communications skills.

Engineers, for example, often select materials for infrastructure or other processes. Infrastructure is highly important, as it is needed by humans to live in urban settings, shelter them from environmental risks, and protect the environment from wastes. Some materials such as minerals are not renewable and may be depleted eventually. Others such as wood are considered renewable. Other materials for construction such as concrete contain a wide variety of materials. Thus, the choice of materials can have significant impacts on resources. Past practices are not sufficient for the changing world. Engineers provide solutions to problems in the real world. However, there are many constraints for engineers as the world is becoming more and more complex. New technologies are being developed. Numerous sciences including biological and social sciences must be considered by engineers.

Engineers must work with people of various cultures and within many different regulations. Different cultures prioritize aspects differently, for example, such as access to clean water over considerations of climate change. Environmental standards may not be stringent in the developing country so higher than local standards must be applied or practices or materials modified for local conditions. The World Federation of Engineering Organisations (WFEO) has developed the Model Code of Ethics and the Model Code of Practice for Adaption to Climate Change (WFEO, 2015). The purpose of these codes is to ensure that ethics based on universal values are practised but modified to local conditions. Engineers must be able to understand the implications of their work in social, economic, and environmental contexts. Budgets and business plans have always impacted engineering projects. More recently, energy efficiency and reduced environmental impact have been incorporated into design. Tools have been developed to assist in this process such as sustainability and life cycle assessments that will be discussed later.

Indicators for social and cultural impacts are more difficult to assess quantitatively and are subject to viewpoint. For example, a mining company might see the project as beneficial to the community for employment. However, the local community might view that the project is negatively impacting their cultural values or land. Allenby (2012) has suggested that engineers should be able to identify potential social and cultural issues of a project or process, enable communication to address concerns, reduce impacts as much as possible, and communicate the changes to the concerned groups before finalizing the work plan. Therefore, engineers now have to think beyond the traditional aspects that engineers have been used to. Many things have impacted the natural environment. Safe service and cost effectiveness have been the main drivers for engineering design without the concern for material or energy reduction.

Technologies are more complicated, and solutions are thus more complex. Engineers have to now think about environmental and social systems over the whole life of a project. Environmental, social, and economic concerns must all be balanced while meeting technical demands. These are the challenges and responsibilities of the present and future engineers, particularly in light of global warming. Reduction in greenhouse gas emissions is essential for slowing climate change. Ainger and Fenner (2014) showed that more natural flood defence schemes such as natural wetlands are now being considered more frequently, as they are less expensive, can increase carbon sequestration, and mitigate urban heat-island effects. The American Society of Civil Engineers (ASCE) has recently developed three policies to reflect the new issues of climate change adaptation and mitigation and sustainable development. One of the policies indicated "the need for social equity in the consumption of resources." In addition, engineers "must actively promote and participate in multidisciplinary teams with other professionals, such as ecologists, economists, sociologists and work with the communities served and affected to effectively address the issues and challenges of sustainable development." In their problem-solving, engineers must use the most appropriate measures to achieve sustainability for society.

Yong et al. (2014) showed that to understand the degradation of the environment, knowledge of the impacts of humans on the environment is required. Some of the issues can be summarized as pollution of (a) water, (b) atmosphere, and (c) land.

- Loss and degradation of soil quality due to the use of pesticides, insecticides, fertilizers, and other soil amendments
- Increased use of natural resources by mining and forestry activities and energy production
- Increased greenhouse gas and other emissions, leading to acid rain and climate change that increases severe weather occurrences, water levels, and erosion of coastal areas among other effects.
- Biological magnification of pollutants by plants, aquatic organisms, and animals

In addition, Yong et al. (2014) also indicated that sustainability principles require the classification of resources as renewable and non-renewable. Renewable natural resources, however, can become non-renewable, if they are used at rates higher than they can be replaced and hence this is not sustainable.

The frameworks related to engineering and development of infrastructure are not novel to the academic body of knowledge as they have been put through across the globe in various sectors. Sushilawati (2018) took a similar study on developing a framework for sustainable industrialised building systems (IBS) for infrastructure projects in Malaysia. The study made use of a preliminary conceptual framework which it developed based on a systematic literature review and gathered data using semi-structured interviews involving 20 participants to have an insightful opinion from construction practitioners and to determine their view on IBS application in the construction industry. Further, a two round Delphi study was undertaken, and it involved 13 experienced and knowledgeable panellists and it was aimed at identifying, verifying, and prioritising the factors developed from the literature review and interview findings. The major findings of the study were that there are four categories of important elements to be considered for implementing IBS in infrastructure projects: design requirements, policy, project characteristics, and industrial readiness.

The study found that the integration of IBS attributes and performance were found to correspond well with the three pillars of sustainability principles: economic, social, and environment. Furthermore, the study results showed that optimisation of IBS application through its capacity of changeability and adaptability can facilitate redevelopment works. Therefore, the results of the study were key in the development of a framework for sustainable IBS application for an infrastructure project that incorporates future redevelopment considerations to enhance the sustainability of infrastructure projects. On the other hand, in South Africa, a similar study was undertaken by Sekhota (2019) on developing a framework for innovation adoption in the development of infrastructure in the public sector in the country.

The aim of the study was to enhance the development of infrastructure through innovative and technological approaches. This was crucial for meeting international standards, while also improving the standards of living for the general population in the country. The study also gathered data through interviews with experts from various related fields, including engineers, environmental agencies, and government representatives. This provided rich data that helped answer the study's key questions. The study findings revealed that ensuring innovation in infrastructure development requires embracing change and being proactive in developing infrastructure that serves future generations. It was found that there should be collaborations amongst different parties to foster idea generation and sharing hence making sure that innovation is adopted in developing public sector infrastructure in South Africa.

In Kenya, a framework was developed by Mugebi (2021) on the sustainable revitalization of infrastructure in the hospitality sector. The primary aim of the study was to guide the modification of hotels in the country. The goal was to ensure these hotels meet international standards and effectively serve the 'Visit Rwanda' initiative, which seeks to attract more tourists and investors to the country. The study findings showed that there is need to be innovative and invest in regular revitalization of the hotel infrastructure, put in modern features and be able to attract foreign and local customers.

The above literature reviewed in this chapter helped to explain the phenomenon of sustainable engineering practices. The literature above was in line with various studies and frameworks from many other countries in the world including the United States of America, the United Kingdom, South Africa and Germany amongst others. The literature however did not mention anything from Zimbabwe let alone in the hospitality sector pertaining to coming up with a framework that helps to enhance the adoption of sustainable engineering practices in the hospitality sector which is a gap that this study sought to explore in the context of Hwange Safari Lodge.

This second chapter of the study was the literature review, and it presented the already existing body of knowledge pertaining to sustainable engineering practices. This was aimed at coming up with a framework to enhance the practices in the hospitality sector in Zimbabwe. The chapter provided an overview of engineering practices and the concept of sustainability. It also provided literature on the sustainable development of infrastructure, life cycle engineering of infrastructure and the challenges faced in enhancing sustainable engineering practices in the sector. The chapter concludes with a knowledge gap. The next chapter is the research methodology.