THE OPPORTUNITIES AND CHALLENGES OF IMPLEMENTING THE LIVING BUILDING CHALLENGE IN SOUTH AFRICA

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Urban Studies in the field of Sustainable Energy Efficient Cities.

Johannesburg, 2022

DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of a Master of Urban Studies in the field of Sustainable Energy Efficient Cities to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other university.

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ABSTRACT

The Living Building Challenge (LBC) is the world's most stringent green building standard and has only recently been introduced into the South African (SA) built environment. This study aims to identify the successes and failures faced throughout the design phase of five LBC case studies in SA. By reviewing the literature and interviewing various sustainability consultants who have worked directly on the case study projects, various opportunities with implementing the LBC presented themselves. These opportunities included breaking down professional silos as well as the positive influence that the imperatives had on the local manufacturing industry. Furthermore, challenges such as fee structures, limited resource availability, complex design solutions, and Covid-19 also impacted the progress of establishing these buildings. By working with local governments and non-profit organisations and educating people on the principles of Biomimicry and Regenerative Design, it would be possible to formulate benchmarks for establishing successful, regenerative building projects in South Africa.

Keywords: *Living Building Challenge, South Africa, Regenerative Design, Climate Change Solutions, Green Buildings, Green Star SA, GBCSA, ILFI*

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BREEAM	Building Research Establishment Environmental Assessment Method
ECSA	Engineering Council of South Africa
GBCSA	Green Building Council of South Africa
IAQ	Indoor Air Quality
ILFI	International Living Future Institute
LBC	Living Building Challenge
LEED	Leadership in Energy and Environmental Design
LFA	Living Future Accreditation
ROI	Return on Investment
SA	South Africa
VOC	Volatile Organic Compounds
WESS	World Economic Social Survey
UNEP	United Nations Environment Programme

CHAPTER 1

1 Introduction and Background to Study

1.1 Introduction

Climate change has become a global concern that threatens the lives of billions of people, and it is often attributed to the expulsion of greenhouse gases (GHG) into the atmosphere, particularly carbon dioxide gas (CO^2). A report from the United Nations Environment Programme (UNEP) stated that the real estate and construction sector is one of the most significant contributors of CO^2 emissions in the world, and the sector uses a third of all energy produced globally (UNEP, 2019). Furthermore, the construction and building sector is one of the biggest consumers of natural resources and produces more than a third of all solid waste globally (ILFI, 2014).

To address this issue, this sector has adopted numerous sustainable design principles and policies that have led to the emergence of green building standards, such as Green Star SA, which is advocated for by the Green Building Council of South Africa (GBCSA). However, these standards often use technical system designs to offset energy and water consumption within a building. This can be seen as a *reactive* way of approaching sustainable development. This approach is often still disconnected from the natural world and does not fully address the environmental impacts a particular building has on its surroundings. However, a more proactive approach towards sustainable and regenerative development would be to adopt a living system design approach that looks at buildings from a holistic point of view (Mang & Reed, 2012).

This has resulted in the adoption of *Biomimicry* and *Regenerative Design* principles that led to the development of the Living Building Challenge (LBC), which is the world's most rigorous set of green building standards (Zari, 2016). Unlike other green building standards that provide certification according to the design of the building, the LBC certifies only buildings that have been

operational for a minimum of 12 months and that have met all the desired design outcomes stipulated within the LBC standard (ILFI, 2021).

1.2 Background and Rationale

The LBC was developed by the International Living Future Institute (ILFI), with the first edition of the standard being released in 2006. The ILFI is a non-profit organisation that seeks to create fossil-fuel-free environments using social and environmental justice principles (ILFI, 2021). Unlike traditional green building standards that seek to reduce negative environmental impacts, the LBC promotes sustainable design and regenerative development by working with the natural landscape to create a positive environmental impact. The LBC accomplishes this by adopting the principles of *Biomimicry*. In its broader definition, *Biomimicry* is the practice of learning and emulating nature's various forms, processes, and systems to solve human design challenges (Learn Biomimicry, 2020). John McLennan, the founder of the LBC, utilised the concepts of *Biomimicry* to understand the comparison between the urban landscape of buildings and the natural life cycle of plants (McLennan, 2015). Therefore, the LBC is seen as a philosophy, certification, and advocacy tool that bridges the gap between nature and the built environment.

The LBC comprises various certifications, with each certification awarded to a project based on a set number of requirements that have been achieved within the LBC standard. As of March 2022, there are approximately 145 certified LBC projects, 30 of which have achieved full LBC certification. However, the first certified LBC project, which gained certification in 2010, was awarded to the Eco-Sense House, a cob-constructed private residence located in Victoria, Canada (Figure 1.1). Since then, over 600 buildings across 40 countries are currently registered for LBC certification, with a living building being designed in almost every known climatic zone (ILFI, 2022). On the African continent, the LBC has been attempted and advocated for only in Egypt and South Africa (SA), with South Africa launching a subsidiary collaborative of the ILFI in 2019. The stringent requirements of the LBC have often made it difficult for local built environment professionals to implement in SA. Nonetheless, with new

investment opportunities and changing regulations and policies, South Africa has recently seen five registered LBC projects being constructed. These projects include two residential buildings found in Oranjezicht in Cape Town; the 76 Corlett Drive office development in Johannesburg; the Green School SA project in Paarl; and Solid Green's new office in Parkhurst, Johannesburg (Specifile, 2020).

Figure 1.1: Eco-Sense House: The first certified LBC project in the world (ILFI, 2022)

1.3 Problem Statement

Numerous Living Building Challenge projects have been successfully certified throughout the world. However, each project is unique and comes with its own set of opportunities and challenges particular to that country or region. As part of the certification requirements, LBC requires all project teams to create a database of knowledge gained from each project. It is vitally important to document these opportunities and challenges as they highlight the current state of pursuing the LBC. This could potentially assist in guiding and informing new projects and developments within the country. This means a vast amount of knowledge about the various opportunities and challenges of implementing the LBC in other countries. However, this has not been completed for LBC projects in South Africa, thus making this research potentially ground-breaking.

1.4 Objectives of the Study

This qualitative research will determine the opportunities and challenges faced during the *design* phase of five registered LBC projects located in South Africa. The opportunities and challenges of each project will be determined by looking at the successes that each project has had in implementing certain aspects of the LBC and the roadblocks that were encountered. These will range from local constraints such as climatic conditions to government regulations and policies that became factors in the design and development of these projects. Therefore, the research highlights the commonalities and differences in how LBC projects have been designed in South Africa compared to other green building projects of a similar building typology. Furthermore, the research will demonstrate how LBC can be incorporated with other green building standards in the country, such as Green Star SA.

1.5 Research Question

What are the opportunities and challenges of implementing the Living Building Challenge in South Africa?

1.6 Sub-Questions

- What are the primary green buildings standards that have been adopted in South Africa?
- How does LBC compare to local South African green building standards such as Green Star SA?
- How can LBC be incorporated or promoted with other green building standards in South Africa?
- What were the predicted and unforeseen challenges that were encountered during the design phase of SA based LBC projects?
- What opportunities and positive impacts presented themselves to the design team of the LBC projects?
- What role did local governments and municipalities play in achieving LBC in South Africa?

1.7 Expected Findings

This research was conducted based on the expectation of finding both unique and shared opportunities and challenges across all LBC projects. It was expected that some common barriers may have included issues around the financing of the project and constraints with construction materials. This is because the material requirements for LBC certification necessitate that 75% of all certified materials must be sourced within a 5000km radius of the project site. This poses a limitation within the Southern African context, as seen in Figure 1.2. Other barriers that were forecast include site-specific climatic conditions and the inability for standards to be met due to municipal or national laws. This was attributed to the fact that local governments are often apprehensive about approving building designs that are not connected to municipal water and sewer systems or that can place excess, generated energy back into the localised electricity grid.

Nonetheless, a variety of possible successes were expected to arise, such as the enthusiasm for obtaining the LBC, which highlights a path towards a more regenerative future in South Africa. Furthermore, although LBC is predicted to be seen as a performance certification that differs from the design certifications of local green building standards, it is expected that there may be a direct overlap between the various categories that are required for both standards. Therefore, there was an expectation of finding commonalities between local green building standards and the LBC and the ability to justify how LBC can work in conjunction with other local standards.

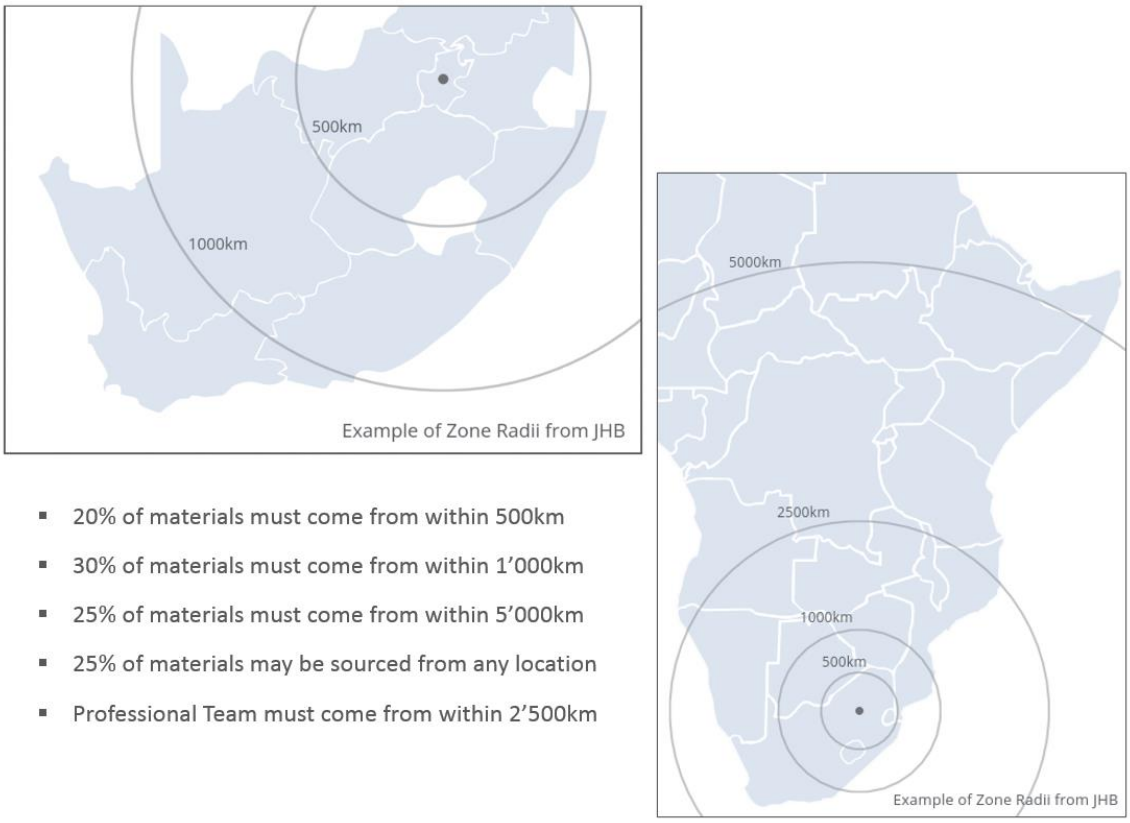

Figure 1.2: Material sourcing in Southern African context (Regenerative Collaborative South Africa, 2021)

1.8 Methods

For this research report, the Research Onion model (Figure 1.3) was used to guide the research design and methods to the study. Firstly, a deductive approach was taken to understand the essential components of the research question and formulate an observable outcome. This approach is typical of research that tries to prove the validity of a hypothesis, which is true for this research. The research was then identified to be mono-method qualitative in nature and this was supported by literature in the form of various peer-reviewed journals, books, and publications. Furthermore, this was accompanied by the collation of grey literature that has not been peer-reviewed such as guidelines, regulations, policies and data obtained directly from the ILFI, such as the LBC guidelines and standard. Additionally, this methodological approach was employed as the only method for the study to understand how the LBC fits into the South African construction industry.

The strategy of case studies was then utilised to ensure the research topic's real-life applicability and to assist in the derivation of the findings. These case studies include South African building projects that have been registered to achieve LBC certification. The time horizon for the research was cross-sectional as the current preconstruction and design phase of each of the LBC projects was observed. Finally, data was collected with purposive samples through semi-structured interviews conducted with sustainability consultants. These consultants were selected as they were the leading sustainability professionals who worked specifically in advising about the requirements of the LBC for each South African case study. It was found that some consultants had worked on more than one project, however this was not seen as a limitation to the research. Each consultant was contacted through email and interviews with were conducted online through the MS Teams platform, with all Wits ethics and Covid-19 protocols being strictly adhered to. This combination of reviewed literature collected from various sources, accompanied by raw data obtained from the interview process, led to the deduction of the required objectives of this research report.

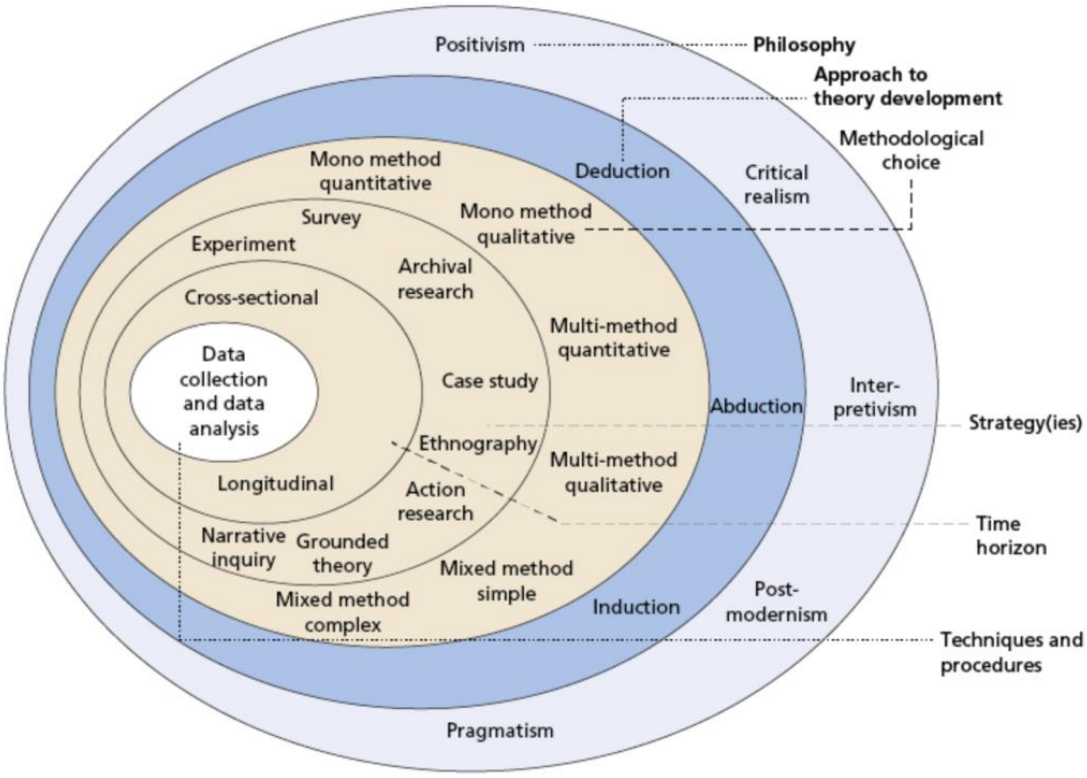

Figure 1.3: The Research Onion model (Saunders, Lewis and Thornhill, 2019)

1.9 Chapter Outlines

Chapter 1 introduces the key concepts and general questions that will be investigated throughout this report. The research objective and conceptual framework have also been elucidated in this chapter.

Chapter 2 presents the literature review, which will focus on the various concepts that have led to the inception of the Living Building Challenge. This chapter also informed the structure of the questionnaires used within the interview process.

Chapter 3 looks at the various case studies that were investigated as part of understanding the research question. Each case study has a unique building typology. This variation has allowed for the input of varied perspectives. It provides a more significant opportunity to investigate the real opportunities and challenges faced by all professionals involved in establishing these projects.

Chapter 4 assesses the findings from the various conducted interviews and attempts to assimilate the knowledge from Chapter 2, with the practical context experienced by various professionals who actively consulted on the various case studies.

Chapter 5 provides the results and conclusions as well as provides recommendations for future research. This is followed by a reference list and related appendices.

CHAPTER 2

2 Literature Review

2.1 Introduction

The purpose of this literature review is to explain how the Living Building Challenge can be used to reduce the effects of climate change and improve the built environment by promoting sustainable development practices and regenerative and biomimetic design principles. This sustainable development tool can connect urban spaces back to the surrounding natural environment. This literature review will also explain what the Living Building Challenge consists of and how it compares to other conventional green building standards.

2.2 Climate Change

Climate change refers to the drastic changes in global weather patterns caused by the vast amount of pollution, and greenhouse gases pumped into the atmosphere from anthropogenic activities (Harrison et al., 2014; Saad, 2016). Hes and du Plessis (2015) highlight this by stating that global emissions of greenhouse gases have steadily increased over the century, which could lead to a 2℃ increase in global average temperatures by 2040. If this occurs, it would have devastating implications for all life on the planet and could pose a threat to billions of people globally.

Climate Change affects populations of every country at different scales because of varying degrees of adaptation and resilience due to socio-economic and environmental factors (Onguntona, Akinradewo, Ramorwalo, Aigbavboa, and Thwala, 2019). Additionally, climate change is often experienced to a higher degree by those living in poverty, as climate change tends to increase stressors such as food insecurity and hinders economic growth and development (Harrison et al., 2014). The IPCC (2014) argues that climate change exacerbates current social and environmental stressors and provides the opportunity for newer risks to develop.

To curb the increase in temperature, scientists have created boundary limits for the number of greenhouse gas emissions that can be safely emitted into the atmosphere. However, these boundary limits only consider the planet's current conditions and do not consider the effects of ecological destruction. Furthermore, Africa et al. (2019) state that the increase in the destruction of carbon sequestering ecologies such as forests and oceans, along with the inability of humanity to restore those ecologies at an appropriate rate, further decreases our ability to absorb atmospheric pollutants. Swilling and Annecke (2012) agree by stating that the carrying capacity of natural ecosystems is limited by their ability to regeneratively cope with pollutants that are introduced into the system. When these pollutants exceed the threshold, often caused by human activity and waste generation, ecosystems experience irreversible chemical and physical changes. This can also be attributed to the growing demand for resource allocation and consumption idealised by capitalist societies.

Capitalist governments around the world often encourage this form of societal consumerism to promote economic development and tend to overlook climate change mitigation strategies (Hes and du Plessis, 2015). This is further exacerbated in developing countries, such as South Africa, that rely on the intensive consumption of natural resources to improve their economy (Oguntona, 2019). This drive for economic success is often maintained by the growing demand for resources and urban infrastructure, and population growth within urban centres such as large cities. It is estimated that 55% of the current global human population lives within cities and by 2050, this figure is expected to increase to more than two-thirds of the population, averaging 68% (Naboni et al., 2019). Africa et al. (2019) state that the creation and maintenance of these larger cities will result in more than 70% of global CO2 emissions, which will further exacerbate the effects of climate change. Furthermore, Naboni et al. (2019) and Oguntona (2019) agree that cities consume approximately 75% of global energy production. With the anticipated increase in population, pollution, energy demand and urban infrastructure, it is expected to place an even more significant strain on the natural environment.

This constant demand for urban infrastructure and development has resulted in the construction industry being one of the most significant contributors to greenhouse gas emissions globally. ILFI (2014), Saad (2016) and Naboni et al. (2019) posit that the infrastructure and real estate industry is one of the most significant contributors to greenhouse gas emissions, accounting for 50-60% of total emissions. Rosenburg and Winkler (2011) and Saad (2016) highlight that the emissions are caused by the embodied energy, which is the energy used during the manufacturing process of materials, such as steel and concrete, utilised in the development of urban infrastructure. Additionally, these emissions are attributed to the fact that the construction industry is also responsible for 40% of raw material consumption, 35% of the total energy consumption (Hossaini, Hewage, and Sadiq, 2017), 12% of global freshwater consumption and that this industry also produces 40% of global solid waste (ILFI, 2014).

Eisenberg (2016) argues that the construction industry's large contribution toward emissions is also due to a lack of regulatory response by governments and non-profit organisations to curb the industry's effects on climate change. This argument notably does not consider those who fund urban development. Many private investors and large corporations often invest in large scale development projects at the behest of governments and non-profits. By doing so, investors play a crucial role in the regulatory process and often promote the narrative of socio-economic development over environmental concerns. Nevertheless, activists and scientists are calling on world leaders to actively focus on enforcing stricter regulations to help reduce the long-term effects of climate change.

Along with implementing stricter regulations, concepts such as sustainable development should be actively promoted to all who contribute to the construction industry. Educating more professionals on the benefits of engaging all spheres of sustainable development could ensure that the construction of future urban developments and cities becomes more aligned with the functions and processes of the surrounding natural environment.

2.3 Sustainable Development

Sustainable development refers to all developmental activities, particularly within the built environment, that meet the needs of human beings, both for current and future generations (Pieterse, 2011). On the other hand, Walker and Salt (2006) argue that sustainable development refers to humanity's ability to live within the planet's carrying capacity and use our resources more efficiently. Therefore, sustainable development can be broadly defined as the harmonious relationship between humanity and the surrounding natural environment. Both Pieterse (2011) and Oguntona et al. (2019) agree that sustainable development encompasses three spheres, namely social, economic, and environmental sustainability. Each sphere has its impacts and challenges to address.

Sustainable development within the social sphere is defined as the rights and appropriation to natural and urban environments and refers to the policies and regulations that govern equitable and justifiable accessibility to those environments (Pieterse, 2011). Simon (2016) agrees and further describes accessibility as the urban opportunities, goods and services that are within proximity of an individual’s location and allow for growth of that individual’s wellbeing. By allowing equitable access to these systems, sustainable economic development can emerge.

Pieterse (2011) describes economic sustainability as the regenerative capacity of the valued resources consumed within the ecological boundaries of an economic and urban centre. This is often driven by the growth in population, which increases the demand for food, energy, and social services. However, to achieve economic sustainability, Simon (2016) argues that these demands should be met with sustainable alternatives, such as increased renewable energy, resource efficiency, waste management plans and the adoption of green technologies. Nevertheless, these alternatives should focus on improving the natural environment and not be primarily based on economic drivers, as suggested by ecological modernization. This optimistic school of thought suggests that there is economic benefit in the pursuit of environmentalism (ibid).

Ecological modernization can be mitigated by adopting the principles of sustainable development within the environmental sphere. This sphere looks at the impact of a development on both the urban and natural environments and seeks to offset any critical aspects by utilizing regenerative and green technologies. Environmental sustainability seeks to balance manufactured urban infrastructure and the natural ecologies surrounding that infrastructure. Sustainable development can therefore only be achieved if each of these spheres is present and maintained within the boundaries of any given system.

Nonetheless, when trying to achieve sustainable development within the urban context of large cities, the concept of sustainable cities emerges. Sustainable cities are defined as urban centres that meet their inhabitants' developmental needs without compromising the sustainability of natural resources and systems, both locally and globally. By integrating the principles of sustainable development, sustainable cities comprise the three spheres of economic, social, and environmental sustainability, followed by a fourth sphere that considers the concepts of security, peace, and governance (UN DESA, 2013). This sphere of sustainable development was highlighted in the Rio+20 Declaration as well as the UN's World Economic Social Survey (WESS) (UN DESA,2013) and has been categorized under the pillar of urban governance (Figure 2.1). Although this framework provides an integrated approach to achieving sustainable development, it is limited by the complexity and operational boundaries of cityscapes and the variation between systems, policies, historical values and stages of urban development.

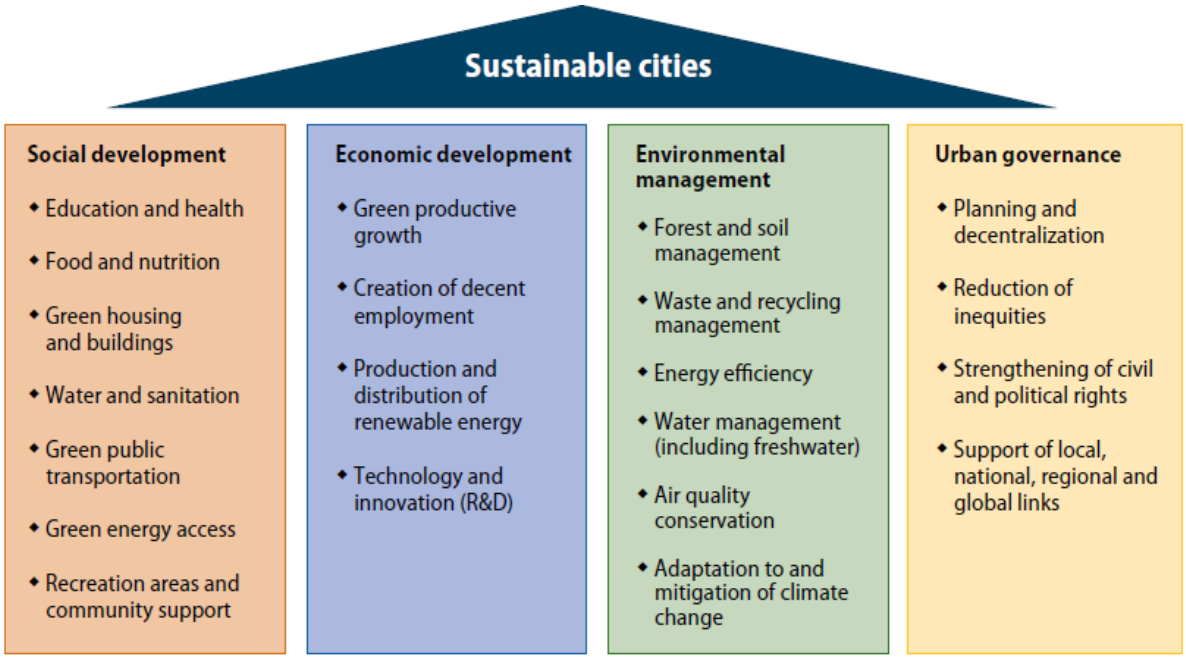

Figure 2.1: Sustainable Cities Framework (UN DESA, 2013)

When looking at the boundaries of modern cities and the urban construction industry, it is evident that sustainability can only be achieved by negating the negative impacts of current construction practices. One fundamental strategy that can be implemented is sustainable and green buildings (Oguntona, 2019). According to Rasekh and McCarthy (2016), sustainable buildings have a minimum negative impact on resource and material consumption and the surrounding natural environment. This solution has been adopted globally, and new research suggests that sustainable buildings could minimize the negative impacts on the outdoor environment; maximize Indoor Air Quality (IAQ) and thermal comfort of the indoor environment; provide greater occupant productivity and satisfaction and have much better long-term economic value (Garzone, 2006; Kibert, 2012, Rasekh and McCarthy, 2016).

Historically, there was significant discussion over whether there was a real benefit to include official green building certification within the built environment as opposed to merely adopting green principles in design and construction a decade ago in South Africa and worldwide. However, the rigorous process of

independent third-party validation and accreditation is now widely acknowledged to have substantial value, and formal certifications are becoming more popular and are no longer primarily linked with groundbreaking breakthroughs (ICLEI Africa, 2015). Nevertheless, to regulate the adoption of this sustainable development strategy, green building standards were developed and are advocated for by a variety of green building councils.

2.4 Conventional Green Building Standards

According to Saad (2016) and Oguntona et al. (2019), green buildings are structures that utilise environmentally responsible processes and efficiently use resources throughout these buildings' entire life cycle. Rasekh and McCarthy (2016) add that these buildings reduce the negative impact that construction has on the natural environment by reducing air and water pollution and solid waste reduction. The Green Building Council of South Africa (GBCSA) further describes green buildings as environmentally responsible through energy and resource efficiency (GBCSA, 2013). Green buildings also have lower operational, maintenance and environmental costs and have been found to improve occupant health and productivity levels (Simpeh and Smallwood, 2018).

Nevertheless, Doyon and Hes (2014) argue that there are certain drawbacks concerning the green building movement. Green buildings are often constructed in isolation from their surrounding environment and, therefore, do not contribute to the more considerable social and environmental opportunities around them. This tends to create a disconnect between the building and the surrounding population. Hes and du Plessis (2015) strengthen the case by stating that green building standards are often structured according to a points-based system and that contractors often perform a "tick-box" exercise that does not address the more significant sustainability issues or create innovative design solutions. Additionally, all authors agree that there is often a disconnect between the design and the actual performance of the building, as the efficiency of the building can often be mitigated through poor occupant behaviour.

However, green buildings still provide better occupant health conditions. They have less impact on the environment than older buildings that utilised Industrial era construction methods. Therefore, green buildings are often advocated for by green building councils (GBCs) throughout the world. Like other green building councils, GBCSA is a member-based, non-profit organisation that often advocates developing green buildings within a specific country or region (UN-Habitat, 2010). Additionally, green buildings are based on a set of guidelines and best practices documented in green building standards. These are often used to regulate the construction of these buildings. These standards are governed by the various GBCs worldwide, with the most noteworthy standards being the Leadership in Energy and Environmental Buildings (LEED) rating system from the United States of America and the Building Research Establishment Environmental Assessment Method (BREEAM) from the United Kingdom.

In South Africa, the most prominent green building standard used is the Green Star SA rating tool, which was launched in 2008 by GBCSA (Saad, 2016). This tool was based on the Australian Green Star tool but was adapted to serve the local South African built environment (GBCSA, 2020 and Hoffman et al., 2020). As of October 2022, the GBCSA has 905 certifications across Africa, with 165 of those being completed in 2021-2022. This is in comparison to the first 50 certifications that took 5 years to achieve at the inception of the tool. This steep uptake is due to the environmental and financial benefits of green building becoming more apparent across all of the construction industry in South Africa (GBCSA, 2022).

The Green Star SA rating tool assesses 9 core categories: management, indoor environment quality; energy; transport; water; materials, land use and ecology, emissions, and innovation (Figure 2.2). Each category has a prescribed number of points that address various environmental initiatives. A certain number of points need to be accumulated for the design of the building to be considered a green building. Each green building using this rating system is then given a star rating based on the accumulated points, with more significant numbers of

stars equating to a more excellent star rating (Green Building Council of South Africa, 2011 and Slabbert,2013).

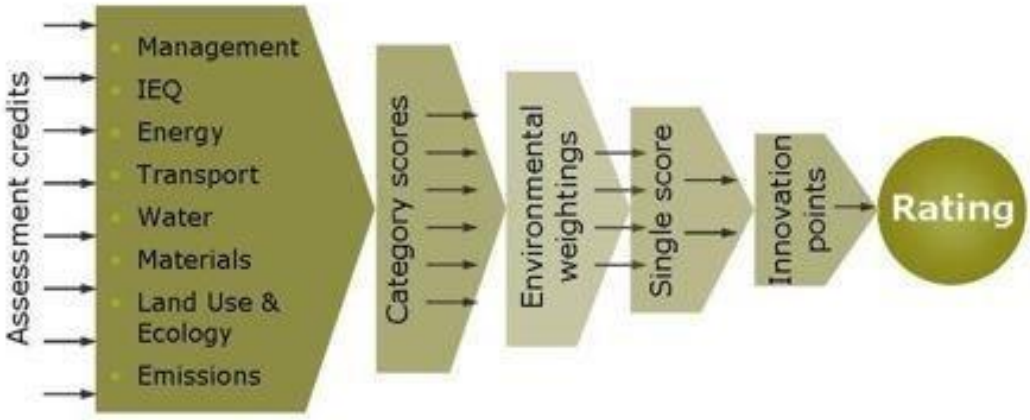

Figure 2.2: Structure of the Green Star SA Rating System (GBCSA, 2014)

Other rating systems such as LEED and BREEAM rate their buildings using the names of precious metals, such as gold and platinum, or words such as Pass and Outstanding, respectively. Nonetheless, each system is still based on the building's design and the point accumulation of the rating system. Furthermore, although these standards advocate for sustainable development, they are often prescriptive, anthropocentric and lack a harmonious relationship with the surrounding natural environment. This, however, can be corrected through the use of regenerative and biomimetic design principles.

2.5 Biomimicry and Regenerative Design

2.5.1 Biomimicry

Biomimicry is defined as the emulation of nature's genius. It is seen as a framework and the practice of mimicking the various forms, processes and systems that can be found in nature to help solve human-centred design challenges (Learn Biomimicry, 2020). Mang and Reed (2012) describe *Biomimicry* as an emerging design discipline that finds sustainable design solutions by looking at nature for inspiration. This broad definition of *Biomimicry* highlights the potential for the natural world to hold all of the answers to many

of humanity's modern-day design challenges. By emulating natural organisms and ecosystems, various solutions can be found that work in tandem with the natural world. The world's leading bio-inspired consultancy, Biomimicry 3.8 (2016) state that these solutions can be found by understanding and utilising the principles and strategies that have allowed all life on Earth to function for the past 3.8 billion years at the same operating conditions. The Earth's stable operating conditions are broken down into five concepts: cyclical processes, the presence of sunlight; water and gravity; dynamic non-equilibrium; and limits and boundaries of the Earth and its biological systems.

These operating conditions have allowed life on Earth to thrive with the adoption of six specific strategies that all forms of life have utilised. These strategies are known as Life's Principles and are the basis upon which *Biomimicry Design Thinking* comprises. By looking for solutions that are locally attuned and responsive to their surroundings; are adaptive to constantly changing conditions; can integrate developmental growth; are both material and energy resource-efficient; make use of life-friendly chemistry and are constantly evolving to survive; designers can create products and systems that are attuned with their natural surroundings (Biomimicry 3.8, 2016). These systems and products can then provide relief for socio-economic and environmental stressors that have been induced by climate change. Furthermore, these solutions can allow the rapid adoption of sustainable solutions; allow for the integration of natural landscapes and urban infrastructure and allow for circular and *Regenerative Design* to be employed.

Additionally, the *Biomimicry Design Thinking* methodology and the Design Lens (Figure 2.3) encourage professionals to look at nature as the basis for their inspiration (Biomimicry 3.8, 2016). This can be achieved by mirroring the shapes and structures found in plants and animals, through the adoption of biochemistry and biophysics or by emulating natural ecosystems found at all scales within nature (Learn Biomimicry, 2020). *Biomimicry* can therefore be applied to all sectors of society and have actively been utilised within the construction and building industry, where it is referred to as biophilic and

Regenerative Design approaches (Naboni, Natanian, Brizzi, Florio, Chokhachian, Galanos, and Rastogi, 2019).

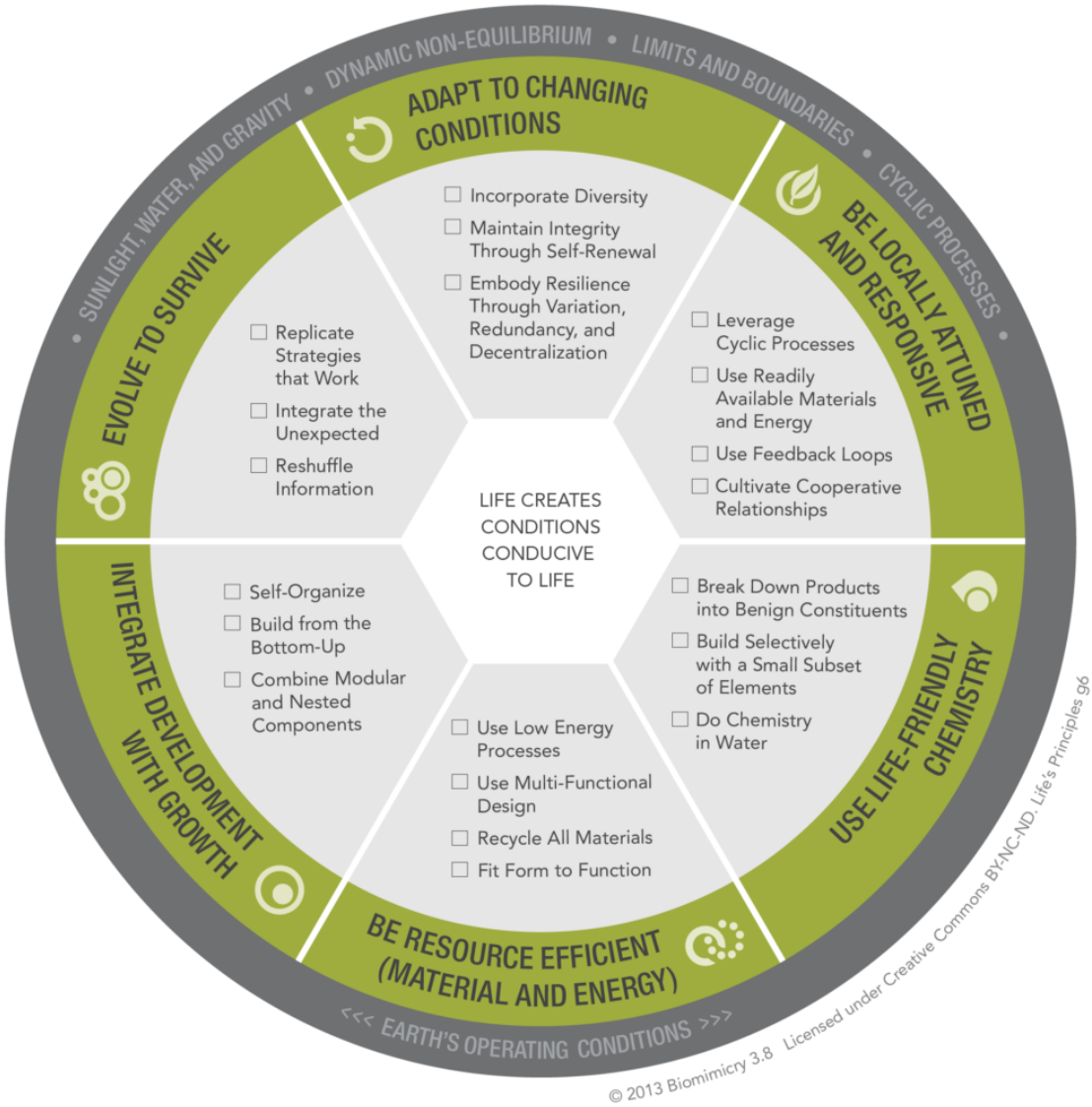

Figure 2.3: DesignLens showing Life's Principles (Biomimicry 3.8, 2016)

2.5.2 Regenerative Design and Biophilia

Regenerative Design is defined as going beyond the limits of resource efficiency towards resource regeneration. This includes the restoration of natural habitats, watersheds and even materials through reforestation and carbon offsetting. Furthermore, Regenerative Design helps with climate change adaptation, ecosystem enhancements and the improvement of human health (Naboni et al., 2019). Mang and Reed (2012) agree that Regenerative Design is based on the underlying knowledge of how ecological systems work and how

these systems often restore previously used resources without depleting existing resources. Furthermore, Zart and Cruz (2016) state that built environment professionals often seek to provide ecosystem services that produce more than they consume instead of reductive series that only seek to reduce energy and water consumption. Net positive design is based on the same principles and form an integral part of the LBC.

Furthermore, specific characteristics of *Regenerative Design* solutions include the physical, economic, and ecological improvement of natural and human communities; the evolution of communities by the reintroduction of surplus resources and energy back into the environment; and by creating communities that are resilient to both external and internal influences (Mang and Reed, 2012; Doyon and Hes, 2014). Another critical aspect of *Regenerative Design* that the construction and building sector has adopted is biophilic design, which seeks to integrate elements of the natural world into the built environment.

Biophilic design uses engineering and design principles that draw inspiration from nature-based systems to support the improvement of environmental quality, health, and well-being (Ryan and Browning, 2018; Africa, Heerwagen, Loftness, and Balagtas, 2019). Biophilia differs from landscape urbanism and ecological infrastructure because it recreates regenerative habitats in and around the building for its occupants. These habitats encompass the building's materials, structure, façade, waste, energy, water systems, and the surrounding environment, creating a symbiotic relationship between the indoor and outdoor environments. It ensures that occupants are in close contact with natural elements, be it through physical plants, natural materials and colour tones, or even through subtle planes such as geometry and patterns found in nature.

By using a variety of principles, all five human senses can be engaged to bring the occupant closer with nature, both physically, through the incorporation of natural elements such as plants, natural materials, and water features and psychologically, through the adoption of light, sound and patterns that remind

the occupant of their natural surroundings. By incorporating these various biomimetic, regenerative and biophilic design principles within conventional green building standards, it is possible to create new standards and guidelines that are holistic and create a lasting relationship between humans and nature.

2.6 Introduction to the Living Building Challenge

The International Living Future Institute (ILFI) is a non-profit organisation that prides itself in advocating for socially just, culturally rich, and ecologically restorative communities by re-establishing the connection between humanity and the natural world (ILFI, 2021). The ILFI has a wide variety of accreditations, transparency labels and initiatives that advocate for communities, buildings and products that are regenerative and restorative towards ecological habitats throughout the world. Their flagship programme is known as the Living Building Challenge (LBC). The ILFI defines the Living Building Challenge as a philosophy, advocacy and certification tool that encourages buildings to have a minimum impact on the environment while simultaneously integrating and living (ILFI, 2014).

The LBC is a set of the world's most stringent green building standards, with the first edition of the standard being released in 2006. Unlike traditional green building standards that seek to reduce negative environmental impacts, the LBC promotes sustainable, Regenerative Design and development by working with the natural environment to create a net positive impact on the building's surroundings. The LBC accomplishes this by adopting *Biomimicry* principles, which are actively incorporated within the standard. Founder and architect Jason McLennan designed the LBC by comparing the urban landscape of buildings to the natural life cycle of plants and wondered what the requirements would be for buildings to behave like plants (McLennan, 2015). McLennan then discovered the concept of the 'living building'.

According to Hegazy, Seddik, and Obrahim (2017), a building is considered to be 'living' when it has the ability to capture, store and treat all of the water that

it consumes; it generates all of the renewable energy that it requires; it is constructed from non-toxic materials; it benefits its occupants and the surrounding community and environment, and it does not encroach on non-developed plots of land. These attributes correlate to the life cycle of plants and form the basis of the various categories, also known as 'Petals', that make up the LBC standard (Broachard et al., 2014 and McLennan, 2015).

There are seven Petals that make up the standard: Place, Water, Energy, Health and Happiness, Materials, Equity and Beauty, and each of these contains multiple imperatives. These Petals encompass the four sustainability spheres mentioned in the UN DESA (2013) Sustainable Cities Framework. Nevertheless, each imperative deals with specific regenerative measures that ensure that the building becomes coherent with its natural surroundings. For a building to achieve LBC certification, all 20 imperatives are to be met over 12 months. Therefore, unlike conventional green building standards, the LBC is a performance-based standard and encourages occupants to work together with the building to achieve certification.

Additionally, there are several other differences between the LBC and other green building standards, such as Green Star Africa. Both Rasekh and McCarthy (2016) and Zari and Cruz (2016) highlight that conventional green building standards are a strict rating tool that advocates for a reduction in the negative ecological impact of buildings but does not provide sustainable solutions that could become health-giving vehicles for both ecosystems and people such as the LBC does. However, a drawback to the LBC is that the standard contains references and assumptions particular to the American context, which cannot be directly translated into the other regional contexts, such as South Africa. An example of this would be the materials imperative that states that 75% of all construction materials are expected to come from a 5000km radius of the project site, which may prove difficult in South Africa but is more achievable in the US. This can be attributed to the fact that most sustainably manufactured products come from either the North America or

Europe and this is beyond the range that South Africa can import materials from.

Furthermore, Hossaini et al. (2017) highlight that the LBC does not provide a straightforward methodology to achieving specific net-zero outcomes, while Hegazy et al. (2017) prove that the constraint of the LBC lends itself to being more costly, which may deter potential projects from being established, particularly in less developed countries such as South Africa. Nevertheless, as more green materials, technologies and techniques are expected to grow in the building industry, it is believed that LBC will become more of an achievable standard throughout the world. Unlike conventional green building standards, the LBC can be seen as a standard that fully integrates all three spheres of sustainable development and addresses climate change by combining urban infrastructure with the principles of biomimetic and Regenerative Design principles.

2.7 Harmful Components to Avoid During Construction

2.7.1 The Materials Red List

The International Living Future Institute (ILFI) defines the Red List as a compilation of materials, chemicals and elements found in building products that are harmful to the health of both humans and ecosystems (ILFI, 2022). This list, therefore, guides toxic ingredients that pose a danger to building occupants and the surrounding environment to assist in conserving energy embodied carbon and limiting waste production (Green Building Alliance, 2021). The Red List is not only intended to help phase out the production and use of these materials and chemicals but is subsequently used as a tool to help influence the materials and manufacturing industry to move away from the production of toxic products and towards the manufacturing of “non-harmful-to-humans” products (Green Building Alliance, 2021).

Furthermore, while a vast amount of chemicals and materials may pose a threat to human and environmental health, the Red List focuses on categories that

are the “worst in class” as these pose the highest risk to the health and safety of the building’s occupants. For a building to achieve a Living Building certification, it is imperative that no materials or products used within the building contain any items that have been listed in the Red List. This is an imperative under the Materials Petal category and is often seen as one of the more difficult imperatives to achieve (Green Building Alliance, 2021 and ILFI, 2022). Although exceptions can be made, the ILFI encourages all living buildings to meet this requirement or ensure that these products are not endorsed and for alternatives to be found. Through the advocation of the Red List and ingredient transparency, the ILFI believes that change in the manufacturing industry can occur that benefits all spheres of sustainable development.

2.7.2 Volatile Organic Compounds (VOCs)

The LBC is made up of various Petals and imperatives that ensure the wellbeing of building occupants and the environment. Certain concepts are often reinforced when they overlap, which can be seen with Volatile Organic Compounds (VOCs). Both the Red List imperative under the Materials Petal and the Healthy Interior Environment imperative under the Health and Happiness Petal advocate for the removal of materials containing VOCs (ILFI, 2022). VOCs are a large group of organic compounds found in multiple building products such as paints, refrigerants, building materials and furnishings (US EPA, 2022).

These compounds are often released or “off-gas” as they evaporate at ambient air conditions and create harmful conditions for IAQ and affect outdoor air quality through the creation of photochemical smog (ILFI, 2022). VOCs have varied health effects but are often most concerning to construction workers and installers who are often exposed to these compounds when applying wet products such as paints, adhesives, and sealants. Furthermore, unlike other materials found on the Red List, VOCs are not banned from use but are to be used sparingly, not to affect the health of any humans or the IAQ of the living building (ibid.).

2.8 Theoretical Framework

2.8.1 Existing Research

Throughout this chapter, literature about crucial concepts pertaining to LBC projects has been used to understand the framework of the LBC standard and how it has been applied at an international level. Research pertaining to *Biomimicry* and *Regenerative Design* principles have also been investigated as these forms the basis of the LBC standard. Additionally, literature on common practice and green building standards, particularly within South Africa, has also been utilised to identify the role of green buildings within the South African building market and how they are influenced by regulation and policies. While research on green buildings and *Regenerative Design* is expanding within South Africa, limited research has been conducted on the topic at hand. Nonetheless, several international LBC projects have been used for research purposes. These papers assist in drawing up a comparison between LBC projects that have been implemented internationally and those that have been proposed to be implemented within South Africa.

2.8.2 Conceptual Framework

The conceptual framework highlights the key concepts discussed and defined in the literature review and provides a holistic view of where the topic fits into the overall body of knowledge. Figure 2.4 shows an interlocking conceptual framework highlighting the three essential themes that form part of the Living Building Challenge. These themes include the *urban landscape*, which looks at the human ecological environment; *sustainable development* that interrogates development through social, economic, and environmental responsibilities; and *Biomimicry*, which emulates nature's genius. At the intersection of each of these themes, there are intermediate themes that look at nature-inspired urban innovations such as sustainable urban drainage systems; technical system design where green building standards can be found; and living system design that seeks to find the human-nature connection within urban development, similar to the design principles of biophilia. The LBC can be found at the intersection of each of these themes and addresses all of the concerns associated with each theme.

Figure 2.5 delineates the various themes previously mentioned into a nested conceptual framework that highlights the relationship between key concepts and provides a more holistic viewpoint. This conceptual framework shows how the production of climate change and sustainable development has influenced national and local governments, building councils and advocacy groups to address the issues of climate change by proposing avenues for achieving energy efficiency through sustainable policies, regulations and building standards. This then leans toward technical system design that prescribes ways of achieving sustainable development through conventional practices and living system design that encompasses restorative principles to build a connection between humans and nature. Technical system design then focuses on green building standards such as LEED and Green Star SA, which advocate for resource efficiency during the design phase. Living system design leads to the Living Building Challenge, which advocates for the restoration of various natural processes and considers the occupational phase of the building. Both systems utilize framework targets to achieve their respective goals. This in turn is influenced by implementation rationale of those who see benefit from the framework, which has a cascading impact on the local natural and built environment.

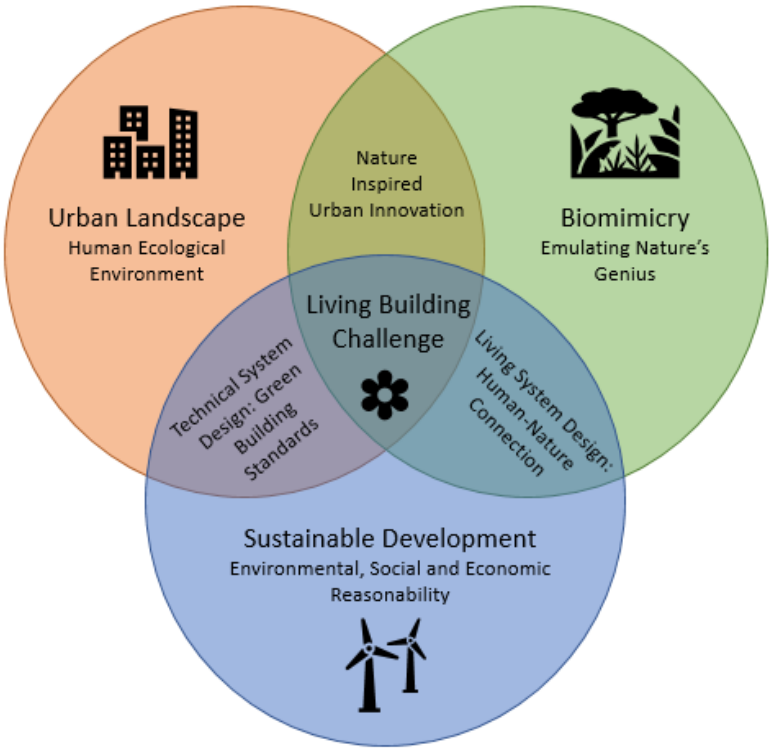

Figure 2.4: Interlocking Conceptual Framework

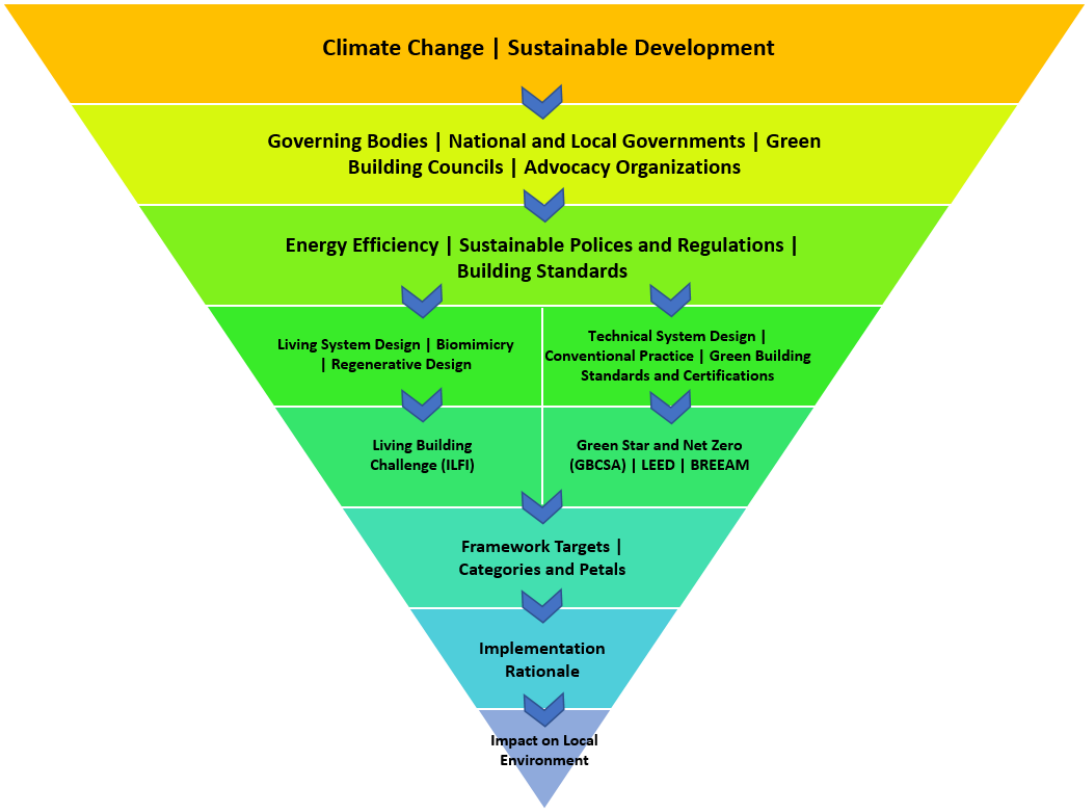

Figure 2.5: Nested Conceptual Framework

2.9 Limitations of the Study

One of the significant challenges that arose, particularly within the South African building market, was the lack of available information since only three of the five projects are currently in their construction phase, and none of the projects has achieved any of the certifications as of the time that this research was conducted. There is no local proof that any imperatives are achievable until the 12-month occupational evaluation has concluded. Therefore, it is difficult for current clients to stay motivated to continue to pursue the Full LBC certification. Additionally, due to the confidentiality of these projects, no true cost estimate was provided by the consultants or building owners for these projects, and to date no estimate of the impact that these projects have on local labor markets and municipalities has been quantified. This was found to be beyond the scope of this report along with the analysis of the socio-economic and political impact that these projects have over surrounding communities and local municipalities.

Another limitation is the lack of awareness and education about *Biomimicry* and *Regenerative Design* within South Africa. This limits the number of consultants who are qualified to work on LBC projects and, therefore, have the knowledge to comment on the ability for LBC to be adopted as a green building standard in SA. The limit on the number of knowledgeable consultants available to conduct the interviews also posed a challenge. The Covid-19 pandemic further provided the limitation of not conducting in-person interviews or the ability to visit various project sites and gain a deeper understanding of what the project sites look like. Nevertheless, these limitations could be overcome if a similar study is conducted in the future when the projects have become further established and LBC certifications have been achieved.

2.10 Conclusion

The literature provided an overall view of how climate change shapes sustainable development and how the construction industry plays a vital contribution to the growth of the human species. As a potential strategy, green buildings can further enhance sustainable development, particularly within urban environments. Nevertheless, the literature highlights the lack of environmental consideration through the conventional green building approach. A lack of regenerative principles has led to point-based standards dominating the green building movement. However, visionaries, such as Jason McLennan, have utilised principles of *Biomimicry* to actively bridge the gap between green buildings and the surrounding natural environment. Through LBC, buildings can become “living” and contribute to their occupants and surroundings. LBC is a standard that should be advocated for but utilised within the local context to achieve a truly sustainable and regenerative future for all future generations.

CHAPTER 3

3 Context Chapter

3.1 Introduction

The purpose of this context chapter is to explain how the Living Building Challenge was introduced into the South African green building market and provide background information on the various case studies that will be utilized when conducting the research. Five case studies are discussed in this chapter. These case studies look at various buildings in South Africa that have registered for the Living Building Challenge.

3.2 LBC in South Africa

In November of 2019, the Living Future Collaborative of South Africa (LFCSA) was launched with its first event titled ‘Truth in Action’. This event saw various people from different industries coming together to learn more about how the South African built environment can move towards a regenerative and net-zero future. The LFCSA was established out of the necessity of many professionals, who realised that change is required to address the many injustices and spatial planning challenges South Africa currently faces. This volunteer organisation believes that these challenges can be addressed by the holistic approach that Living Building Challenge offers. This is echoed by Living Future Education (2021), who stated that if only 1% of all new construction in the US were LBC certified, then 5.7 million tons of CO2 would be prevented from entering the atmosphere, and this could, in turn, save 14 000 years of human life.

Nevertheless, by being directly associated with the International Living Future Institute, the LFCSA was tasked to promote a built environment that is socially just, culturally rich, and ecologically restorative. Their mission was to advocate and work collectively with all stakeholders to promote strategies and approaches that promote the principles of *Regenerative Design* while creating awareness and contextualising the LBC in South Africa (Creamer Media Reporter, 2020).

Since then, the LFCSA has seen the rise of five registered LBC projects being developed in South Africa, and this is set to keep growing. These five projects include residential buildings on Glencore Road and Rugby Road in Oranjezicht, The Green School in Paarl, and 76 Corlett Drive and Solid Green's offices in Johannesburg (Figure 3.1). This chapter will look at each of these buildings in more detail. However, it should be noted that each of these buildings has been registered for a different certification that makes up the LBC.

Figure 3.1: Map showing various LBC project locations around South Africa (not to scale)

The Living Building Challenge is a philosophy tool, advocacy programme, and certification standard that encourages a coherent and regenerative future. According to the LIFI (2021), the LBC is holistic because it includes categories such as equity, beauty, and health; it is not a prescriptive checklist because it is measured and validated by the performance of the building; it removes the barriers for change by providing a guide to collective advocacy, and it this ever-evolving through the application as it there is constant communication between the organisation and project teams.

By applying these principles to the built environment, the ILFI believes that the LBC can be a tool to combat the challenges that many cities face today. However, it was often difficult for project teams to achieve full LBC certification due to its stringent requirements. Therefore, the ILFI has broken down the challenge into various certifications that can be achieved under the challenge. These certifications include:

- Zero Carbon Certification that looks at the operational and embodied carbon associated with the building
- Zero Energy Certification that focuses on energy reduction on site. It advocates for the production of more energy that is consumed.
- Core Certification is seen as the best practices guide. To achieve this certification, there 10 imperatives, that make minimum requirements for a green building, must be achieved.
- LBC Petal Certification is achieved by meeting all of the requirements of the Core Certification imperatives as well as additional imperatives in the areas of Water, Energy, or Materials.
- LBC Full Certification can only be achieved if all 20 imperatives of the standard are achieved.

The LBC is therefore seen as more than just a green building standard and advocates for a variety of certifications that can be achieved. The LBC projects that have been registered for in South Africa include Core Certification, Petal Certification, and Full LBC Certification. These will be further elaborated on under each case study.

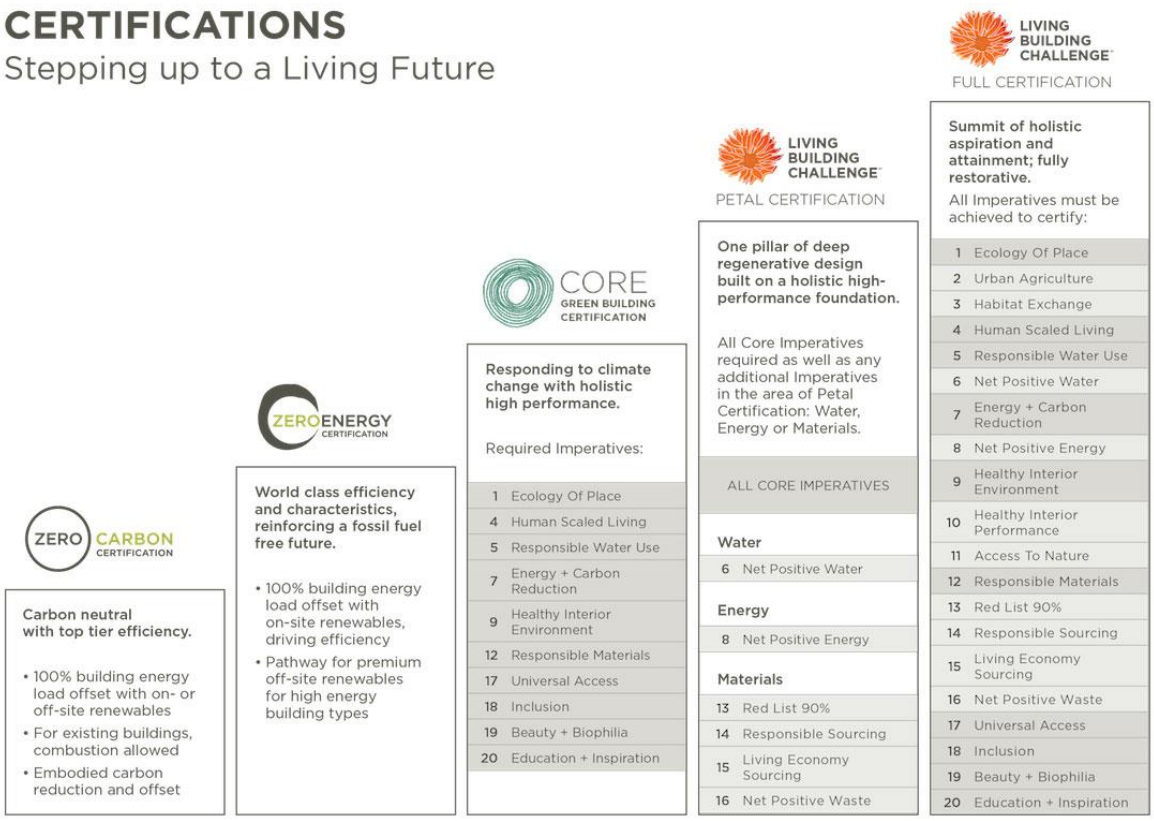

Figure 3.2: List of available LBC Certifications (ILFI, 2020)

3.3 Case Study 1: Solid Green Consulting Office

Solid Green Consulting (2019) is a consulting firm that specialises in green building consulting, Green Star certification, and building simulation. Solid Green's co-founder and director who is also a Living Future Accredited professional, believed that the only way to showcase the company's dedication towards Regenerative Design would be to work out of an office that is LBC certified. In 2019 the company set out to begin construction on their new offices in Parkhurst, Johannesburg.

The new offices were designed by Activate Architecture around the existing 200sqm residential building that previously occupied the site. The building includes an open plan office design that can accommodate 20 people, multi-purpose rooms, shower and changing facilities, bicycle storage, and outdoor seating that overlooks a vegetable garden. The main aim of the building was to ensure maximum occupant comfort, which was achieved through a variety of planned strategies. These strategies include the provision of good air quality

through air quality sensors, operable windows, and natural ventilation; occupant health by encouraging naturally grown, organic foods found in the on-site vegetable garden as well as filtered drinking water; ensuring natural light and views into the garden; the promotion of natural movement through ergonomic workstations, walkable destinations and a multi-purpose studio that can be used for mindfulness activities such as yoga; good acoustics achieved through sound mapping and thermal comfort and control through thermal monitoring.

Additionally, the main roof of the existing building was replaced with a pre-cast concrete slab that was designed to become a second storey floor in the future, if required, and allow for photovoltaics to be installed efficiently. Johannesburg has 277 hours of sunshine per month (9.3 hours per day), making it an ideal location for photovoltaics to be installed (Climate-Data.org, undated). Furthermore, the old pool is planned to be repurposed into a stormwater retention system that allows for on-site greywater cleaning and storage. Johannesburg receives around 784mm of yearly rainfall, mainly within the summer months (Nov-Feb), and although this may not be sufficient through the year, particularly within the winter months, the use of a stormwater retention system may provide enough greywater storage for the building.

The project aims to achieve a Net Zero Carbon certification through the GBCSA and the LBC CORE Green Building Certification from the ILFI (Solid Green, 2021). The design has added to the project's cost savings as well as by saving on the use of more construction materials. The required materials were chosen based on their embodied energy and guided by the LBC’s Material Petal, which requires locally sourced and recycled materials. Construction of the offices is expected to be completed by 2022, and LBC CORE certification can only be granted after the building has been occupied (Solid Green consulting, 2019).

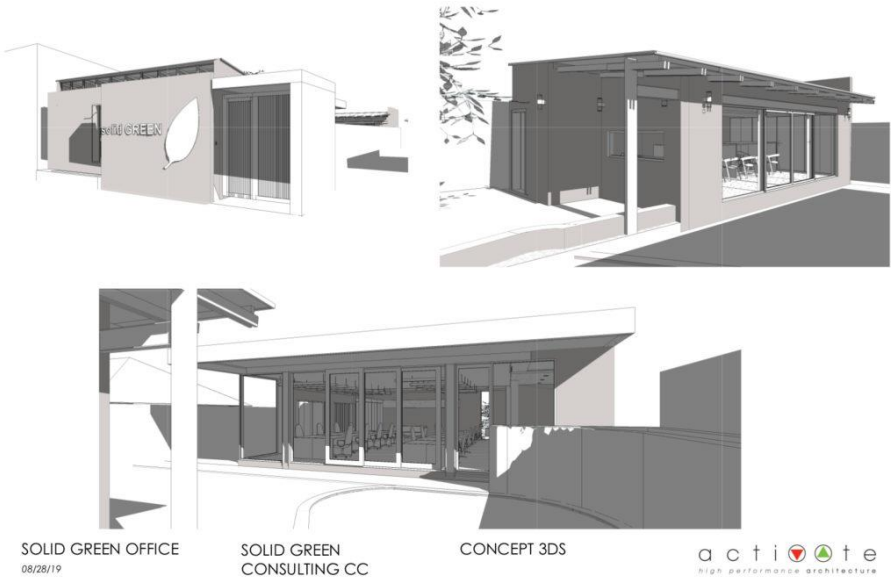

Figure 3.3: Solid Green Consulting Offices: Concept Drawings (Regenerative Collaborative South Africa, 2021)

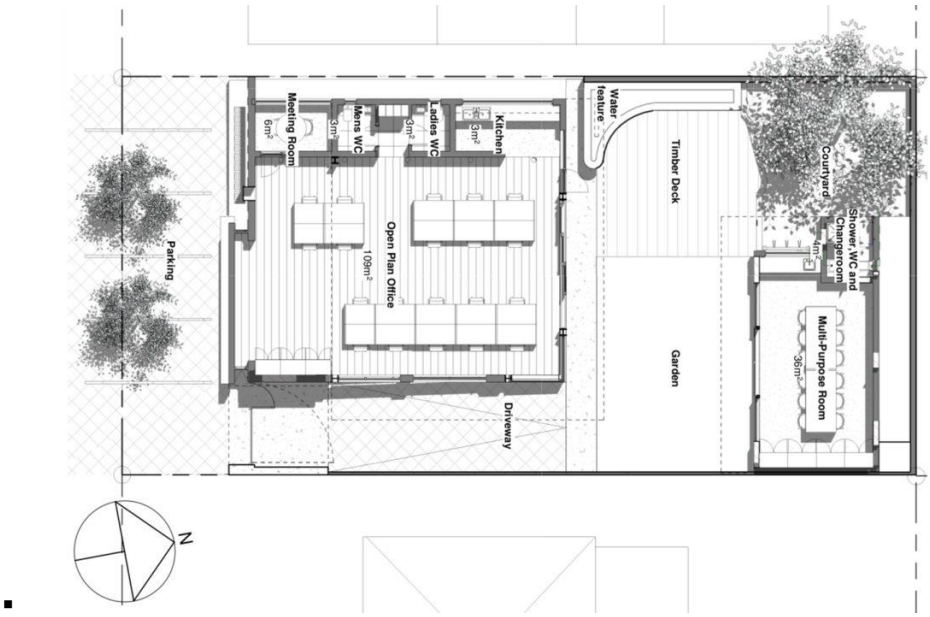

Figure 3.4: Solid Green Consulting Offices: Floor Plan (Regenerative Collaborative South Africa, 2021)

3.4 Case Study 2: 76 Corlett Drive

76 Corlett Drive is the name of a high-end office block situated in Melrose North, Johannesburg. In the heart of a mixed-use suburb, 76 Corlett Drive aims to contain a variety of commercial office spaces and medial suites that will see to the needs of various patients and corporate clients. The 3-storey building aims to have a gross leasable area (GLA) of 2060m2, a multi-use rooftop venue and

will contain 105 parking bays that would serve both the building's clients and visitors alike. The street façade is a mix of aluminium screens that are used as shading devices and vertical gardens that echo the design of the building's neighbour.

The building is being developed by Legaro properties and sits next to the Legaro Head Office located at 78 Corlett Drive. By incorporating similar design elements, both buildings will complement each other and create a seamless transition between the two properties. Biophilic elements used in conjunction with modern architecture are what the architects set out to achieve. The building was designed by Daffonchio architects, who wished to incorporate the highest achievable Green Building Standard and rating tool available for an office block. By using the theoretical knowledge gained from the Living Building Challenge and Green Star SA, the architects set out to achieve a building that would be the first of its kind, particularly on the African continent. Their challenge was to design a building that would continuously improve its performance while reducing construction and development costs. The architects accomplished this by creating a building that is in tune with its surroundings while having as little impact on the environment as possible throughout the life cycle of the building (Daffonchio Architects, 2021).

Additionally, the building was designed to be the highest possible rated Green Star Building in SA. It hopes to achieve this by further providing Net Zero Ratings for all 4 Categories of Waste, Energy, Water, Land-use and Ecology and targeting Petal certification from the Living Building Challenge. Once completed, 76 Corlett Drive is expected to achieve a 6-Star Green Star Medical suites v1.1 Design certification and be the first office building in South Africa to achieve LBC Petal Certification and be the first medical facility in the world to obtain the LBC water accreditation. Certification will only be granted once the building has been constructed, and construction of the building is expected to begin in the second half of 2021 (Legaro Property Development, 2021).

Figure 3.5: 76 Corlett Drive: Front Facade Concept Drawing (Regenerative Collaborative South Africa, 2021)

3.5 Case Study 3: Green School South Africa

Green School South Africa (2020) is a school that prides itself in incorporating sustainability principles through its curriculum and its surrounding environment. The Green School movement was founded by John and Cynthia Hardy, who wished for their children to be taught in a holistic learning community. They established the first Green School in Bali in 2008, and since then, they have driven the movement to include Green School Tulum, Green School New Zealand, and Green School South Africa.

The school is located 7km from Paarl in the Western Cape between the Drakenstein Mountains and Simonsberg. Surrounded by orchids and vineyards, the school sits on 8 hectares of land that include clusters of buildings, sports fields, communal areas, landscaped terraces, and gardens where their food is grown. Designed by Gass Architecture Studios, the campus was carefully planned out by adopting the principles of passive design, biophilic design, feng shui, and the Living Building Petals. This has led to an organic design that connects all occupants directly with the natural world. To reinforce these principles, all of the buildings that make up the school were constructed from locally sourced, natural materials. Furthermore, each building was organically shaped, with each roof having an overhanging leaf-like structure

and clusters of buildings forming the shapes of flowers (Green School South Africa, 2020).

Additionally, in keeping with the theme of sustainability, the school aims to have a minimal impact on the environment while trying to maximise how it can capture solar energy and capture and reuse all the rainwater acquired on the property. Paarl has, on average, 101 hours of sunshine per month (3.4 hours per day) and receives around 821mm of yearly rainfall, mainly within the winter months [Apr-Sept] (Climate-Data.org, undated). This makes it an ideal location for solar voltaic, wind turbines water retention, particularly for use within the summer months.

Figure 3.6: Aerial view of Green School South Africa (Regenerative Collaborative South Africa, 2021)

The project is registered with the ILFI and aims to achieve Full LBC Certification. Fabio Venturi from Terramanzi Consulting is a qualified Living Future Accredited professional who oversaw the school's design to ensure that all of the LBC imperatives were achieved (Mall et al., 2021). Construction of the school was completed in early 2021 and is operating under the current Covid-19 restriction. Certification is expected to be achieved once the school has

demonstrated that it can achieve its operational objectives within 12 months (Living Future Education, 2021).

3.6 Case Study 4: Residences of Oranjezicht

Two residential buildings are planned for construction in Oranjezicht, a suburb located in Cape Town. These projects include 4 Rugby Road and 28 Glencoe Road that plan to be densified to accommodate two-family duplex-style houses on each plot. Both plots were commissioned by Francesco Svelto, a civil engineer and builder. He believed that these buildings should behave independently from the municipal system, and the LBC proved to align with this vision, both mechanically and ecologically. Designed by US-based architectural firm A-I-R Inc, each house was designed with maximum solar orientation and views of the surrounding natural landscape. Additionally, to bring down the construction costs and save on essential space, each plot is expected to have shared utilities and infrastructure, such as water collection systems and an elevator for universal access to both houses located on each plot (Regenerative Collaborative South Africa, 2021).

The main strategies included in the design of these buildings include that each house has been designed with passive design principles in mind, taking advantage of the solar orientation and light shading capabilities of the site. The roof has been designed to accommodate at least 100 photovoltaic panels, which has proven advantageous, considering that Cape Town has 102 hours of average sunshine per month. Furthermore, the roof areas were designed to capitalise on rainfall collection, particularly within the winter months [Apr-Sept], where Cape Town has an average of 621mm of yearly rainfall (Climate-Data.org, undated). This collected rainwater will be used for toilet flushing and irrigation. The integrated use of water on each site led the architects to design a series of gardens that would allow greywater from the buildings to be filtered through a closed-loop system. This would culminate in an aquifer that would contain potable water that on-site boreholes would supplement. A composting system, including composting toilets, was also integrated to ensure that any

black water was treated accordingly. Additional passive design principles used include light shading to reduce glare and the use of thermal suction to manipulate the natural airflow to cool down the houses. These strategies allow the houses to become both comfortable and functional for the residents. Furthermore, the architects believe that this would future proof the houses and allow them to still operate even in conditions of serve drought as previously experienced in Cape Town (Mall et al., 2021).

Figure 3.7: Conceptual Drawings of Rugby Road and Glencoe Road (Regenerative Collaborative South Africa, 2021)

Both projects were initially registered to achieve Full LBC Certification. However, due to reasons that will be highlighted in this research report, the clients chose to look at Petal Certification, emphasising the categories of Energy, Beauty, Health and Happiness (Solid Green, 2021). Additionally, the buildings aim to achieve net positive energy as these houses have been designed to produce 105% of all required energy on-site; net-zero water that means that the water used on site does not exceed the water obtained from reused water sources and rainwater; and net-zero waste that indicates that all waste generated during the construction and operation of the building will be required to be recycled. 4 Rugby Road is expected to begin construction in August 2021, while 28 Glencoe Road is expected to only begin construction in April 2022. Both buildings, however, will only receive accreditation after 12-months of operational performance. Nevertheless, these houses are expected

to showcase how regenerative architecture can be implemented in South Africa and hopes to inspire many more house to follow in its path (Mall et al., 2021).

3.7 Conclusion

With the establishment of the LFCSA, the Living Building Challenge has been actively promoted within South Africa as a tool for achieving a regenerative built environment. These five case studies provide an overview of the various registered LBC projects found within South Africa. They showcase the variety of available projects and how they each vary between location and building typology. Solid Green Consulting's new offices in Parkhurst, Johannesburg, is the only registered building that aims to achieve Core Green Building Certification and is still under construction. Additionally, 76 Corlett Drive, also located in Johannesburg, is registered to achieve Petal Certification, with the construction of the building starting in 2022. These projects provide an overview of how LBC can be implemented within the temperate grasslands found in the Highveld regions of South Africa.

Nevertheless, when moving down to the fynbos regions of the Western Cape, 4 Rugby Road and 28 Glencoe Road have been registered to achieve Full LBC Certification but have since reregistered to achieve Petal Certification, with Full LBC as a future goal. Furthermore, to date, Green School South Africa is the only project in South Africa still registered to achieve Full LBC Certification and is expected to begin operations in early 2021. All of these case studies that have been discussed prove that LBC certifications can be achieved in varying parts of South Africa and that Regenerative Design of the built environment can be achieved even if there are challenges to be faced.

CHAPTER 4

4 Findings and Discussion

4.1 Introduction

This chapter aims to present the findings obtained from conducting interviews with various sustainability professionals who are proficient with the processes of the LBC. Respondents were purposefully selected based on their knowledge about the Living Building Challenge and their experience in working with implementing the standard for projects located in South Africa. A total of five sustainability consultants were interviewed for this research, with each consultant working on one or more of the case studies. Table 4-1 shows the various projects that each consultant worked on.

Table 4-1: Various projects that interviewed consultants have worked on

Project	Consultant 1	Consultant 2	Consultant 3	Consultant 4	Consultant 5
Solid Green Offices		X			
76 Corlett Drive	X				
Green School SA				X	
4 Rugby Road		X	X		
28 Glencoe Road		X	X		
Other (Advisory)					X
Date Interviewed	07-Dec-21	07-Dec-21	13-Jan-22	19-Jan-22	26-Jan-22

A questionnaire was designed to understand what opportunities and challenges presented themselves to these consultants while implementing the LBC on the various projects. Data collected from these interviews were then analyzed to determine the outcome of the research question. A discussion about different green building standards that are implemented in South Africa, along with a comparison between LBC and other green building standards such as Green Star SA, can be found in this chapter. Furthermore, an overview of the opportunities and challenges encountered during the implementation of the LBC in SA and the motivational factors for wanting to implement the LBC is also included.

4.2 Green Building Standards in SA: The Good, the Bad and the Regenerative

There are a variety of green building standards that are available globally. Green Star SA is the most widely used green building standard in South Africa as it is attuned to the South African built environment and climate. The standard has been actively promoted by the Green Building Council of South Africa (GBCSA) and is the standard upon which most green buildings, both in the public and private sector in South Africa, are based on. Additionally, although this tool is aimed at middle to high income building projects, the principles of sustainability upon which this tool is based, can be applied to all spheres of the built environment. However, the socio-economic and political aspects of how Green Star SA fits into the South African construction market was beyond the scope of this research report.

Four out of the five interviewed consultants had a Green Star SA professional accreditation. Nevertheless, each consultant argued that certain concepts and benchmarks found in other international standards provided them with more clarity regarding particular categories they were interested in. Consultant 2, who has been at the forefront of advocating for green buildings in South Africa, chose to pursue the most significant number of professional accreditations for different green building standards. The professional accreditations obtained by Consultant 2 include LEED, WELL, EcoDistricts, Fitwell and Living Future Accreditation (LFA) from the ILFI, which includes knowledge about LBC (interviewed 7 December 2021). By being accredited with multiple standards, Consultant 2 argued that they have a deeper understanding of the various concepts that truly define what a green building is, and they can provide a more extensive range of consulting services throughout the country and continent.

This is in contrast to Consultant 1, who chose to pursue an EcoDistricts certification, as it aligned more with their expertise of designing sustainable infrastructure at a community level, addressing the concept of green infrastructure at a larger scale (interviewed 7 December 2021). Consultant 3 is accredited with Green Star SA and the Fitwell standard. The primary focus of

Fitwell is to assist in generating healthy living environments and how buildings affect the welling of their occupants. Consultants 2, 3 and 5 also believe that an LFA was required for them to advocate for Regenerative Design within the South African built environment. This demonstrates that no single green building standard can provide all of the criteria and benchmarks required for a particular green building project. By understanding the various standards, a more holistic approach can be undertaken.

Nonetheless, when comparing the various standards with each other, Consultant 4 argues that the certifications granted through the implementation of these standards are often limited to specific building typologies. A typical example of this is a single unit residential home often excluded from achieving green building certifications such as Green Star SA. Furthermore, most green building standards often limit the criteria to the footprint of the building and do not consider the surrounding environment. This often isolates the building and narrows the regenerative capability of the building to provide resources back to its surroundings.

According to Consultant 4 (interviewed 13 January 2022), large-scale property developers often take advantage of this foresight and only seek to achieve certification for recreational buildings within gated communities but tend to promote the entire gated community as green building certified therefore sustainable. All five consultants agreed that the concept of applying sustainability principles to a single building does not truly address the current issues of urban development, such as the heat island effect and urban flooding, but that it amplifies these issues. A more holistic approach is therefore required to address urban developmental issues, and this approach can be found within the LBC (Consultant 1, interviewed 7 December 2021).

When looking exclusively at the LBC, all consultants agreed that it was the most stringent standard they had come across and worked with. According to Consultant 1, LBC is a commitment from all stakeholders to follow the holistic design principles of *Biomimicry* and ensure that the proposed building performs

precisely the same way a flower would function (interviewed 9 December 2021). This is echoed by Consultants 3 and 4, who states that the LBC standard encourages the regenerative concept of doing “more good” by contributing back to the surrounding environment, as opposed to the other green building standards that only promote sustainability through reduced resource consumption. Nonetheless, like all green building standards discussed thus far, the LBC also has limitations.

Both Consultants 1 and 3 agreed that specific Petal categories such as the Water and Material Petals, which are fundamental towards the progression of *Regenerative Design*, are often discarded first when clients are forced to downgrade their designs from Full LBC certification to Petal certification. Furthermore, Consultant 2 argues that the registration fee that the ILFI charges for applying for either a Full LBC certification or Petal certification is the same price, even though a Petal certification requires less assistance from the ILFI and consultants. Although this may encourage clients to pursue Full LBC certification initially, it undoubtedly leaves them discouraged to know that a lower-tier certification has a similar registration fee (interviewed 7 December 2021). Additionally, the registration fee only serves a particular income bracket and is not truly inclusive of all members of society (Consultant 1, interviewed 7 December 2021). Nonetheless, all five of the consultants agreed that the LBC is still a step in the right direction and that it has provided a steppingstone towards *Regenerative Design* for the South African built environment.

4.3 LBC vs Conventional Green Building Standards

When comparing the LBC to conventional green buildings standards, such as Green Star SA Office Tool (v1.1), it is apparent that both commonalities and differences arise. One of the significant differences in how the certifications are awarded. Green Star SA, like most other green building standards, is a point-based system, where points are awarded by achieving the criteria of each category at the design stage of the project. The number of points obtained often dictates the rating awarded to that building. The LBC, however, only grants

certification after 12-months of proven outcomes that are aligned with the certification tool. This encourages the building's occupants to be aware of the systems present within the building and ensures that the building contributes positively to its surrounding environment after it has been constructed (Consultant 4, interviewed 19 January 2022).

Nevertheless, when comparing the two standards, there is a definite overlap of criteria. Figure 4.1 shows a diagram with three distinct rows. The inner row indicates the various LBC Petal categories; the second row shows each of the different LBC imperatives for each Petal. The outer row indicates the corresponding Green Star SA category aligned with the LBC imperative. As can be seen, there is a vast similarity between the two standards, with definitive overlaps occurring in five of the seven LBC Petal categories.

However, Green Star SA also fails to incorporate some of the categories such as the Equity Petal and Beauty Petal and regenerative imperatives such as Net Positive energy, Net Positive water, urban agriculture, and habitat exchange (Figure 4.1). Approximately 40% of the LBC imperatives do not correspond with any Green Star SA credits. In comparison, 39% of the Green Star SA credits do not correspond with any of the LBC imperatives, as shown in Table 4-2 and Table 4-3, respectively. This indicates that both standards have room for improvement as the non-common imperatives and credits can be combined to formulate a genuinely holistic green building standard. Appendix A provides a more detailed comparison between the LBC standard and the Green Star SA Office Tool (v1.1).

Additionally, when analyzing the comparison between the Green Star SA Office tool and the LBC standard, it was found that the 6-star Green Star SA certification would ideally be more challenging to achieve than the LBC Core certification but less challenging to achieve than the LBC Petal Certification. In addition to the Full LBC certification tool not encompassing all of the credits mentioned within the Green Star SA standard, it is more holistic and rigorous. It is, therefore, seen as the most demanding certification to achieve. Figure 4.2

provides a modified version of the various LBC certification options, with the Green Star SA certification placed according to the degree of achievability of each certification.

Furthermore, when looking at policy formulation and policy implementation, it is observed that there are various combinations of scenarios in which specific standards can be placed. Policy formulation is defined as the development of efficient and appropriate tasks that address the agenda of the policy (Hayes 2014), while policy implementation is defined as the actions taken towards the establishment of a given policy.

Figure 4.3 shows a graph that indicates the various quadrants of green building standards and regulations in South Africa. The horizontal axis shows the scale of policy formation with well-formulated standards on the right and poorly formulated standards on the left. The vertical axis shows policy implementation with well-implemented standards above the horizontal axis and poorly implemented standards below the horizontal axis. As seen in the figure, Green Star SA falls within the top quadrant of a well-formulated, well-implemented policy. Most green buildings certified with this standard are implemented to a high degree in South Africa. The standard is also well formulated as it accounts for local construction and weather conditions. Other green buildings standards such as LEED, which is also implemented within South Africa, would also fall within this quadrant but are seen to be less well formulated.

However, the LBC can be found in the lower quadrant, where a well-formulated policy is poorly implemented, particularly within the South African context. It is further to the right-hand side of Green Star SA because it encompasses more ideas around *Regenerative Design*, equity, and place. However, it fails to account for the local South African building industry and, therefore, falls short of being well implemented. Additionally, the SANS 10400-XA document, a building regulation that promotes sustainable design principles, is included for comparison. Nevertheless, it has still not been actively adopted within the construction industry and, therefore, lacks a degree of implementation. The

regulation is also limited and does not account for the ideas that have been formulated within the LBC. Hence it is found to be closer to the horizontal axis. The graph is likely to change if a longitudinal study on this topic is conducted. Nonetheless, it provides a basic understanding of the current standards within the graph.

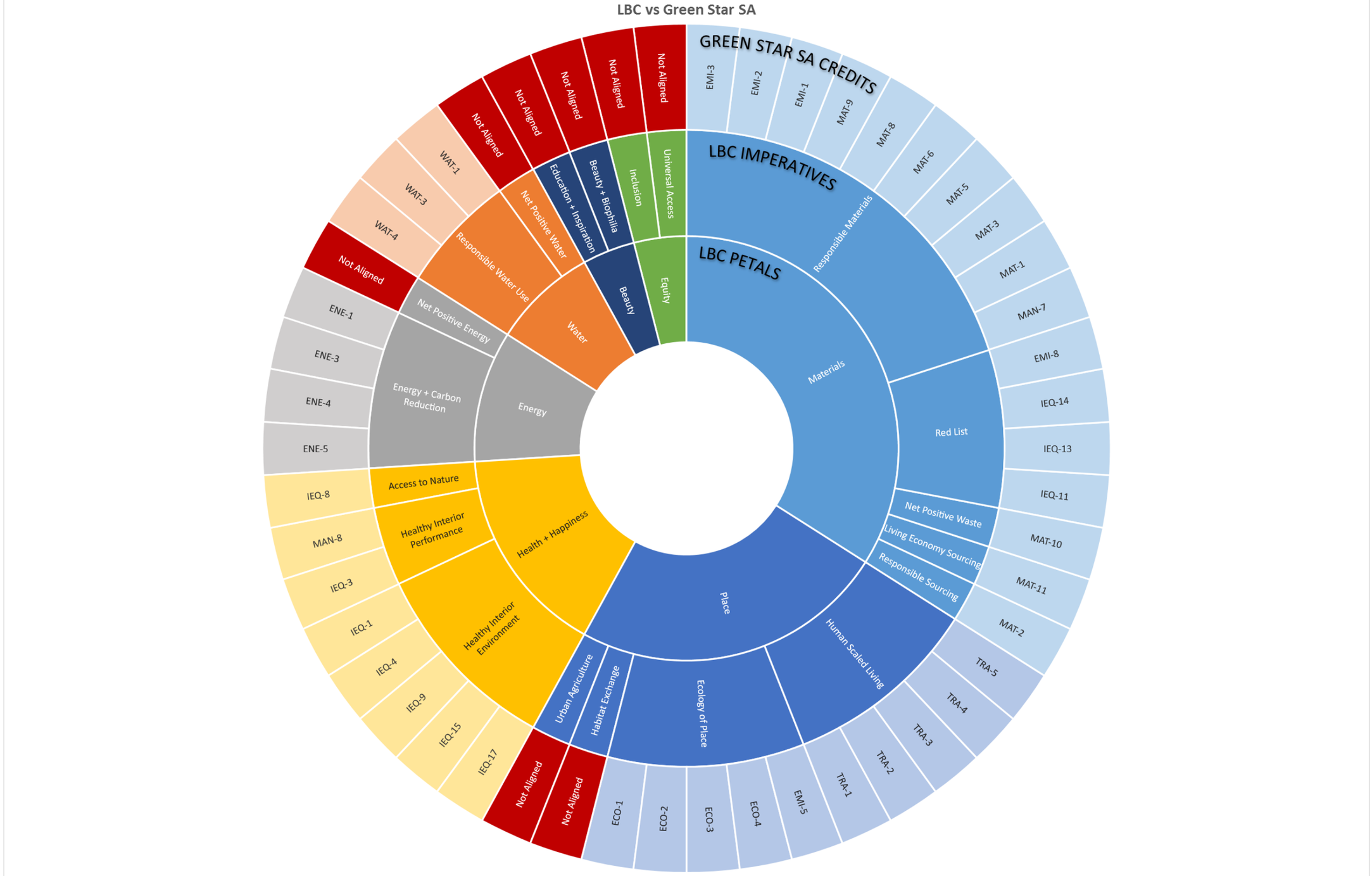

Figure 4.1: LBC and Green Star SA Comparison Diagram

Table 4-2: LBC imperatives that do not align with the Green Star SA standard

LBC Petal Category	Imperative not aligned with Green Star SA
Place	Urban Agriculture
	Habitat Exchange
Water	Net Positive Water
Energy	Net Positive Energy
Equity	Universal Access
	Inclusion
Beauty	Beauty + Biophilia
	Education + Inspiration

Table 4-3: Green Star SA Credits that do not align with the LBC standard

Green Star SA Category	Credit not aligned with LBC	
Management	MAN-1	Green Star SA Professional
	MAN-2	Commissioning Clauses
	MAN-3	Building Tuning
	MAN-4	Independent Commissioning Agent
	MAN-5	Buildering Users' Guide
	MAN-6	Environmental Management
Indoor Environment Quality	IEQ-5	Daylight Glare Control
	IEQ-7	Electric Lighting Levels
	IEQ-10	Individual Comfort Control
	IEQ-12	Internal Noise Levels
	IEQ-16	Tenant Exhaust Riser
Energy	ENE-2	Energy Sub-metering
	ENE-3	Lighting Power Density
	ENE-4	Lighting Zoning
	ENE-5	Peak Energy Demand Reduction
Water	WAT-2	Water Meters
	WAT-5	Fire Systems Water Consumption
Materials	MAT-4	Shell and Core or Integrated Fit-out
Emissions	EMI-4	Insulant ODP
	EMI-6	Discharge to Sewer
	EMI-7	Light pollution
	EMI-9	Boiler and Generator Emissions
Innovation	INN-1	Innovative Strategies & Technologies
	INN-2	Exceeding Green Star SA benchmarks
	INN-3	Environmental Design Initiatives

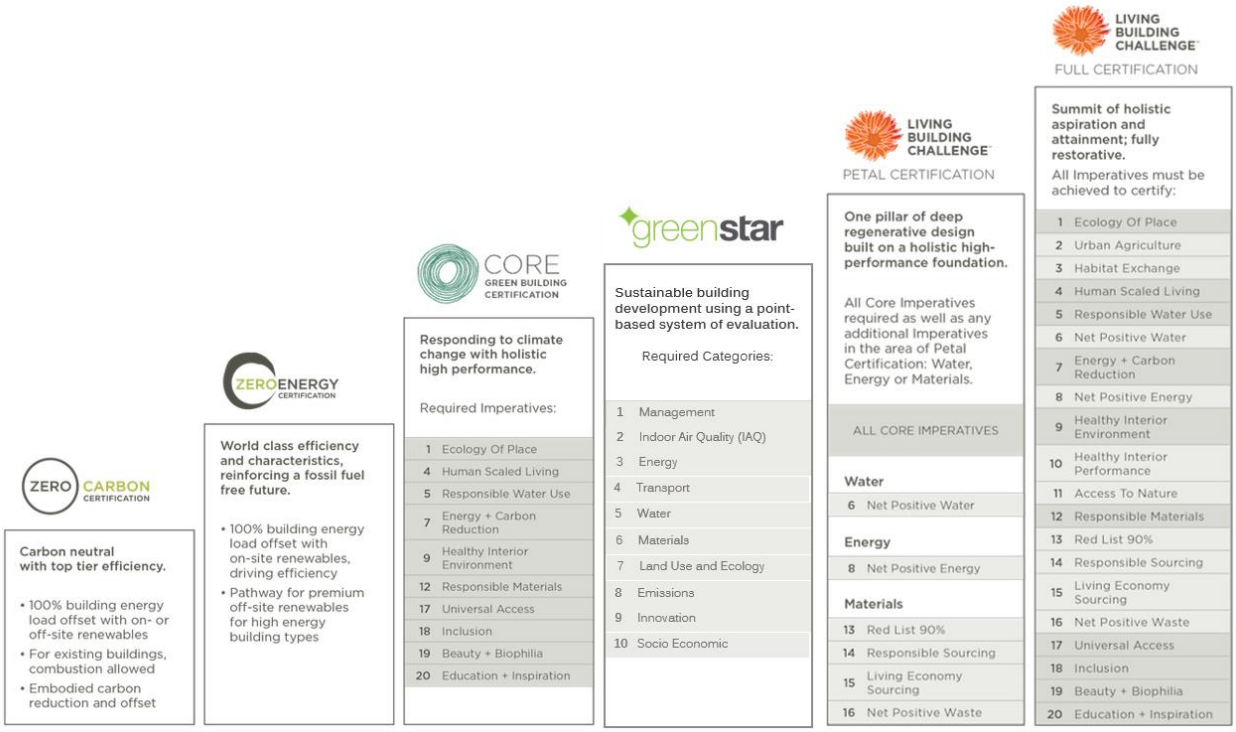

Figure 4.2: Modified version of the ILFI's LBC certification structure including the Green Star SA standard

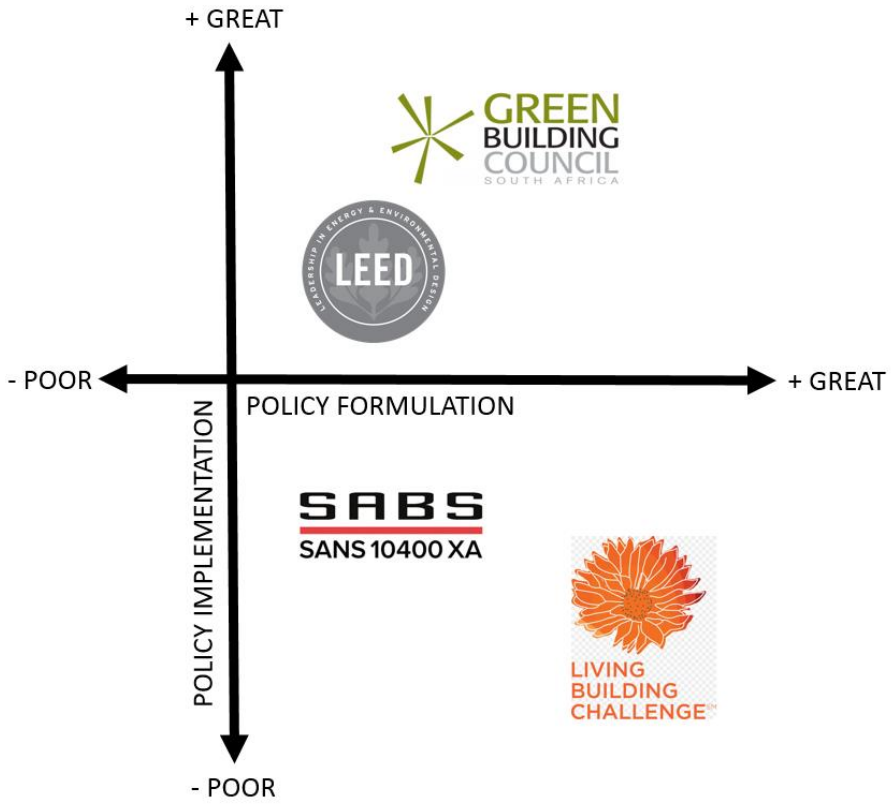

Figure 4.3: Policy Formulation vs Policy Implementation for Green Building Standards and Regulations in South Africa

4.4 Roots, Stigmas and Petals of the South African LBC Flower

The LBC has been based on the metaphor of a flower, where each Petal category was inspired by a particular function of a flower in nature. This section will continue the metaphor of the flower by looking at the root cause of why clients chose to pursue an LBC certification and the various stigmas that the South African construction industry has about LBC. This chapter will also look at the achievability of each Petal and how each of the Petal categories was ranked by the interviewed consultants.

One of the root causes in the success of obtaining full LBC certification is the rationale behind why the project was first conceptualized. Implementation rationale plays a crucial role in the project's development and is often the main driving force for seeing the completion of the project when things do not go as planned. Consultant 1 stated that many of the projects were often rationale of obtaining specific accolades. However, this rationalisation on implementing any green building certification does not always ensure that clients can overcome ordeals that appear during the full life cycle of the project (interviewed 7 December 2021).

When looking at international LBC projects that have been completed, one understands what is indeed required when committing to projects of this magnitude. Consultant 2 (interviewed 7 December 2021) argued that for an LBC project to be successful, all members of the team, including the client, contractors, engineers, product manufacturers and anyone who would contribute toward the project, needs to be wholly aligned with the understanding of what the LBC tries to achieve. The Bullitt Centre is an excellent example of this, where Denis Hayes and the Bullitt Foundation were motivated by the ideals of proving that the philosophy of the LBC can be applied in a commercial building (Bullitt Foundation, 2013).

Consultant 3 claimed that another critical factor in establishing LBC buildings is the mindset and cultural values that a particular client holds. When looking at the Te Kura Whare building, located in New Zealand, built by the indigenous Māori community, Consultant 3 observed that the surrounding natural environment had a cultural significance to the community and wished to preserve those principles within the

building project. The clients found that their motivation stemmed from these cultural beliefs by utilising a nature-based mindset. This relationship between project teams, the building and the natural environment is often the deciding factor between the success or failure of completing a fully certified LBC building (interviewed 13 January 2022).

When looking at the South African context, Consultant 1 (interviewed 7 December 2021) acknowledged that projects such as the 76 Corlett Drive project and the Rugby Road project were often driven by the promise of accolades and acknowledgement within the industry. This form of rationalisation is often not influential and tends to dissipate once challenges within the project arise. When specific design challenges occurred within the 76 Corlett Drive project, the client objectively wanted to change the building's typology away from its initial design of being the first medical suite in the world to achieve full LBC certification. However, when the client was told they would lose the accolade, the client shifted back to a medical suite typology. The consequences of this change in plans left both the clients and the consultants with confusion and disparity in wanting to achieve full LBC certification due to the complexity of the required amendments.

Similarly, the Rugby Road project aimed to become the first residential building with full LBC certification on the African continent. However, this form of motivation was not prominent to overcome the challenges encountered. Subsequently, the client opted to move the project towards the Petal certification as this required a less complex design and became more achievable and affordable for the client.

In contrast, the Solid Green office project was motivated by the company's founders, who wanted to advocate for the challenge by achieving it themselves. This form of motivation is often less susceptible to being influenced by external forces but is still driven by accolade achievement. Although not as powerful as other forms of motivation, it is often the basis for accomplishing more LBC projects. However, when looking at the success of the Green School project, it was evident that the source of motivation was similar to those of the Te Kura Whare and Bullitt Centre projects. The

school owners looked at various green building standards and found that the LBC resonated with the curriculum and brand ethos that they were trying to establish with the school. This gave a more profound sense of meaning for wanting to obtain the full LBC certification, which has proven to be the case.

Analysis of the case studies proves that clients who are unaware of what the LBC entails often do not understand the complexity of the project and are often required to move to a lower certification to ease the registration process. Consultant 5 (interviewed 26 January 2022) stated that most South African clients are still not educated enough on the impact of the built environment on natural ecosystems. Unfortunately, most investors still finance green building projects purely for their financial benefit, as they receive revenue from completed projects, irrespective of the environmental damaged caused by that project. Consultant 4 (interviewed 19 January 2022) agrees and states that current South African clients and investors often become complacent with how the industry performs and, therefore, do not wish to evolve and adapt when new challenges are presented. This makes the LBC seem out of place in the context of the South African construction industry. Nevertheless, with increased education and awareness about the establishment of successful LBC projects in the country, South Africa could potentially see a rise in the demand for *Regenerative Design* within the next decade.

Furthermore, this demand for *Regenerative Design* could be influenced by how the South African construction industry adopts the principles of *Regenerative Design*. When looking at the achievability of each of the Petal categories, all the consultants agreed that some Petals were more accessible to achieve than others. Consultants were asked to rank each of the Petals according to their achievability in South Africa, with 1 being the most achievable and 7 being the least achievable (Table 4-4). According to the consultants, the Place, Health and Happiness and Beauty Petals were the least challenging to adopt as the imperatives of these Petals are often in line with what is currently being done within South Africa. When looking at the Energy and Equity Petals, it was found that certain imperatives became more challenging. Imperatives such as adding electricity back into the municipal grid and providing equitable investment often became a challenge for project teams to achieve.

Nevertheless, all interviewed consultants agreed that the Water and Material Petals were the toughest to accomplish. The complexity of the integrated water systems, the constraints of material sources and stringent requirements of the Red List meant that consultants were often faced with the difficult task of ensuring that alternative solutions were found. Unfortunately, these Petals also proved to be the costliest amongst many other challenges and were, therefore, ranked as the least achievable Petals. By understanding this, the South African construction industry can begin to understand what is required for adopting regenerative development and what concepts need additional attention before implementation.

Table 4-4: LBC Petal Achievability Ranking (1 = most achievable and 7 = least achievable)

LBC Petal Category
1. Place
2. Health + Happiness
3. Beauty
4. Energy
5. Equity
6. Water
7. Materials

4.5 Challenges of Implementing LBC

After interviewing the various consultants, it was found that there were numerous challenges that occurred while trying to implement the LBC in South Africa. One of the fundamental challenges with the LBC, particularly in South Africa, has been the cost of establishing such a project. Compared to traditional building projects, many consultants found that the initial capital expenditure costs for LBC projects were much higher than costs for traditional buildings and even Green Star SA rated buildings. This can be attributed to the fact that LBC buildings are designed to be completely off-grid and do not rely on municipal services for resources such as water and electricity. Furthermore, the addition of off-grid solutions makes the design of a building more complex. A multitude of engineering services, not traditionally used for traditional buildings, are now employed due to the innovative technologies applied to

ensure that the building becomes self-sustaining. These engineered services are often very specialized, and it was found that there may be a lack of skilled professionals within the country that can design for these systems (Consultant 1, interviewed 9 December 2021). Nevertheless, when professionals with qualified skills are available, two main challenges arise that deal directly with the fee structures set out by the Engineering Council of South Africa (ECSA).

For regular buildings, the engineering services are often calculated as a percentage of the total cost of works of the project. This, however, cannot be applied to LBC projects due to the complexity of the systems used, as each system is unique and site-specific, and no evaluation of specialized engineering services has been completed for such services in the past. This, in turn, leads to increased capital expenditure costs for clients who often do not understand the complexity of these engineered services. Secondly, Consultant 3 stated that ECSA fees are often based on the size of the installed system (interviewed 11 January 2021). This creates a challenge for innovation, as engineers are not motivated by the ECSA fee structure to want to develop more efficient systems that would benefit the client as this would result in reduced fees being paid toward the engineers for their services.

Additionally, older generation engineers are often accustomed to strategies that have worked in the past and are hesitant to implement newer solutions, as the risk of these solutions becomes far higher than traditional solutions. The risk to reward ratio outweighs the motivation for innovation. This paradox of cost, risk, and innovation will only be solved if the ECSA fee structure is revised to allow more complex and efficient solutions adopted within the construction industry. By doing so, clients would also understand the cost of engineered solutions, particularly for off-grid solutions that the LBC requires.

The significant capital expenditure costs that are associated with achieving the LBC often deter clients and investors away from such projects because these costs are often much higher than for traditional buildings or traditional green buildings. Consultant 3 has found that when clients, particularly those working on Green Star

SA accredited projects, are confronted with decisions based on the project's finances, it is often the sustainability systems that are discarded first. This counterintuitive decision is based on short term returns on investment, as investors are primarily focused on the monetary outcome of the project. This idea extends further into other financial industry sectors and institutions such as large banks, who often advocate and fund sustainable developments for corporate accolades. However, these primary funders for green building projects often invest in projects that cause ecological destruction, such as offshore fracking and mining. This does not address the sustainability crisis and often leaves those who advocate for regenerative solutions with a sense of despair (Consultant 4, interviewed 19 January 2022).

Furthermore, Consultant 1 also argued that it is not profitable for green building consultancies to work exclusively on LBC projects. Clients are often not willing to pay for the hours of work required for such projects. Extensive research and information are required at all levels of the LBC certification. It is often not viable for professional sustainability consultants to focus on one particular aspect of a project for months on end without utilizing their skills in other areas of the project well. This is highlighted in the case of the Rugby Road project, where a consultant was based full time on the Materials Petal to focus on the research of products and their compliance with the LBC Red List imperative requirements.

There are also a variety of challenges experienced with the various Petal requirements of the LBC. The consultants agreed that the Materials Petal is one of the hardest to achieve, with the Red List imperative being the most strenuous, particularly in South Africa. This imperative is intended to ensure that all of the materials used for the project are free of toxins and harmful chemicals that have been listed in the ILFI’s Red List of ingredients. This can only be achieved through the transparency of manufacturers and suppliers. All of the consultants agreed that this is one of the most challenging exercises to perform, particularly in South Africa, as many manufacturers and suppliers often hesitate to share information about what ingredients are contained within their products. This lack of transparency and inability to find alternative ingredients or products that comply with the Red List has been one of the most challenging tasks for all of the consultants working on LBC projects in SA.

Additionally, another challenging imperative associated with the Materials Petal is the Living Economy Sourcing imperative which promotes the use of materials sourced within a certain radius of the project site. This imperative promotes local communities and businesses and limits the transportation costs associated with the importation of materials. Consultant 2 argued that this imperative in its current phase limits the South African market to only import materials from other African countries. They believe that the most suitable products for projects, mainly commercial office buildings, are often only found in North America or Europe, where they are exclusively manufactured. This imperative, therefore, does not apply to the South African context (interviewed 9 December 2021). The materials locality radius for a project located in Johannesburg can be found in Figure 1.2.

Another particularly challenging imperative is the Healthy Interior Performance imperative, found in the Health and Happiness Petal. This imperative promotes healthy environments and high-quality indoor air circulation through active air quality testing. However, many air quality experts in South Africa are not aware of the stringent requirements that this imperative recommends should be tested. Most of the locally manufactured equipment often does not cover the full range of indices and testing the IAQ of an LBC building is often difficult to execute. Consequently, testing equipment imported from other countries is required. The cost of testing also becomes a factor as any failed tests often require a new set of tests. This also produces a financial burden on the client as well as the consultant.

Another financial challenge specific to the LBC Petal of Place is that of the Habitat Exchange imperative. This imperative encourages all stakeholders to donate money towards protecting natural habitats through an approved land trust organization to offset the carbon associated with the project, equivalent or larger to the land on which the project will be located. Both Consultants 2 and 4 agreed that this payment often has no impact on the project and discourages clients from investing in the imperative. There is no direct return on investment (ROI) for such a large sum. Particularly for small projects such as residential houses or projects that benefit the community, such as schools and public buildings, investors would often prefer to donate the money to

a cause that directly impacts their immediate surroundings or community. Nevertheless, the imperative still promotes the conservation of protected natural landscapes, which is key to preserving animals and plant life.

When looking at the Water Petal, it was found that the complexity of the off-grid design solution makes it both expensive and challenging to comprehend for clients. Consultant 2 emphasizes that the water systems required to be integrated within an LBC building include stormwater management systems, including rainwater harvesting, wastewater management systems, recycled greywater or treated effluent systems, and potable water systems that need to incorporate heating elements as well. This example demonstrates the complexity of a single element of the house that needs to be simultaneously interconnected. Additionally, this needs to speak to the architecture of the building, which in turn needs to respond to the contours of the land. This becomes particularly challenging if a solution such as a gravity-fed water system wants to be employed or if retrofit systems are required for existing buildings.

LBC also requires for all the systems to be part of a closed-loop system, and Consultant 2 highlights that if these considerations are not taken into account from the initial design phase, it is often difficult to retrofit such a system at a later stage of the building's life cycle and this could prove to be more costly (interviewed 9 December 2021). Furthermore, South African municipalities are often wary of approving off-grid water solutions as they are not liable for the standard of potable water circulated throughout the building, which could pose a potential health risk to the building's occupants. Nevertheless, these complex systems often provide cleaner drinking water than the conventional municipal water systems as the standards are often far higher and require less water transportation through large underground pipes.

Lastly, an unforeseen challenge that has also dictated the projection of LBC projects in SA is the effect of the Covid-19 pandemic. Clients were often faced with difficult decisions as many project timelines got pushed back. LBC projects intended to be completed by 2020-2021 often fell short of their completion date due to the harsh

lockdowns and labour restrictions imposed by the South African government. Many clients were forced to reevaluate their situation. An example of this was the Solid Green offices who were forced to change their designs to accommodate their staff during the pandemic, as well as the clients of the Rugby Road project who were concerned that off-grid water solutions could potentially fail to function if no occupants were living in the building at the time of the pandemic.

Furthermore, consultants found it challenging to work on certain LBC imperatives, such as the IAQ testing that required machinery to be imported from overseas but halted due to the impending lockdowns. Additionally, a spotlight was often cast on finances during the lockdowns. This also contributed to the ideas that shaped the LBC projects currently being constructed in SA, as many clients opted to move to lower certifications to retain cash flow. Nevertheless, the consistent pursuit for accolades and being at the forefront of *Regenerative Design* within South Africa has also led to a vast number of opportunities that were available for these projects.

4.6 Opportunities for Implementing LBC

Although the LBC presents a variety of challenges in South Africa, it undoubtedly has many opportunities associated with it. One of the most significant opportunities that the consultants agreed upon was introducing a regenerative building standard into the South African built environment. With many policies and standards focusing on sustainable outcomes, the LBC provides a roadmap to become regenerative and promotes the design of buildings tuned with the surrounding natural environment. This goes beyond the conventional standards of LEED and Green Star SA and has shown that certifications such as Net-Zero Energy or Net-Zero Water can surpass the threshold and become Net Positive, indefinitely contributing back to the community and the environment. This, in turn, fosters environments that encourage the emergence of innovations and ideas.

Another fundamental opportunity that comes with establishing LBC projects is that the ROI can be far greater than for conventional Green Star SA rated buildings. Consultant 3 argues that although there is insufficient evidence to prove this within

the South African context, LBC buildings would, in theory, have a higher rental and sale value. Additionally, Consultant 1 had performed a theoretical cost-benefit analysis for the 76 Corlett Drive project and found that the ROI would be in the range of 10-12%, as opposed to a standard green building that would only provide a 7-10% ROI (Consultant 1, interviewed 9 December 2021).

Nevertheless, the analysis also showed that the 76 Corlett Drive building could recover its initial capital expenditure costs within 7 years and would only have operational and maintenance costs associated with the building because all of the other required resources would be provided by the building no additional cost. Furthermore, when looking at international case studies, Miller (2009) stated that this analysis differs depending on the climatic conditions and size of the building as the ROI can range between 4% to 49%, with recoverability ranging between 2 to 44 years. Further investigations and research would be required to confirm these figures for the South African market. Nevertheless, the initial analysis proves that LBC buildings in South Africa are a greater investment and can provide additional resilience in a country faced with rolling power outages and the threat of water demand that could exceed the country's supply by 2030 (Adam, 2021).

As mentioned above, all the consultants agreed that the initial capital expenditure costs to establish a fully certified LBC building and the cost for registering with the ILFI could seem daunting to clients and potential investors. However, the multiple certification options offered within the LBC allow more buildings to enter the market while targeting specific outcomes. Consultant 1 said that these intermediate certifications, such as Core and Petal certifications, provide a bridging gap between Green Star SA certifications and the full LBC certification (interviewed 9 December 2021). Consultant 3 also argues that when clients opt to go from full LBC to Petal certification, it becomes more achievable as fewer imperatives are required, and fewer restrictions are needed within the design. Nevertheless, all of the consultants agreed that minimum benchmarks for resources such as water and energy should still be applicable to achieve Core and Petal certifications. This is an opportunity for the ILFI to revise the certification requirements.

Many opportunities have presented themselves when looking at specific imperatives and Petals. One of the main opportunities that arise from the Beauty Petal is the opportunity to integrate the African landscape and narrative into the architecture of the building and to have the ability to celebrate South Africa's unique heritage. Consultant 3 stated that the South African built environment has often copied the architectural styles of Europe and North America. However, the LBC encourages designers to create buildings that talk to the cultural heritage of South Africa. Consultant 4 gave an example of this with the Green School project located in Paarl. When the consultants were looking at how they could incorporate the history of the town into the project, they were faced with the dilemma of looking at the colonial settlers who established the town or looking beyond that time to the original, wealthy Khoi-San clans that inhabited the area thousands of years prior. Both histories were honoured through the design process, and a genuinely South African blend of buildings was designed within the school. Through these imperatives and exercises, we often learn more about our heritage and acknowledge the almost forgotten history of the land upon which the building stands.

Another imperative found in the Health and Happiness Petal that has provided opportunities for the consultants is the Healthy Interior Performance imperative. Although it was challenging to achieve this imperative, Consultant 4 said it provided an opportunity to show organizations, such as the ILFI, that South Africa has equivalent air quality laws and standards similar to those found in the US that would be more applicable to the local context. Furthermore, Consultant 3 also demonstrated the opportunity for consultancies to invest in air quality testing equipment that would then allow them to offer it as an additional service to future clients. The innovation brought about by the LBC improves the local built environment. However, it would also help provide local benchmarks against which future buildings can be compared and thus could strengthen local regulations and standards that govern particular aspects of the building industry.

This also can influence the market and change perceptions of those who contribute to the building industry. Consultant 4 demonstrated this by using the example of obtaining the volatile organic compound (VOC) free paint that would be compliant

with the Red List imperative. The consultants found a paint manufacturer willing to create a blackboard paint free of VOCs for the Green School project. By doing so, they have influenced the market by proving that certain hazardous chemicals can be removed from products and, in turn, have created a new market for safer and healthier materials and products that could positively impact other buildings across the country. Furthermore, when looking at the industry, the LBC has also provided an excellent opportunity for inter-disciplinary collaboration. Consultant 3 stated that meetings held for LBC projects often included people of various professional backgrounds that are not usually included in meetings pertaining to the built environment.

Professionals from asset management and finance, environmental, social and governance (ESG) departments, engineers, architects, and sustainability consultants were all present when certain decisions were required. Consultant 4 also highlighted that departmental silos were often broken down when activities such as the Biophilia Exploration Day, a requirement of the Beauty and Biophilia Petal, had occurred. This provided the opportunity for cross-pollination of ideas and aligning stakeholders around specific biophilic design goals and project outcomes (ILFI, 2020). Ideas around *Regenerative Design* and *Biomimicry* also become more commonly used terms, and these concepts then become exposed to more industries due to the cross-pollination that occurs. These ideas could, in turn, influence how the built environment is steered within South Africa.

4.7 The Role of Municipalities

Municipalities play a vital role in controlling and governance of resources such as water and electricity within communities. However, this centralised control system has become redundant and cannot keep up with the growing demand for these resources. Municipalities, therefore, have to acknowledge that their role in the future will be forced to change if more off-grid solutions, such as LBC buildings, are to be developed in line with the global trends of regenerative infrastructure. Nevertheless, in countries of the Global South, such as South Africa, it is often difficult to change

the mindsets of people accustomed to the many systems of structure and control introduced in the past through colonial doctrines.

Local municipalities often feel threatened by the idea of off-grid solutions as many municipal workers believe that their jobs are at risk of becoming irrelevant because developments such as LBC buildings do not require any connections to municipal infrastructure. It is believed that less income would filter back into the governmental structure, and fewer employment positions would then be required. Nevertheless, it is up to local governments to ensure that people are skilled enough to maintain these off-grid systems and promote regenerative solutions. The Inclusion imperative within the Equity Petal further encourages high-skilled job opportunities to become more accessible to local communities where the project is located, and this could, in turn, provide better opportunities for those who were previously employed by the municipality.

For most South African LBC projects, all consultants said that the municipalities and local governments that oversee the sites where the projects are located are often not approached or are told about the general critical areas of the development. In particular, municipalities often discourage off-grid water solutions and insist that every site have a municipal water connection for health and safety reasons. In order to get around this, Consultant 3 said that although this connection was available on-site, it would not be used within the building, which in turn still ensures that the building is eligible for an LBC certification. Consultant 2 also highlighted the fact that when off-grid solutions are applied at a larger scale, for example, at a community level, the responsibility of the quality of water is often then required to be checked by individuals, and this, in turn, creates a structure of governance similar to the structure of local municipalities.

Another critical aspect controlled by local governments is the interpretation of national legislation and the establishment of regional bylaws. Consultant 1 argued that although specific legislation addresses aspects such as septic tanks and black water recycling, the municipality often decides how that legislation is implemented within

their area. Therefore, each municipality often has the role of deciding how the legislation is enforced by establishing bylaws. These bylaws, however, are often established for personal gain and not for the betterment of the community. Chipkin and Vidojevic (2022) argue that these policies and regulations are often drafted without thinking about which organisations will inevitably implement these policies, which raises the risk of policy failure.

Klaaren, Belverdere and Brunette (2021) state that the current political landscape in South Africa that governs urban management is dotted with maladministration and corruption in all spheres of authority. This form of corruption diverts public money and resources for private gain and negates the authority of the organisation where the corrupted official departs from their formal role (Chipkin and Vidojevic, 2022). This further challenges those who wish to establish standards and regulations that benefit the sector, as this is in direct conflict with those in power who benefit from their own selfish political and financial agendas. Nevertheless, Consultant 2 argued that the national building regulations often supersede the need to abide by particular bylaws and as such many property developers tend to overlook them well. Regulations such as SANS 10400-XA are therefore crucial in governing how regenerative principles are adopted within the building industry in South Africa.

Consultant 2 has stated that in the case of remote developments such as eco-estates that are located far away from municipal infrastructure, it is often in the interest of the municipality to co-operate and approve off-grid solutions as they would primarily benefit from taxes and services such as waste management removal that would not otherwise be present without the establishment of such a development. Nevertheless, building regulations such as SANS 10400-XA offer a more comprehensive approach to sustainable development within the country. While revised regulations such as these are only recently being introduced into the construction industry, it may take some time before they are widely understood and implemented throughout the country. Nevertheless, introducing these standards into the construction market will assist in pushing future construction in South Africa towards a regenerative direction.

4.8 Conclusion

This chapter provided an overview of the opportunities and challenges encountered when trying to implement the LBC in SA. When looking at the various standards, it is evident that consultants are often limited in their knowledge when they are only accredited in a single green building standard and, therefore, look to other standards to clarify certain aspects of the green building industry. Although the LBC is the most stringent green building standard globally, it often also has limitations and promotes *Regenerative Design* only to a certain degree. Furthermore, when comparing both LBC and the Green Star SA standards, it was found that both standards lack approximately 40% of what the standard requires, and this indicates that there is definite improvement required in both standards. Consultant 2 stated that the Green Star SA will undergo a reevaluation in 2022 and that there would be a more significant overlap between Green Star SA and LBC in the future. This could see the push towards more *Regenerative Design* principles adopted within the Green Star SA certification tool.

There are a variety of challenges that arose from the implementation of LBC in SA. Some of these challenges include the idea that the ECSA fee structure requires updating to promote innovation, and financing LBC projects is a crucial challenge. Certain LBC Petals were also especially challenging, such as the Water and Materials Petals, which contain complex designs and are limited to the geography of the African continent. Healthy indoor environments and the indoor quality testing associated with the imperative was also challenging. A final challenge that was unforeseen by all consultants was the impact that the Covid-19 pandemic had on the progress of LBC projects in the country.

Nevertheless, many opportunities also presented themselves during the implementation of the LBC. These include a more significant ROI and shorter payback periods. Additionally, opportunities presented themselves, such as the breaking down of departmental and occupational silos that often prevented projects from finding optimal solutions. Specific imperatives also allowed consultants to acknowledge the cultural history of South Africa and provided the opportunity to

influence key manufacturing markets. Another critical area was local governments and municipalities' role in establishing these projects. Most of the consultants agreed that local governments often felt threatened by the idea of LBC, and therefore, consultants had to find solutions around this collaboration. This also heightened key aspects of bylaws and legislation and how they can be incorporated or often misused by developers.

The implementational rationale behind wanting to accomplish full LBC certification is one of the determining factors when anticipating if the project will ultimately be successful or not. This is also determined by the level of education about the LBC philosophy and the dedication to accomplish the goals set out by the standards of the clients and investors. Education plays and will continue to play a critical role in developing LBC projects in SA. All sectors that contribute to the built environment should be encouraged to learn more about how biomimetic and *Regenerative Design* principles can be applied to the building sector.

CHAPTER 5

5 Conclusion and Recommendations

5.1 Introduction

This chapter provides an overall summary of the objectives and findings of the research. It highlights vital discussions that were made in previous chapters. The study's limitations then follow the summary of the results. Finally, recommendations and future avenues of research are explored.

5.2 Summary of Results

The research aimed to determine the opportunities and challenges encountered by sustainability consultants during the implementation of the Living Building Challenge in South Africa. Chapter 2 focused on reviewing both national and international literature to guide the research in understanding how the LBC came into existence and its role within the South African green building industry. Several sections were discussed in the literature review, namely climate change and its impact on the world, sustainable development, and the role of conventional green building standards. Finally, *Biomimicry* was looked at and how it inspired the formulation of *Regenerative Design* and how LBC introduced the ideas of *Regenerative Design* into the green building sector.

Climate change has had a significant influence on the lives of billions of people, particularly those living in urban environments such as cities and those living in poverty. It has forced many to rethink how our urban environments have been constructed and how disconnected these spaces have become from the surrounding natural environment. This has led to the concept of sustainable development that considers social, economic, ecological development and urban governance and how it can be used as a framework for enhancing suitability within cities. The green building movement has been one such tool that has evolved out of the sustainable development framework and seeks to create buildings that can provide sustainable solutions that benefit both the occupants of the building and the surrounding environment. This global initiative has resulted in a variety of green building standards that have been established around the world. Nevertheless, most of these standards

often focus primarily on sustainable design but fail to account for *Regenerative Design* principles that will have a greater impact on climate change.

Regenerative Design is the concept of going beyond the limits of resource efficiency towards resource regeneration. It provides enough resources for its intended use and those around it. This concept is related to *Biomimicry* which looks to nature's wisdom for inspiration. Most of nature's systems are often regenerative and closed loop and do not exclude any of its surroundings. By applying these principles to the green building sector, the idea of the LBC was created by Jason McLennan. Therefore, the LBC is a regenerative development tool that goes beyond the sustainability approach of traditional green buildings and allows for excess resources to be given back to the surrounding environment. This holistic construction approach is often challenging to accomplish. However, it was recently introduced into the South African built environment with some success.

Five registered LBC buildings located in South Africa were selected as the case studies for this research. The Solid Green Offices are currently under construction and are hoping to achieve the Core LBC certification. They are located in Johannesburg and hope to be one of the first Core certified buildings on the African continent. The 76 Corlett Drive project is also located in Johannesburg is expecting to achieve Petal certification for a commercial and medical suite, mixed-use building. The residences in Oranjezicht in Cape Town are two high-end residential buildings hoping to achieve the first LBC certifications for residential homes in Africa. The Glencoe Road project hopes to receive Petal Certification, while the Rugby Road project aims to achieve full LBC certification. Finally, the Green School project located in Paarl is actively pursuing a full LBC certification for several buildings located within its premises.

Five sustainability consultants, who had worked with executing the imperatives of the LBC for the various case studies, were interviewed to understand their perspective on working with the LBC standard in South Africa. All of the interviewed consultants agreed that the LBC was the most stringent green building standard that they had

worked with and that it was leaps and bounds ahead of what was usually adopted in the local building sector, which was the Green Star SA standard. When comparing the Green Star SA Office Tool (v1.1) and the LBC, it was found that there was a 60% correlation between the two standards; however, each standard also contained imperatives and credits that were not aligned.

Furthermore, the study's findings revealed critical aspects of what makes an LBC project successful in South Africa. A client's intentions behind why they want to achieve an LBC certification is often a critical factor in determining the success of a project. Various industries often indoctrinate building owners into believing that they are providing a sustainable solution, which is often referred to as greenwashing. Additionally, when clients pursue the LBC certification to achieve a particular accolade, they often do not have enough motivation to overcome adversities and downgrade their certification to Petal or Core certification. However, when clients are motivated by cultural beliefs about nature or find an alignment between the philosophy of the LBC and their ethos and beliefs, full LBC certification is often achieved irrespective of the challenges that may arise.

When identifying the challenges faced during the implementation of the LBC in SA, it was found that finance plays a crucial role in determining the project's outcome. Many clients who initially chose to pursue LBC certifications are often unaware of the complexities of the integrated systems required for their projects and the price associated with these systems. This has proven challenging, particularly when trying to convince clients that the complex applied systems will function and that their initial capital expenditure investments will pay off in the long term. Consultant 1 argues that reevaluating the fee structures and providing accurate statistics and quotations to clients can only be done once benchmarks have been established, and these benchmarks would need to come from already established projects.

Furthermore, engineers responsible for the designs of these complex systems on the projects often follow a structured fee agreement as set out by external organizations such as ECSA. When these fee structures do not correspond with the design

requirements, the engineers tend to default to well-established designs, limiting their ability to innovate efficient solutions.

The research findings also expose a variety of challenges associated with specific Petals and imperative requirements. When the consultants were asked to rank the Petals according to the achievability of each Petal, it was found that the Water and Materials Petals were the hardest to achieve. When looking at the Materials Petal, restrictions such as the Red List and ingredient transparency for manufactured products became frustrating for most consultants. This, coupled with the issue of only sourcing materials available on the African continent and ensuring that waste is limited on-site, proved to be the most challenging aspects of the LBC for many consultants and clients alike.

When looking at the Water Petal, it was observed that the complexity of the required integrated water collection and treatment systems proved to be particularly difficult for all consultants as factors such as architectural constraints and the costs associated with the systems were challenging to overcome. Additionally, Muller (2020) state that this is only further acerbated by South Africa's water challenges which include unpredictable rainfall, which is also linked to climate change; the deterioration or lack of suitable water infrastructure, and the maladministration of local governments which has been fueled by corruption.

A final challenge that any of the consultants did not anticipate was the implications that Covid-19 had posed to the projects. The stringent restrictions on labour and accessibility to the site that came with the wave of lockdowns made it a challenging time for all LBC projects in South Africa. The lack of security about the future led to unforeseen decisions being taken by all of the clients. Nevertheless, all five projects are still progressing irrespective of the setback faced by the pandemic.

On the other hand, a vast array of opportunities presented themselves to the various consultants. These opportunities included the breaking down of departmental silos and structures between various disciplines and allowed each profession to actively

contribute to the design process and decision making of the projects. LBC projects have also been proven to provide a better ROI than other green building types. The opportunity for clients to modify which LBC certification that they wished to pursue also helped to refine the process and gave clients added relief when particular aspects of the project became challenging.

Other vital opportunities that presented themselves regarding the various Petals and imperatives included the ability for consultants to share the African narrative and provide cultural nuances into the projects that reflect South Africa's diverse history. Consultants were also given a chance to influence the construction industry and manufacturing market, allowing them to showcase products that are Red List compliant and demonstrating a new pathway in the manufacturing process. The opportunity to add additional equipment and skills offerings to clients from the consultants was also presented. Indoor Air Quality (IAQ) testing is set to become more available in South Africa thanks to the circumstances that presented themselves in these LBC projects.

A significant opportunity that presented itself was the ability to begin to advocate for off-grid solutions to local municipalities. Although local municipalities did not play a crucial role in establishing LBC projects in South Africa, the consultants have identified that off-grid solutions may provide further opportunities and revenue for municipalities to provide additional services to communities in remote locations that cannot connect to traditional municipal infrastructure. Additionally, it was found that local municipalities are often hesitant to approve projects that do not have water connections. However, this was overcome by proving to the ILFI that the connection would not be utilized within the building. Furthermore, local bylaws and building regulations such as SANS 10400-XA will play a crucial role in changing the minds of municipal workers towards the adoption of more sustainable and regenerative infrastructure.

In conclusion, there were many opportunities and challenges that presented themselves to sustainability consultants who were trying to implement the Living Building Challenge for their clients. This allows the construction industry and

associated markets to understand the concepts of *Regenerative Design* so that it can be applied for all future building projects in South Africa. A collaboration between organizations such as the Green Building Council of South Africa (GBCSA), stakeholders, municipalities and industry professionals is required for South Africa to adopt regenerative principles to combat the adverse effects of climate change in the decades to come. Nevertheless, the Living Building Challenge could be used to further the discussion about *Biomimicry* and *Regenerative Design* in South Africa.

5.3 Recommendations for Future Research

This research attempted to highlight the successes and constraints of establishing the Living Building Challenge in South Africa. With this research being the first of its kind to be conducted on the continent and with the concept of LBC being a relatively new approach to the green building sector, there is a vast opportunity for further research to be developed in this field. Extensive research should be conducted after LBC certifications have been achieved with the case studies. A longitudinal study could be conducted to further understand the requirements of the 12-month observation period and how this process may differ in South Africa compared to other countries. The data can then be used to create benchmarks for future projects.

Furthermore, economic analysis of LBC projects is also required to understand the true ROI and if it would be economically viable to pursue LBC projects in the future. A comparison between LBC projects from countries with the same climatic conditions as South Africa, such as Australia, can also be conducted to understand the similarities and differences between the two countries. Additionally, understanding how countries such as Australia have successfully implemented green building projects and LBC projects could provide South Africa with a better forecast for what to expect in the coming years. A statistical analysis could determine if a similar trend could potentially occur in South Africa.

Additionally, future research could be conducted to better understand the complex relationship that these buildings have with local governments and municipalities and how future relations can be built to support them while promoting regenerative design

principles that do not accommodate for centralised infrastructure. Another critical area for future research would be to compare the updated GBCSA Green Star SA tool that is expected to be launched in 2022/2023 and the revised SANS 10400-XA document and to identify if there are any overlaps between these documents and the LBC. This, in turn, could be used to estimate how far South Africa is from adopting *Regenerative Design* principles and what impact that would have on local populations through the lens of socio-economic and political influences in addressing the needs of climate change.

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7 Appendices

7.1 Appendix A: LBC and Green Star SA Comparison Table

Table 7-1: Table showing comparison between LBC imperatives and the corresponding Green Star SA credit

LBC Petal	LBC Petal Imperative	Corresponding Green Star SA Credit
Place	Ecology of Place	ECO-1 Topsoil
		ECO-2 Reuse of Land
		ECO-3 Reclaimed Contaminated Land
		ECO-4 Change in Ecological Value
		EMI-5 Watercourse Pollution
	Urban Agriculture	Not Aligned
	Habitat Exchange	Not Aligned
	Human Scaled Living	TRA-1 Provision of Car Parking
		TRA-2 Fuel Efficient Transport
		TRA-3 Cyclists Facilities
		TRA-4 Community Mass Transport
		TRA-5 Local Connectivity
Water	Responsible Water Use	WAT-1 Occupant Amenity Water
		WAT-3 Landscape Irrigation
		WAT-4 Heat Rejection Water
	Net Positive Water	Not Aligned
Energy	Energy + Carbon Reduction	ENE-1 Greenhouse Gas Emissions
		ENE-3 Lighting Power Density
		ENE-4 Lighting Zoning
		ENE-5 Peak Energy Demand Reduction
	Net Positive Energy	Not Aligned
Equity	Universal Access	Not Aligned
	Inclusion	Not Aligned
Beauty	Beauty + Biophilia	Not Aligned
	Education + Inspiration	Not Aligned
Health + Happiness	Healthy Interior Environment	IEQ-1 Ventilation
		IEQ-4 Daylight
		IEQ-9 Thermal Comfort

		IEQ-15 Mould Prevention
		IEQ-17 Environmental Tobacco Smoke Avoid
	Healthy Interior Performance	MAN-8 Airtightness Testing
		IEQ-3 Carbon Dioxide Monitoring and Control
	Access to Nature	IEQ-8 External Views
Materials	Responsible Materials	MAN-7 Waste Management
		MAT-1 Recycling Waste Storage
		MAT-3 Reused Materials
		MAT-5 Concrete
		MAT-6 Steel
		MAT-8 Sustainable Timber
		MAT-9 Design for Disassembly
		EMI-1 Refrigerant/Gaseous ODP
		EMI-2 Refrigerant GWP
		EMI-3 Insulant ODP
	Red List	IEQ-11 Hazardous Materials
		IEQ-13 Volatile Organic Compounds
		IEQ-14 Formaldehyde Minimisation
		EMI-8 Legionella
	Responsible Sourcing	MAT-2 Building Reuse
	Living Economy Sourcing	MAT-11 Local Sourcing
	Net Positive Waste	MAT-10 Dematerialisation

7.2 Appendix B: Ethics Clearance Confirmation

Milan Master <793731@students.wits.ac.za>

Ethics clearance

Lerato Nkosi <lerato.nkosi@wits.ac.za> 31 August 2021 at 11:17
To: Milan Master <793731@students.wits.ac.za>
Cc: Brian Boshoff <Brian.Boshoff@wits.ac.za>

Dear Milan

Your ethics application has been approved, please use clearance number: SOAP122/06/2021 for your reference.

Thank you

Lerato

7.3 Appendix C: Plagiarism Declaration

Faculty of Engineering and the Built Environment

Private Bag 3, Wits 2050, South Africa * Telephone (011) 717 – 7007 * Fax: (011) 717 7009 * Email: febe.pg@wits.ac.za

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Milan Master (Student number: 793731) am a student registered for the degree of MUS SEEC in the academic year 2022.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this in not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature:  Date: 31/01/2022

7.4 Appendix D: Interview Sheet

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INTERVIEW SHEET

THE OPPORTUNITIES AND CHALLENGES OF IMPLEMENTING THE LIVING BUILDING CHALLENGE IN SOUTH AFRICA

This document serves as an information sheet provided by the researcher, Milan Master, for research undertaken at the University of the Witwatersrand in partial fulfilment of the requirements of the degree of Master of Urban Studies in the field of Sustainable Energy Efficient Cities. [Ethics Clearance Protocol No.: SOAP122/06/2021]

The following questions will be asked during the interview process. Please answer all questions with as much detail as possible. If there are any further issues or suggestions that have not been addressed throughout the interview, these may be added at the end.

RESPONDENT INFORMATION

1. What is your title and profession?

2. Which of the following Green Building Accredited Professional (AP) qualifications do you hold?

Green Star SA AP		Living Future AP	
BREEAM (Building Research Establishment Environmental Assessment Method) AP		LEED (Leadership in Energy and Environmental Design) AP	
WELL AP		EcoDistricts AP	
Green Globes AP		Other	

3. How long have you been working in the Green Building Industry/Sector?

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4. To date, approximately how many green building projects have you been involved with and what was your main role for these projects?

5. Which of the following green building types have you worked on?

Office Buildings		Public and Educational Buildings	
Retail Centre Buildings		Multi-Unit Residential Buildings	
Special Purpose (i.e.: Hotels)		Other	

6. Please rank the following green building types according to the frequency of projects that you have worked on (i.e.: 1 = most common building type project, to 6 = least common building type project)?

Office Buildings		Public and Educational Buildings	
Retail Centre Buildings		Multi-Unit Residential Buildings	
Special Purpose (i.e.: Hotels)		Other	

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THE LIVING BUILDING CHALLENGE IN SA

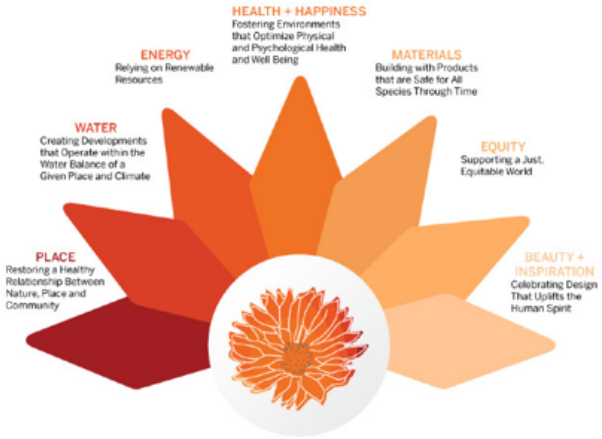

Figure 1: Diagram showing 7 main Petals that make up the LBC standard (Image source: https://stanleycenter.org/publications/living-building-challenge-accepted/)

7. Are you familiar with the Living Building Challenge (LBC)? If yes, how did you come across the Living Building Challenge and when did you first hear about it?

8. How long have you been working with the Living Building Challenge?

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9. In your professional opinion, how does the Living Building Challenge compare to other Green Building standards that you have worked with?

10. Which Living Building Challenge (LBC) projects have you worked on?

Solid Green Offices		76 Corlett Drive	
4 Rugby Road		Green School SA	
Glencoe Road		Other	

11. What was your role within the project team and how long were you working on the project?

12. Can you provide more information about the project? (i.e.: Where is the project located; what is the main function of the building; who are the intended end users; etc.)

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13. What LBC certification is the project aiming to achieve?

Core Certification		Petal Certification		Full LBC Certification	

14. Was this the original LBC certification that was intended for this project? If not, why did it change?

15. Do you think this project could achieve a higher LBC certification in the future? If so, how does the client plan to achieve this?

16. Why do you think the LBC was best suited for this project? i.e. Why did the client opt for LBC certification?

17. Did the client always intend for this project to be LBC certified? If not, what other certification was this project meant to achieve and can it still obtain it?

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18. In your professional opinion, can this project also qualify for a Green Star SA certification? Which certification would it achieve and why?

19. If your client requested both LBC and Green Star Certification, how would you obtain both certifications? What processes would be required? Would this be an easy or challenging exercise?

20. Do you see any conceptual overlap between the requirements for achieving LBC and Green Star SA certifications?

21. Figure 1 shows the various Petal categories that are required to obtain the LBC certification. Which of the Petals were targeted for this project?

Place		Water	
Energy		Health + Happiness	
Materials		Equity	
Beauty			

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22. Of the 7 petals found within the LBC standard, which of the petals do you generally gravitate towards and why?

_____

_____

_____

23. In your professional opinion, how would you rank the achievability of each of the Petals? Please rank in order with 1 = most achievable and 7 = least achievable?

Place		Water	
Energy		Health + Happiness	
Materials		Equity	
Beauty			

24. Each Petal comprises of a variety of imperatives. In your professional opinion, how would you rank the achievability of each of the imperatives? Please rank in order with 1 = most achievable and 20 = least achievable?

Petal	Imperative	Ranking	Comment
Place	Ecology of Place		
	Urban Agriculture		
	Habitat Exchange		
	Human Scaled Living		
Water	Responsible Water Use		
	Net Positive Water		
Energy	Energy + Carbon Reduction		
	Net Positive Energy		
Health + Happiness	Healthy Interior Environment		
	Healthy Interior Performance		
	Access to Nature		
Materials	Responsible Materials		
	Red List		

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	Responsible Sourcing		
	Living Economy Sourcing		
	Net Positive Waste		
Equity	Universal Access		
	Inclusion		
Beauty	Beauty + Biophilia		
	Education + Inspiration		

25. Why do you think that your top 3 ranked imperatives are the most achievable, particularly within South Africa?

_____

_____

_____

26. Why do you think that your bottom 3 ranked imperatives are the least achievable, particularly within South Africa?

_____

_____

_____

27. Scale jumping refers to the scale at which certain imperatives are achieved at and may include infrastructure that is larger than the scale of a single project. Did this project apply any scale jumping for any of the Place, Water or Energy Petals? If so, how did you achieve this?

_____

_____

_____

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28. Please indicate, by ticking the appropriate boxes, which of the following opportunities presented themselves during the conceptual phase of this project when attempting to achieve LBC certification, as compared to conventional buildings of a similar building type:

Economic Opportunities:			
Initial costs for LBC projects are lower or equal		LBC buildings provide a greater return on investment	
Annual energy costs for LBC buildings are lower		Annual water cost savings for LBC buildings are higher	
Maintenance and repair costs for LBC buildings are lower		Waste disposal costs for LBC buildings are lower	
Environmental and emissions costs of LBC buildings are lower		Profitability of the company increases by the help of improved environmental quality (lower absenteeism and increased productivity)	
Costs of dealing with occupant complaints are lower		LBC buildings have a higher rental and sale value	
LBC buildings are easily approved by local authorities and therefore less time and money is required to establish a LBC building		There are tax incentives from government to establish an LBC building	
Social Opportunities:			
LBC buildings provide better health for building occupants due to improved indoor quality		LBC buildings improve comfort, satisfaction and well-being of building occupants	
LBC buildings increase the occupant safety and security		LBC buildings improve the quality of life for individuals	
Environmental Opportunities:			
LBC buildings reduce the negative impacts of buildings on the environment		LBC buildings support the control of climate change	
LBC buildings increase water and air quality		LBC buildings lead to the decreased use of natural resources and in turn protect ecosystems	
Organisational Opportunities:			
LBC buildings demonstrate corporate social responsibility		LBC building strategies are an integrated part of corporate	

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		strategic planning and risk assessments	
Companies have improved public image by adopting buildings with LBC certifications		LBC buildings provide construction companies with new projects by creating value within the compatible market	
LBC buildings make risk management easy (economic, financial, market, etc.)		Construction of LBC buildings can lead to the development of new, more energy-efficient products and services	
Market Opportunities:			
LBC buildings have positive impact on the Construction Industry market (non-traditional processes, new materials and technologies)		There is an increasing media attention on the sustainability and green building market	
There is an increase of client demand for LBC building projects in the market		All green building rating systems (Green Star SA, LBC, LEED) gain attention and popularity	

29. Are there any additional opportunities that presented themselves for this project?

_____

_____

_____

30. Please indicate, by ticking the appropriate boxes, which of the following barriers/challenges presented themselves during the conceptual phase of this project when attempting to achieve LBC certification, as compared to conventional buildings of a similar building type:

Economic Challenges:			
LBC buildings provide lower return on investment		The length of the payback period of the initial cost of a LBC buildings is too long	
Initial construction costs of LBC buildings are very high		Operation, maintenance, and repair costs of LBC buildings are higher	

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The cost of sustainable and green technologies and materials are too high		Clients are unwilling to pay for the LBC building projects	
Government incentives are not enough to encourage the LBC building movement in South Africa		Financial risk of LBC building projects is too high because they require some additional time due to integrated systems and new technological approval processes	
Awareness/Educational Challenges:			
What sustainable/regenerative means is not widely understood due to complexity issues, jargon and uncertainty about this is applied to the built environment		There is not enough consultants available or educational programs and awareness about the LBC building concept	
Researchers have not empirically proven the benefits of LBC buildings and so there is no accurate information to easily convince decision makers		Because the LBC concept and knowledge (technologies, materials) is relatively new, particularly in SA, there are not enough resources or documentation to support its use	
There is a shortage of professionals and workers with suitable experience in SA		There are not enough cost-benefit analysis studies that have been performed on LBC buildings	
There is not a robust tracking and performance measurement system to evaluate environmental and financial performance data of LBC buildings in SA		Life cycle cost assessment results for LBC building projects are not guaranteed	
Organisational Challenges:			
Senior management does not see LBC and green buildings as a priority		Most of the construction company's financial conditions are not appropriate for LBC building projects	
Financial methods of the company are not appropriate to calculate life cycle costs of the building		Construction companies do not have enough experience	
Market Challenges:			
The building and construction sector is resistant to change and innovation		There is insufficient number of investors for the construction of LBC buildings in SA	

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Building contracting and tendering process focus on low cost and less time rather than performance of the building		Regulations do not insist on a higher standard of building design and construction	
There are barriers for system and product innovation due to regulations and existing standards		There is no available LBC approved technologies for LBC buildings in the SA construction market	
It is difficult to find certified LBC building materials		There is a lack of consensus in the market about leading green building standards	
Insurance companies do not have LBC building risk-specific policies		Stakeholders involved over the lifetime of a building project have separate and distinct interests and so this makes it difficult to reach certain agreements	

31. What other design barriers/challenges have you faced with this project?

32. Were you able to overcome these barriers/challenges? Please explain how.

33. What stand-out innovations were achieved during the conception and design phase of this project?

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34. What local governmental legislation and policies have encouraged or discouraged the establishment of the project?

35. What role did the local municipality and Provincial government play in establishing the project and were they open to the requirements of the LBC?

36. Do you think the South African Government would invest in a public LBC building project? Please explain.

37. If you were a client/investor, would you also invest in the construction of an LBC project? Please explain why or why not?

38. In your professional opinion, do you believe that LBC projects could add market value to the South African built environment and what is the reasoning behind your answer?

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39. In your professional opinion, does the South Africa built environment have the resources and capital to move towards a sustainable and regenerative built environment within the decade? Please explain why or why not.

40. Does this questionnaire address the main research question which aims to look at the opportunities and challenges of implementing the Living Building Challenge in South Africa? Please feel free to provide any further comments.