EXPLORING THE RELATIONSHIP BETWEEN THE NATURAL ECOSYSTEM AND THE BUILT FORM:

TOWARDS AN ECOLOGICAL CONSERVATION CENTRE IN SAINT LUCIA.

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DECLARATION

This dissertation is a presentation of my own original work. Where contributions of others are involved, every effort is made to acknowledge this clearly, with due reference to the literature, all citations and discussions. This dissertation is being submitted to the College of Humanities, School of Built Environment and Development Studies at the University of KwaZulu-Natal, Durban, South Africa in fulfilment of the requirements towards the degree of Master of Architecture in the Graduate Programme in Architecture, University of KwaZulu-Natal, Durban, South Africa. This dissertation has not been previously submitted for any examination or degree at any university.

Signed:

Raaziq Laljit

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ABSTRACT

Natural ecosystems are essential for all life processes that take place on earth. They comprise living and non-living things that function as a whole while continually undergoing intense systematic processes (Yeang, 2008). Human beings are dependent on these bio-diverse organisms and systems, which define human settlement and dwellings. Therefore, biodiversity is of fundamental importance to the functioning of all natural and human-engineered ecosystems, such as the built form.

According to findings, the building and construction industry is responsible for the depletion of 50% of natural resources. Therefore, the focus of the study is primarily based on how natural ecosystems could encourage responsive and sustainable architecture. The research explores literature and theories that influence how architecture can symbiotically co-exist with the natural environment, particularly within a sensitive and biodiverse context such as the St Lucia wetland area.

Similarly, the investigation focuses on how architecture can improve both individuals' experience and the existing natural ecosystem to create environments that are responsive, interactive, and conducive. The methodology includes analysis of literature review, interviews with relevant personnel, precedent studies, and a critical desktop study of the research area. As a point of departure, the literature analyses the complex relationship between nature, man, and architecture to understand essential turning points in ecological history. This information becomes vital to help recognize past mistakes and determine solutions for the future. The literature review examines the theoretical framework of phenomenology, place theory, and sustainability while also paying attention to ecological architecture, empathetic design, and critical regionalism. These key areas start to focus on mutually symbiotic spaces for man and nature, and how architecture and the built environment can begin to support this.

Key words: sustainability, conservation, ecosystems, natural environment, experience, innovation, phenomenology

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CHAPTER 1

1.1 Introduction

1.1.1 Background

Historically, human survival fundamentals revolved around most primal needs, such as food, shelter, and water. Humans relied entirely upon natural ecosystems for existence. They constructed dwellings in areas that seemed most favourable to anthropological conditions, such as zones that held rich water sources, arable land, and vast food supplies. Similarly, some of the earliest cave paintings depict that humans traditionally lived harmoniously among the natural landscape. These paintings exhibit humankind interacting with wildlife and conserving the natural environment (Guthrie, 2005). There is also evidence of this mutualistic relationship intertwined throughout ancient civilizations, including Africa, Egypt, the Indus River Valley, China, Greece, and the Christian Bible (Conover, 2002).

As the era of co-existence passed, the *age of the machine* (Kurokawa, 1994) rose to the surface. This period brought along new technological advances, the growth of industrialization, urban sprawl, and a dramatic upsurge in land use. As settlements began to urbanize and the convenience of basic needs became more readily accessible, built interventions began to transition away from its vernacular needs.

> "*The world revolved around human existence while the pollution of the air, rivers, and seas, the destruction of forests, and the extinction of animals and plants were regarded as unavoidable events in the development of the technology and the economic activity necessary to support human society and its cities and buildings*." (Kurokawa, 1994:19)

The rapidly advancing population growth continuously increases the pressure placed upon the natural environment for resources. This phenomenon occurs not only in big cities but in rural areas. In South Africa, human settlements contribute to more than 90% of all economic activity and house over 70% of the entire population (CSIR 2011). According to the South African Environment Outlook (2012), these sprawling settlements severely impact water dependency, ecological systems, carbon emissions, waste, and energy levels (SADC, 2012).

An increase in demand for the built form to meet various needs has initiated an exponential rise in anthropocentric developments, which progressively advanced human dominance over nature. The consequent detrimental impacts are currently demonstrated through the increasing

destruction of habitats, the extinction of species, and the disregard for natural resources in the design of built form.

Inadvertently, humankind will face an indisputable truth when population levels rise further, and not only will nature be impacted, but the population's dependency on the natural environment itself. According to the UN Sustainable development goals summit of 2019, it is calculated that the demand for raw or natural materials has increased by 113% since 1990 (The Sustainable Development Goals, 2019). This research argues, however, that the impact of the built form on the natural environment can be mitigated and alleviated through alternative sustainable design solutions.

1.1.2 Motivation of Study

Ecosystems are essential for all life processes that take place on earth. They comprise living and non-living things that function as a whole while continually undergoing intense *systematic processes* (Yeang, 2008). Human beings are dependent on these bio-diverse organisms and systems, which define human settlement and dwellings. Therefore, biodiversity is of fundamental importance to the functioning of all natural and human-engineered ecosystems, such as the built form, and by extension, to the ecosystemic services that nature provides to human societies.

Currently, South Africa ranks as the third most biologically diverse country globally, with more than 40% of its species being endemic (SADC, 2012). These ecosystems provide substantial socio-economic value, provide essential resources to communities, contribute to tourism, subsistence farming, grazing, and environmental education and awareness (Kotze, D.C. and Breen, C.M, 1994).

Saint Lucia, the site for the proposed development, currently forms a part of the iSimangaliso Wetland Park, which is South Africa's first UNESCO World Heritage Site. Wetlands are essential in an arid, water-scarce country such as South Africa, yet an estimated 50% of South Africa's wetlands are destroyed through human intervention (Kotze *et al.*, 1995). During the past century, the area has undergone numerous anthropogenic development changes (Perissinotto *et al.*, 2013). The exploitation and degradation of South Africa's wetland ecosystems are set to rise as the human population grows and increases its demand for water and land around urban areas (Adie *et al.*, 2004).

With the rise of the global population, humans have since expanded infrastructure and insensitively penetrated natural habitats. Over the last few decades, there has been a notable increase in habitat loss, deprivation, and fragmentation, resulting in the decline and extinction of species (SANBI, 2015). According to the Department of Environmental Affairs (2007), the destruction of natural habitats to provide land for other human development is one of the most significant causes of biodiversity loss in South Africa. (DEA, 2007) Unfortunately, nature cannot sustain its biological prosperity due to unsustainable development driven by economic and social factors (SADC, 2012). This statement is affirmed by the UN World Summit (2002), declaring that cities and urban developments are accountable for 60% of resource usage and cause 70% of global carbon emissions (The Sustainable Development Goals, 2019).

The research explores how architectural design can take an alternative position that advances human potential through a reciprocal relationship with the natural ecosystem. Therefore, it is crucial to think of design not as a closed system but as an integrated and informed part of the natural environment (Janks, 2010). This architectural exploration is focused on a research and conservation facility to discover how built form could symbiotically co-exist with the natural environment, forming a rich metaphor of learning and awareness.

1.2 Definition of the Problem, Aims, and Objectives

1.2.1 Definition of the problem

Man-made interventions negatively impact natural ecosystems (Kurokawa, 1994). Saving the environment is the most vital issue that humankind must address; thus, to design *ecologically* is crucial (Yeang and Powell, 2007).

Globalization, industrialization, and increasing anthropocentric views had resulted in the gradual collapse of the once symbiotic relationship between man and nature. Human-made interventions continued to dominate over nature while consequentially depleting non-renewable resources and destroying habitats (SANBI, 2015). The construction sector alone is liable for 50% of the resources taken from nature (Anink *et al.*,1996). The general indifference of built form on the ecological impact forges barriers that disconnect the natural and built environments humans create.

As a consequence, this indifference increases the lack of awareness of adverse ecological concerns when addressing human intervention through the built environment. Sustainability will continue to remain an intangible goal until a vital shift occurs in values and relations towards the natural world (Kellert, 2018). The link between architecture and the natural world is intricately intertwined, yet the detrimental impact of this relationship is often overlooked. It can be argued that architecture should strive for harmony between the built form and the natural environment. The relationship between humans and nature should strive to be one of mutual respect and consideration rather than dominance (Dubos, 1980).

This research will explore environmental concerns regarding the effects of built form on natural ecosystems. This will also require an inquiry into how public education and awareness can be enhanced through appropriate sustainable architectural strategies for the conservation of endemic flora and fauna.

1.2.2 Aim

This research aims to investigate how architecture can respond symbiotically to the natural ecosystems to develop a set of sustainable architectural principles for the design of an ecological conservation centre in the Saint Lucia Wetland area. A key objective is to explore how responsive architecture can form narratives of ecological awareness through the built form.

1.2.3 Objectives

The objectives of this research are:

- To analyse the impact of built form on natural ecosystems.
- To explore how technological development can aid ecological conservation and socio-economic advancement.
- To critically assess how responsive architecture can enhance ecological conservation facilities in the 21st century.
- To define a set of sustainable architectural design principles for an ecologically responsive built form in the 21st century.

1.3 Setting Out the Scope

1.3.1 Delineation of Research Problem

The research scope will critically investigate how ecological architecture can responsibly foster co-existence between man and nature through the design of a research and conservation centre in St Lucia.

Although natural ecosystems comprise several environmental factors, the study will primarily concern itself with the research and rehabilitation of the endemic species. The impact of built form on environmental factors such as air, water, and soil pollution, will also be addressed.

1.3.2 Definition of Terms

Conservation - Conservation's goals include protecting species from extinction, maintaining and restoring habitats, enhancing ecosystem services, and protecting biological diversity. In the context of this research, it refers to the Education, protection, and rehabilitation of endemic flora and fauna through responsive architecture.

Endemic- The research will investigate the native flora and fauna of the Saint Lucia wetland area.

Anthropocentric – This term identifies man as the central or most important element of existence. In the context of this research, the anthropocentric design will be investigated to critique modern architectural philosophy.

Sustainable design – This philosophy of thinking focuses on developments that meet the present's needs without compromising future generations' ability (Brundtland, 1987). Sustainable architecture will focus on preserving natural resources and ecosystems throughout a building's life cycle.

1.3.3 Stating the Assumptions

It can be assumed that the detrimental impact of the built form on natural ecosystems is a direct result of human neglect towards biodiversity. Alternative architectural design approaches/strategies can for a responsive precedent for a mutually symbiotic relationship between man, nature, and built form in the 21st century.

1.3.4 Key Questions

Primary Question:

- How can natural ecosystems influence responsive built form?

Secondary Questions:

- What are the detrimental effects of building on natural ecosystems?
- How can technology be beneficial to the well-being of natural ecosystems and socio-economic development?

- How can responsive architectural design impact ecological conservation in the 21st century?
- What are the relevant, sustainable design strategies for the design of an ecological conservation centre?

1.3.5 Hypothesis

It can be hypothesized that sustainable architecture will foster a symbiotic relationship between man and nature, thereby creating the optimal setting for research, rehabilitation, and public awareness of the conservation of natural ecosystems.

1.4 Concepts and Theories

As the research topic focuses on exploring the relationship between the natural ecosystem and the built form to form a basis of knowledge to design a sustainable ecological conservation centre in Saint Lucia, concepts and theories are sourced from varied disciplines to address the research problem.

The concepts and theories form the lenses for critical analysis of primary and secondary data. The research will explore both theories of place and sustainability in a phenomenological paradigm. At an interdisciplinary level, the theoretical framework seeks to bridge the gap between philosophy, ecology, technology, and architecture in order to construct a set of architectural guidelines for sustainable built development (Leman-Stefanovic, 2000).

1.4.1 **Phenomenology as a Philosophical Paradigm**

Phenomenology as a paradigm is intended to raise a consciousness of space, towards contextually-responsive, eco-sensitive, sustainable place-making. According to Heidegger (1962), phenomenology can be defined as the science of phenomena, which presents the notion of generating a linguistic affiliation between space, occupants, and the environment (Seamon, 2017). It introduces views of spatial experience, which is stated as a dimension of human existence (Norberg-Schulz, 1971).

This paradigm enables a critical understanding of experiential, multisensory spaces that generate synergetic relationships between humans, architecture, and the environment. A phenomenological approach further strengthens the conceptualization of meaningful spaces that foster thought, biological awareness and ultimately achieve place-responsive interventions by understanding man, dwelling, and nature. The conceptual tools gathered from the

phenomenological inquiry will be applied to the context of this research to execute sustainable and ecological design strategies that enhance the physical and psychological aspects of dwelling in place.

1.4.2 **The Phenomenological Theory of Place**

Place theory ultimately prioritizes the fragile relationship between man, architecture, and nature as well as how well these three entities engage with one another. In the context of this research, conceptual tools implemented from place theory will be pivotal in ensuring contextually conscious processes that preserve natural resources, ecosystems, and memory. Place theory is vital towards the development of phenomenological design strategies for sustainable human-built form (Relph, 1976). This theory aims to unravel the multi-layered attributes of place and explore how dwelling, existential space, genius loci, and identity all play a vital role in space perception. In a sensitive natural setting, place theory will further enable conscious and socio-ecologically sensitive design strategies. Therefore, place theory in the context of this research allows for the creation of meaningful spaces that generate a sense of belonging and natural integration.

1.4.3 **Sustainability Theory**

Sustainable development is posited as an innovative design theory and strategy that consciously minimizes the negative impacts of built form on the natural environment. It focuses on progressive strategies and approaches in architecture that meets the needs of the present without compromising future generations (Brundtland, 1987). In the South African context, sustainability is a crucial issue due to the reliance on energy-intensive resources, as well as the goods and services that ecological systems provide (DEA, 2012). In this technological era, sustainable development presents as more than a technical concern and should, therefore, be interpreted through a philosophical lens (Leman-Stefanovic, 2000). Taking prompts from a philosophical approach, this theory can formulate sustainable development and simultaneously question the foundations of current interpretations of place (Leman-Stefanovic, 2000). The theoretical theme of sustainability will underpin the core design principles to take a critical position towards an ecologically conscious intervention. This position reinforces the affirmation that architecture has the conscious ability to preserve the ecological environment's collective well-being and, thereby, contribute to society's economic and social vitality.

1.4.4 Conclusion

Conceptual tools obtained within the literature by key theorists and authors will be sensitively transliterated to develop design concepts for conducive sustainable environments. Through the lenses of the paradigms, themes, and theories, the research will be able to critically analyse the relationship between human-built intervention and natural ecosystems to design an ecological conservation center in the St Lucia wetland area.

1.5 Research Methods and Case Study

1.5.1. Introduction

The following section sets out the framework of the methodology adopted in the research. This section will depict the process related to data collection, interpretation, and analysis regarding human intervention and its relationship with the natural environment. The section also outlines the primary and secondary data compilation, which are directly linked to the topic.

1.5.2. Research Philosophy and Strategy

A qualitative approach is used within the scope of this research to investigate human intervention and the impact of architecture on the environment. The core of qualitative research is to identify patterns among words to create a meaningful depiction without compromising its richness and dimensionality (Leung, 2015). In qualitative research with diverse paradigms, the definition of reliability is challenging; therefore, the assurance of reliability for qualitative research is principally based on consistency (Carcary, 2015).

Qualitative methods include interviews and literature reviews to address the research problem. Data is collected from various theorists through literature review. The literature review and theoretical positions are supported by precedent studies and interviews in order to cover the bases of different research aspects related to people, spaces, or strategies.

Both primary and secondary data are utilized to acquire a substantial amount of knowledge relevant to the topic to systematically resolve problems and critical research questions. All data collected will be evaluated and represented through narrative, illustrations, and diagrams.

1.5.3 Research Materials

Both primary and secondary research material, which all link to the main topic, were used. These comprised of:

- Interview schedule
- Electronic research instruments
- Photography
- Sketchbook
- Online literary sources

The information was translated and represented in the form of text, statistical diagrams, sketches, and graphical illustrations.

1.5.4. Secondary Data Collection

Secondary data sources are in the form of books, journals, literature, online sources, articles, and precedents. These sources provide support and relate to the main topic of conservation as well as the creation of mutually symbiotic spaces through sustainable architectural approaches. The theories and concepts used are accumulated from various books and online sources to guide the research and assist with critical information dealing with the built form on sensitive natural settings.

1.5.4.1 Precedent studies

Precedent studies are explored to investigate how architecture has responded to ecological issues in different locations. These studies additionally offer information on how architecture and societies have responded to the research problem and its related issues. The over-arching themes of sustainability and place theory are explored through the precedents to identify various built environment problems and architectural responses.

The following factors are considered in the Precedent Studies:

- The dialogue between the architecture and its environment.

- The type of facility and the objective of the facility.

- The context of the site and surroundings.

- The spaces that are used by people within the building.

- The incorporation of the defined concepts and theories into the designs of the respective precedents.

1.5.4.2 Literature reviews

The literature review probes the current discourses and positions on sustainability, place, and responsive architecture by analysing relevant published work. The literature is gathered from journals, articles, books, and online sources to provide an understanding of the unanswered questions through concepts, theories, themes, and precedents.

To ensure reliability and validity in the study, various authors' work is cross-referenced through defined theories and concepts.

The research material is prepared in a way that allows for a better understanding of the different aspects explored and to correspond with the primary objectives directly. The literature review, therefore, focuses on the theoretical and philosophical base to answer questions adequately. Literature forms a fundamental source of data in the research study is thoroughly scrutinized using thematic and document analysis techniques to ensure validity, reliability, and credibility.

1.5.5. Primary Data Collection

Primary data can be defined as any information gathered first-hand or indirect interaction with the source. This data consists of semi-structured interviews that were carried out to seek relevant information related to the research objectives. All interviews were completed online, and anonymity was upheld in order to safeguard a truthful representation.

The centres and facilities involved in the research were at minimum five years or older to ensure the legitimacy and reliability of all data collected. Photos, sketches, and recordings- upon consent, are utilized to further document and analyse work. Due to the advent of COVID 19, online methods of observations are employed to examine existing facilities and sustainable built intervention in the form of desktop studies.

1.5.5.1 Semi-structured Interviews

Semi-structured interviews were conducted to investigate the impact of architecture on the natural environment and acquire an understanding of the most pertinent concerns and issues related to the ecologically-sensitive design of facilities. These types of interviews allowed for a further flexible approach, which afforded more open-ended or followed up questions (Williams, 2015). Semi-structured interviews provided an insight as to how skilled

professionals treat issues related to the scope of study within their respective fields. These interviews were carried out via online platforms due to the advent of COVID 19. Due to their knowledge and experiences, various experts from different fields relating to ecology, architecture, and environmental research were interviewed to understand the problem in more depth as well as to understand appropriate design strategies.

The key informants were:

- Professional architect

  Engaging with a professional architect dealing with sustainable design development was beneficial to understand the impact of built form on the natural environment as well as to learn fundamental sustainable design principles. All communications with the informants were carried out via emails, phone calls, or online video meetings.

- Environmental Conservation Specialist

  Environmental specialists provided tangible knowledge of current ecological problems facing South Africa and information on the existing solutions to many of these concerns. They also provided an understanding of how built form directly impacts natural ecosystems and habitats. Two key personnel in the field of Biological Science were interviewed for relevant information regarding wildlife conservation and design strategies. All communications with correspondents were carried out via emails, phone calls, and online video meetings.

Interviews consisted of a discussion with professionals currently practicing in each respective field. To ensure the interviews are answered accurately, they were unambiguous and anonymous to avoid misunderstandings. These discussions were carried out via online platforms due to the advent of COVID 19.

1.5.6 Sampling

- Targeted Purposive Sampling

The method was used as it contributed to the researcher's judgment in selecting the key respondents. This method, classified as non-probability purposive sampling, allowed the researcher to use discretion in determining sample groups and sizes depending on what was best suited to the research problem. Purposive sampling is utilized to focus on the specific

characteristics of a populace that is of relevance to the study topic. This selection method will best allow the research questions to be answered effectively (Tongco, 2007).

With non-probability sampling, the numbers are usually kept smaller because the sample being studied is not representative of the population, but for a targeted research purpose. These sample groups should include skilled personnel from various relevant facilities, which will further help understand sustainable design and ecological environments.

Concerning data sampling size, architects were interviewed, and environmental researchers were interviewed. This sample was deemed sufficient to support the findings obtained from other primary and secondary methods. The use of thematic analysis was used to interpret findings from interviews. Strict anonymity is maintained throughout the research.

1.5.7 Data Analysis Methods

- Thematic analysis

Thematic analytical techniques were employed when interpreting secondary data to conceive information and construct themes within data (Braun & Clarke, 2006). This form of analysis provided a comprehensive outlook to pinpoint common patterns emerging from the data to ensure the reliability and credibility of the information.

- Discourse Analysis

Discourse analysis shall be relevant throughout interviews and discussions with key personnel where the language is more specific. In this context, language implies either dialogue, transcript, or social context, which the communication transpires. (Salkind, 2010).

A great deal of importance is placed upon the primary and secondary data. Primary data provided the first-hand experiences of people within the fields that are relevant to the topic. This will prove useful as it focuses on the various perceptions of multiple individuals. Information from primary data will be evaluated through discourse and document analysis.

The material gained from secondary data sources such as literature reviews and precedent studies offers an in-depth understanding of theories and concepts. Secondary data have been analysed using thematic and discourse analysis to provide insight, meaning, and strategies related to the research subject. Evaluation and observation of research will be pivotal in providing answers to research questions.

Data has been portrayed using diagrams, sketches, photography, statistical illustrations, and tables. All investigative information will be condensed into text and compiled into the document legibly and related to the central theme of natural ecosystems and their relationship to architecture.

1.5.8 Research Matrix

Objectives	**Research Question**	**Data Sources**	**Sample size**	**Data Collection Methods**	**Data Analysis Method**	**Data Presentation Forms and Style**
To analyse the impact of built form on natural ecosystems.	What are the detrimental effects of building on natural ecosystems?	Published documents, Books, Journals, Articles, Key informants	Adequate literature, 3 Interviews	Semi-structured interviews, Literature	Thematic analysis, Discourse Analysis	Text / Narrative, diagrams, Analytical Sketches, Themes
To explore how technological development can aid ecological conservation and socio-economic advancement.	How can technology be beneficial to the well-being of natural ecosystems and socio-economic development?	Published documents, Books, Journals, Articles, Key informants, Precedent studies.	Adequate literature,3 interviews	Semi-structured interviews, Desktop study, Literature	Thematic analysis, Discourse Analysis	Themes, text/ Narrative, Analytical Sketches.
To critically assess how responsive architecture can enhance ecological conservation facilities in the 21st century	How can responsive architectural design impact ecological conservation in the 21st century?	Published documents, Books, Journals, Articles, Precedent studies.	Adequate Literature, 2 interviews	Desktop study, Literature, 2 interviews.	Thematic analysis, Discourse Analysis	Pictures, Analytical Sketches text/ Narrative.

To define a set of sustainable architectural design principles for an ecologically responsive built form in the 21st century.	What are the relevant, sustainable design strategies for the design of an ecological conservation centre?	Published documents, Books, Journals, Articles, Key informants	Adequate literature, 1 interview.	Semi-structured interviews, Desktop study	Thematic analysis, Discourse Analysis.	Pictures, diagrams, Text/ Narrative. Analytical Sketches, Diagrams.

CHAPTER 2: INVESTIGATING THE RELATIONSHIP BETWEEN MAN, NATURE, AND ARCHITECTURE

2.1 Introduction

This chapter reviews various literary sources relating to the co-existence between man and nature and the impact of built form on the natural ecosystem. Information will be used to form a knowledgeable basis to define the causes of negative impacts that built form pose on the natural environment and to find theoretical and conceptual possibilities for a mutually beneficial co-existence. The literature will inform design development by critically analysing and answering key research questions to provide a suitable response to a sustainable ecological conservation model in the Saint Lucia wetland area.

Sassi (2006:6) stated that "*in order to effectively address sustainability, the construction of a personal stance regarding the relationship between humans and the natural environment must be established. Only then can principles turn into actions*". Therefore, to adequately address sustainability, it is necessary to first critically assess the relationship between man and nature.

The historical relations between nature, man, and architecture are intricately intertwined and will be explored to understand how ecology has historically informed traditional ways of man dwelling in nature. A historical analysis through human interaction with the environment enables us to understand past engagements, actions and to determine the implications for the environment (Barthel *et al.* 2010). This sequentially facilitates improved decision-making for future development (MEA 2005, Costanza *et al.* 2007, Redham 2011).

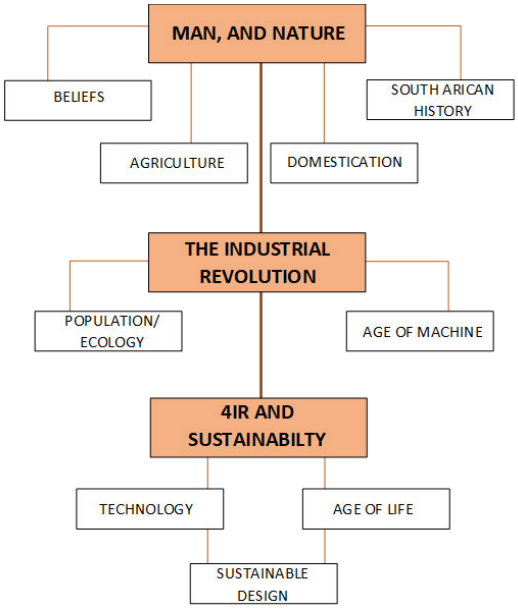

Figure 1: Chapter two breakdown- Analysing the evolution between man and the natural environment (Author)

I

2.2 Analysing the Relationship between Early Man and Nature

Today it is known that man is a part of the great animal continuum (Watson, 2012). A research article titled *The Human Kingdom, Homo Kingdom* (2018) confirms this position by espousing that modern human is a subdivision of the tribe *Hominini*, which belongs to the great apes' family (Fortunado, 2018). This statement suggests that man is part of a greater collective kingdom of fauna. Charles Darwin (1871) affirmed this by stating, "*there is no fundamental difference between man and the higher mammals in their ability to feel pleasure and pain, happiness, and misery*" (Darwin 1871). However, there is a long lineage of man's dominance over nature throughout history. In *Civilizations: Culture, Ambition, and the Transformation of Nature* (2001), it is said that to see man correctly, you have to see him in the context of the rest of nature (Fernandez, 2001).

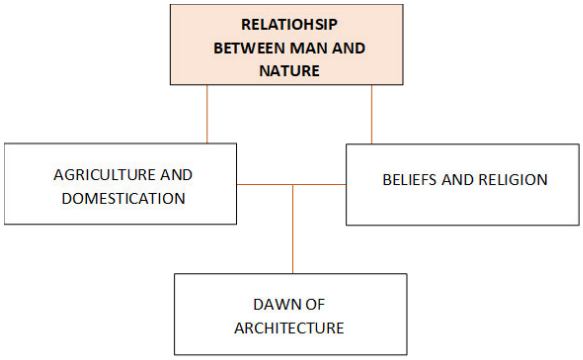

Figure 2: Analysing the relationship between man and architecture (Author)

In *Limits to Growth* (1962), it is inferred that the earth has been made up of a history of interactions between living beings and their environments (Carson, 1962). According to Fernandez (2001), *"The environments we fashion for ourselves are gouged or cobbled out of what nature has given us, and therefore all history is in a sense, historical ecology"* (Fernandez, 2001;16).

Early human shelters are commonly assumed to have been cave dwellings due to the trace evidence present, such as fossil remains and cave paintings (Gascoigne, 2001). These initial shelters were established by making small modifications to existing natural structures: for example, hollowing out or decorating caves (Fernandez, 2001). The hunting and gathering lifestyle suggested the need for a temporary shelter when confronted with exposure to the natural elements. Shelters were, therefore, primarily manifestations of protection from external factors and threats. It can be argued that this notion of protection from hostility is still a function of all buildings today (Jencks and Baird, 1970).

These traditional shelters depicted a healthy relationship between man and the surrounding environment. Until this point, man used nature as is or with small modifications to suit. Architecture was, therefore, primarily formed and expressed as a response to the requirements for shelter. Even at the simplest level, a source of temporary shelter or structures depicted the beginning of something imminent of architecture (Gascoigne, 2001).

The development of permeant structures was only possible through the domestication of plants and animals. Alternatively, this act can be viewed as one of the earliest methods of man's dominance over nature (Onion, Sullivan, and Mullen, 2018), which had led to monumental changes in the development of architecture (Watson, 2012).

The advent of agriculture, referred to as the Neolithic revolution, symbolised the transition in human history from nomadic groups of hunter-gatherers to more substantial civilisations by producing a continuous food source cultivation (Onion, Sullivan, and Mullen, 2018). Agreeably, it is said that plant domestication had swiftly led to the invention of pottery, fabrics, and, ultimately, the conversion of villages into cities (Watson, 2012).

Thus, it is apparent that the impact of agriculture had ultimately led to a global revolution. Unprecedented schemes and monumental, labor-intensive constructions were developed to foster community spirit (Watson, 2012).

2.2.1 The influence of nature on the formation of the built environment.

Throughout history, references are made towards symbiotic relations between man and nature. The early evolution of culture and built form reveal close links between nature, tradition, and beliefs, with theorists linking these factors to the development of early civilization (Watson, 2012).

Geel stated that nature had played an essential role regarding the practice of religion and the spaces it allowed (Geel and Beyers, 2018). In addition, theorists such as Peter Watson (2012) argue further that the development of religion itself can be directly tied to the natural environment. Deities, depicted as non-human or animals, can be traced back to ancient shamanism, which is regarded as the earliest form of religion (Fernandez, 2001). Divinities representing natural elements have been linked to many early religions, including Pagan, Egyptian, and ancient Hindu cultures (Lewis, 2019).

Civilizations such as ancient Mesopotamia- one of the first ancient cities, can be said to have developed based on constructions such as monuments, tombs, and structures constructed for religious significance (Kotkin 2005). In *Mans' Religion* (1984), it is suggested that Megalithic circular alignments such as Stonehenge had served as early ritualistic centres (Noss and Noss, 1984).

However, it can be further described as structures that functioned as prehistoric astronomical observatories introduced to document the tracking of sun movement (Watson, 2012). It was a notable development for an agricultural community, and evidence that built form in the natural environment had played an essential part in early civilization.

Ancient structures such as earthen mounds, monumental stone circles, and megaliths are all elements that are stated to be *lost in time* (Craven, 2020) and can further be depicted as constructions that intrinsically correlate to their natural surroundings. The use of geometric shapes is a typical pattern prominent in man's earliest architecture and is said to represent elements such as the sun and the moon (Craven, 2020). The sun and moon were common symbols in many cultures that characterize life and fertility (Watson, 2012). The correlation between architecture and geometry goes back in time and often influences what humans currently perceive as 'beautiful' (Craven, 2020).

2.2.2 From Early Settlements to Civilization

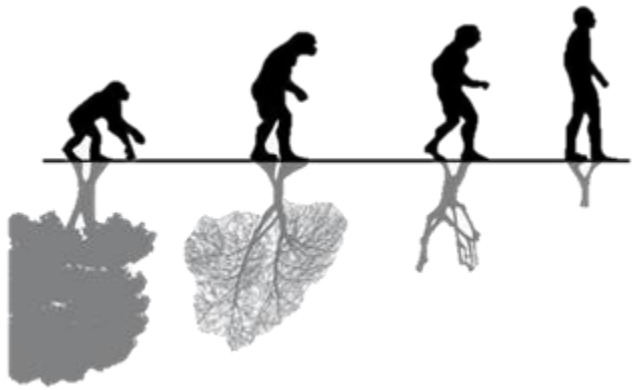

Figure 3:The evolution of man and nature. Source: (Aidonis, 2013)

Each civilization has unique historical implications. In the state of rapid modernization, it is only through critical analysis of the past that will aid in the progress of the future. Understanding architectural history is, therefore, a valuable strategy to advance geographically and culturally responsive contemporary design. In *Understanding History of Architecture through Lost Cities (2015),* it is espoused that we have started to embrace the future but have forgotten that history is what ushers us to a better tomorrow (Mahapatra, 2015).

The progression of civilization was heavily influenced by geographical location and climate. With agricultural development and advancements in technology emerging, many settlements employed new artificial interventions to reshape their environments. This control over nature is explained by Watson (2012), stating that excess water in swamps, lakes, and subsequent flooding was considered problematic, leading to the construction of great drainage systems (Watson, 2012: 319).

Fernandez emphasizes human beings' attempts to "denature" humanity by discussing the increase in the reformation of nonhuman-nature through the destruction of the natural landscapes aimed to support built development (Fernandez, 2001).

Although some environments are more challenging for civilization survival, no habitable environment has resisted man's attempts at reconstruction, leading to current visionaries visualizing settlements on seabed's and colonies in space (Fernandez, 2001). It has now become a given that human settlements can happen anywhere through innovative design and construction afforded by technological advancement.

It is vital to note, however, that not all societies conquered ecosystems. According to Seamon (1986), "*building and landscape more often arose from direct wish and need; the result was a meaningful connection between thing and human world*" (Seamon, 1986). Many indigenous settlements accustomed themselves to living off natural products and occupy the spaces presented to them with minimal impacts on the biosphere (Watson 2012). Fernandez (2001), states that when faced with the need to dwell, humans developed structures close to natural sources with materials that nature supplied.

Agreeably, in *Primitive Architecture and Climate (1960*), it is demonstrated that indigenous communities had used their natural surroundings to generate climatically and environmentally responsive shelters (Fitch and Branch, 1960). Examples of nomadic tribes originating in harsh regions like deserts, tropical forests, and icy conditions have all shown resilience through innovative built intervention.

In regions such as the artic where there are little solar light, heat, and resources, there is a need for temporary shelter to combat extreme weather conditions. The abundant dry snow resulted in the igloo formation, proving to hold the lowest possible heat capacity, optimal for low cold climatic conditions. Additionally, the dome shape offered maximum resistance and minimal obstruction to gale force winds (Fitch and Branch, 1960).

Similar constructions and design considerations can be displayed in many primitive structures, such as flat-roofed dwellings found in Egypt (responding to their low rainfall), to wooden, stilted structures found in the tropical rain forests of Africa (Fitch and Branch, 1960).

Different civilizations had different geographical trends regarding their formation, survival, and dwelling. The physical and climatic context is integral to the formulation of a contextually

appropriate response. It becomes necessary to investigate South Africa's historical ecology to predict and cater to future development.

2.2.3 An Ecological History of South Africa: Examining traditional methods of environmental conservation

South African societies, like most indigenous cultures, depended on the wealth of natural resources for the survival of their settlements and civilizations. According to the Department of Environmental Affairs (DEA), the boundless history of South African early settlements held a great deal of awareness and concern for the conservation and preservation of the natural habitat (DEA, 2019). Their abounding societies and communities demonstrated to believe in a more harmonious relationship between their developments and the natural environment which they inhabited.

South African settlements demonstrated philosophies of sustainability and conservation at the very early stage of civilization (DEA, 2019). To prevent depletion of natural resources, many approaches were put into practice by the indigenous communities. The usage of resources was controlled by respected, influential rulers (DEA, 2019). The practice of sustainability and conservation is still presently evident, with South Africa being recognized as one of 17 megadiverse nations that collectively contain over two-thirds of the world's biodiversity (Klopper, 2010).

Many of Kwa-Zulu Natal's early structures had been contextually and environmentally responsive. It is stated in *Primitive Architecture (1960)* that Nomadic settlements constructed seasonal shelters made of animal skin, hair, and vegetable fibers (Fitch and Branch, 1960). These shelters were also proven climatically responsive through external woven mats that covered wooden framed structures. These modular elements were constructed out of local reeds and could be retracted in hot, dry conditions to allow air movement and cooling. Similarly, these woven structures provided excellent waterproof membranes in rainy seasons (Fitch and Branch, 1960).

Perception in the ideologies between man and nature in the South African context had begun to shift with the introduction of rapid industrialization and the emergence of trade. Suburbs emerged outside towns while farm areas were being mortgaged (Anderson and O'Farrell,

2012). Simultaneously, expansions and rapid divisions of land were eventually sold off for housing and developments (Laidler 1939).

It can be distinguished that there is an evident transition of land and resource usage from the occupancy of indigenous societies to the current state of the natural landscape. In an era of overconsumption, urbanization, and globalization, it is vital to acknowledge the ecological history and principles of the past to achieve sustainability for the future.

2.3 The impact of The Industrial Revolution on architectural development

The Industrial Revolution had significantly influenced the evolution of built form on the natural environment by shaping the turning points in history that ultimately guided many views and ideologies still embedded within modern architecture. Therefore, it displays the transition from the traditional usage of architecture to a more human needs and industrially orientated environment.

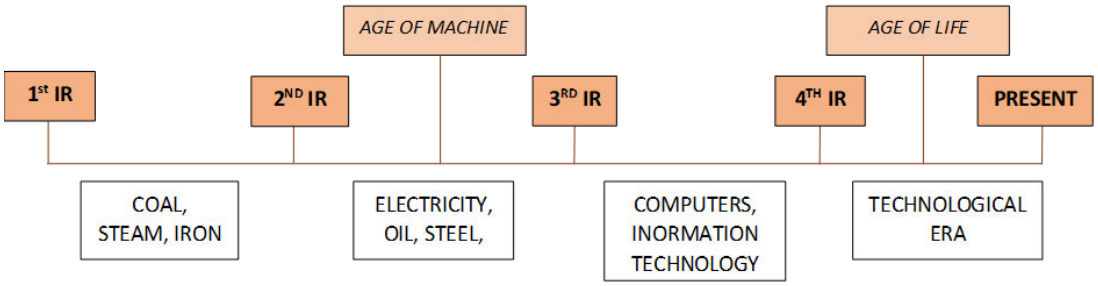

Figure 4: Timeline of the Industrial Revolutions (Author)

The term *Industrial Revolution* refers to the movement from a generally agricultural dominant society to an industrial one (UKEssays, 2018). The industrial revolution catalyzed a disconnection between nature, man, and architecture. It can be specified that the feeling of a close connection between humans and animals were lost to the many highly industrialized societies and had led to a further anthropomorphizing of wildlife (Nature worship, 2015).

The first industrial revolution, which had taken place between the 18th and 19th centuries, had signified a drastic transition of life with the invention of steam, coal, and iron (Leal, B. and

Salgado, M., 2020). The use of coal as the primary energy source for households, especially in rural and informal settlements, is a great contributor to negative environmental impact today (DEA, 2012).

These inventions were built up to the Second Industrial Revolution, which presented the generation of electricity, oil, steel, and glass (Cohen 2013). For architecture, this meant constructing cities and newer developments that were more extensive than before. Social changes radically transformed cities and, together with manufactured materials like steel and glass, promoted the emergence of new building design typologies (Sorguc *et al.*, 2020).

Unquestionably, nothing has come to symbolize industrialization more than the typology of a factory (Vries, 2008). This revolution also affected agriculture since new machines and techniques were introduced that helped advance farming. This had portrayed the thought that humans during this period had mastered nature (Reed, n.d.).

The invention of computers marked the third industrial revolution (Braz, 2016:7) along with the beginning of Information technology (IT), which automated production and integrated the world through networks (Leal *et al.*, 2020). From an architectural standpoint, this signified that the use of digital design, analysis, and fabrication had started to overtake traditional methods of production and representation.

This created a better level of innovation, liberty, and intricacy for architects (Sorguc *et al.*, 2020). As stated by Righi & Celani (2007), the developments within the digital world have an increasing impact on the physical world (Righi, T.A.F., and Celani, G. (2007). This global period had resulted in technological and production drove societies that cared little for future sustainable development.

However, the impact of industrialization had severely affected the natural environment. Land for roads, air, and water pollution from factories, railway lines, and mass developments had devastating effects on natural ecosystems and resources. In *the Handbook of Sustainable Refurbishment: Non-Domestic Buildings* (2009), it is stated that the built environment and industrialization have had an essential effect on the earth's vegetation and the habitats of its wildlife (Baker, 2009).

The profound effect of the third revolution had affected the construction of the built environment in various ways and had given rise to the modern movement. Advancements such

as the internet had brought upon immediate global connection and introduction to contemporary architecture.

It can be rationalised that universal design had seemed to become more popular, enabled by globalization and the internet's formation. Similarly, the introduction of globalization and modernism has resulted in unresponsive, resource consummative developments that did not value or appreciate the natural environment.

Consequently, this had marked another fundamental turning point in the earth's ecology and the human relationship with the built environment (McLamb, 2018). The industrial revolution had resulted in a machine-driven society, which focused on mass production, universalism, and modernism. (Kurokawa, 1994).

2.3.1 The Environmental Impact of Industrialization

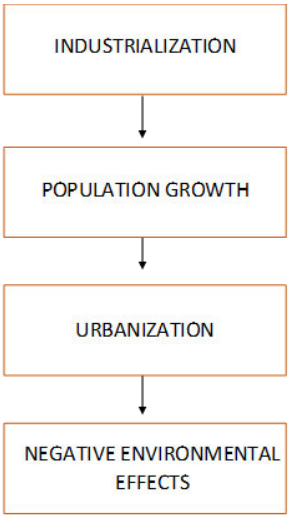

Figure 5: Timeline depicting the effects of the Industrial Revolution (Author)

In *The Ecological Impact of the Industrial Revolution* (2018), it is mentioned that industrialization drove the world's human population into an age of living and production at the ultimate cost of the human condition (McLamb, 2018). It had impacted the resources that had been taken for granted from the beginning of humankind.

In *Sustainable Architecture: Practices and Methods to Achieve Sustainability in Construction* (2013), it is agreed that man has always taken advantage of the planet's raw materials, and in conjunction with the dramatic population increase initiated by the Industrial Revolution, the need for raw materials had vividly increased (Marques and Loureiro, 2013).

It can be noted that the most prolific evidence of the Industrial Revolution's impact on the modern world is seen in the worldwide human population growth (McLamb, 2018). At the beginning of the first Industrial Revolution during the mid-1700s, the population had increased by about 57 percent (McLamb, 2018), and this had started to cause a rise in urbanization (Lennon, 2020). The procedure of urban expansion has caused many complications with the large amount of waste generated by the construction and demolition of buildings.

According to Marques and Loureiro (2013), waste recycling has become imperative since most waste can be altered into a new source of raw material. As stated by Mclamb in *The Ecological Impact of The Industrial Revolution (2018),* human population growth is tied together with an upsurge of natural resource consumption (McLamb, 2018). With minimal space and little consciousness for environmental sustainability, workers and people relocating to cities had expanded urban growth (Lennon, 2020).

"It is a fact that rapid industrial growth has made water, air, and hazardous waste pressing environmental problem in many areas of the developing world." (Magsi, 2014: 24).

While the Industrial revolution tremendously affected human progress, it incurred detrimental costs to the natural environment and ecosystems' global health. The fundamental changes in the way and types of goods produced and transported were bound to have consequences for the development (Vries, 2008) and, in turn, the natural environment. This rapid development of machinery caused rising concerns such as air and water pollution to emerge (Foundations of Western Culture, 2016).

According to the Department of Environmental Affairs, one of the significant threats to the environment is the water pollution caused by increased population density and subsequent developments close to natural water sources (DEA, 2012). Emissions from development combined with vehicle exhausts caused extensive air pollution. Simultaneously, concentrations of heavy metals and ammonia loads were often high enough to cause a significant threat to life down-river from industrial areas (Magsi, 2014). The increase in heavy machinery used for development also progressed the compaction layers on top of many soils, resulting in these areas more likely to erosion (Goldblatt, 2013).

Historically, there are patterns of urbanization and developments alongside large bodies of water. According to an article in *Investopedia* (2019), development around natural sources primarily began to sustain human life but soon transitioned to support industries (Investopedia, 2019). This contributed to pollution, with industrial waste often being discarded on public lands, rivers, or sewers designed to carry only municipal wastes (Magsi, 2014).

It is often architecture rather than individuals that are the drivers of consumption. In the South African context, the lack of appropriate infrastructure provision is problematic to life in informal settlements. People are forced to dispose of their waste within the settlement's vicinity, thus threatening the surrounding ecosystems (DEA, 2012). Furthermore, forests are destroyed for their wood, and ecosystems are replaced with housing, roads, strip mines, gravel pits, and machines (Folk, 2020).

2.3.2 The Age of Machine

To theorists such as Kisho Kurokawa (1994) and Le Corbusier (1927), the industrial society was the ideal of Modern Architecture. Kurokawa states that *"Modern society is a society of the present, with no interest in the past or future. That is why Modern Architecture rejected the history and tradition of the past, along with its symbols and its decorative language. At the same time, it rejected the future as unfathomable."* (Kurokawa, 1994: 198)

In *the Philosophy of Symbiosis*, author Kisho Kurokawa refers to the late parts of the second industrial revolution as the *age of the machine* (Kurokawa, 1994. Like the construction of a machine, architecture was organized, structured, and analysed to achieve the universal design. Means of brute force were used to dominate nature and simultaneously enforce universal design solutions on varying cultural contexts and conditions (Mc Donough & Braungart, 2002: 30).

The age of machine ranked humans next to divinity and disregarded the worth of all other living things such as plants and animals. The world revolved around human existence, suggesting that there is only one distinctive truth for all the world and that this truth can be demonstrated with human intelligence (Kurokawa, 1994).

Le Corbusier(1927) had his own interpretation of the machine age and viewed the *home* as a machine for a living. Corbusier expresses the Pantheon as an example of the age of the machine, which he feels exemplifies a norm and acclaims as a definitive and eternal monument to the

European spirit (Kurokawa, 1994). The age of machine was an ideal of Modern architecture as this aimed to banish all forms of historical or environmental expressions as it highly idealized abstraction.

The influence of iron - and particularly steel- on architecture substantially grew during this era, expanding the structural capabilities of existing materials and creating new ones altogether (Gaber, 2017). Concurrently, architectural movements were emerging, revolting modernism and reverting to traditional styles of architecture. Restoration movements such as the Gothic Revival and Art Nouveau were re-emerging. (Gaber, 2017). As pointed out by Craven (2020), periods inventing new approaches often re-awaken older movements of design.

However, along with rapidly advancing technology, newer systems of sustainable development, resource management, and waste renewal had become tangible. Through these radical approaches, a new age had dawned for environmental consciousness. The next industrial revolution has begun to usher in a new era of combined physical, digital, and biological spheres to rectify the evident mistakes of the past (Schwab, 2017).

2.4 The Fourth Industrial Revolution: An age of life and environmental consciousness

Many authors, such as Klaus Schwab, refer to the beginning of the 21st century as the Fourth Industrial Revolution (Schwab, 2016). It is notable for the extraordinary advancements in technology (Sorguc *et al*., 2020). As defined by Vestberg in *World Economic Forum* (2019), this era blends the physical, digital and biological worlds through a range of technologies (Vestberg, 2019). However, Farrelly (2018) argues that the significant difference between the fourth industrial revolution and the previous three is the unpredicted global impact it poses (Farrelly, 2018).

The Fourth industrial revolution critically informs strategies to improve research in architecture and, concurrently, environmental issues. From the emergence of humankind to the Industrial Revolution, it is evident that man has exploited the natural environment for different needs and wants. Technology has proven to advance architecture and development, yet the need for ecosystemic conservation and environmental consciousness through architectural practice has remained submerged.

The Fourth Industrial Revolution can be perceived as a paradigm shift in environmental awareness and will be critically explored to investigate sustainable development and design. In *The Ecological Impact of the Industrial Revolution* (2018), it is said that humans are now entering the next revolution, which is the era of sustainability (Mclamb, 2018)

In *A Philosophy of Symbiosis* (1994), Kurokawa implicitly acknowledges the impact of the future, the fourth industrial revolution as a technical context that has prompted a series of concepts and inventions, which are orchestrating a radically new world (Kurokawa, 1994). Yet, according to Kurokawa (1994), the 21st century can also be thought of as the '*age of life'* (1994), which emphasizes the importance of human impact on the environment (Kurokawa, 1994). Research during this era displays the conversion from the standpoints of Eurocentrism to the symbiosis of different cultures and ecology (Kurokawa, 1994).

Similarly, Farrelly (2018) refers to the 21st century as the "*Anthropocene, 'a geological epoch'- the human age*" (Farrelly, 2018:1). This, in agreement with Kurokawa, is a period in the history of the world in which human activities are the primary force in influencing all life-sustaining systems on Earth (Farrelly, 2018). The architecture of the age of life should express meaning through design and was brought into existence in the context of a highly *'informationalized society'* (Kurokawa, 1994). This is a progressive counterposition against the age of machines, which followed function and had come into being by a background of a production-driven and industrial society.

2.4.1 Reintroducing the need for sustainable design

According to the *National Framework for Sustainability* (2008), in order to meet the demand for human development's future growth, more sustainable construction methods need to be considered (DEA, 2008). It is critical to ensure that growth strategies are not reliant on exhaustive resource usage. Defining sustainable development as a philosophical strategy will benefit the understanding and identification of appropriate approaches to maximize quality and minimize developments' environmental impact (Sodagar *et al.* 2006).

Sustainability isn't a recent invention but an idea embedded in architecture's traditional use (Feisal and Reham, 2010). The primary influence that drove sustainable development was the environmental movement, which took place in the 1960s. Literature such as *Silent*

Springs(1962) and *Limits to Growth* (1972) raised important questions about humans' impact on nature and the concept of sustainable development (McLamb, 2018).

Sustainable architecture as a concept had originated from prior design practices such as *green architecture, ecological design,* and familiar practices (Farmer 1996; Ryn and Cowan, 1996; Wine 2000; Steele, 2005). According to Anink *et al.*, in the *Handbook of sustainable building* (1996), the construction sector is responsible for 50% of the material resources taken from nature, 40% of energy consumption, and 50% of total waste generated.

Similar findings were noted in *Life cycle assessment: A case study of a dwelling home in Scotland* (2007), stating the construction industry consumes 40% of the materials entering the global economy and is responsible for almost half of the worldwide greenhouse gases (Asif, Muneer, and Kelly, 2007).

In *Sustainable Architecture: Practices and Methods to Achieve Sustainability in Construction* (2013), findings posit that the overconsumption of these natural resources radically reduces biodiversity, modifies the landscape and, generates large volumes of waste (Marques and Loureiro, 2013).

The natural environment affects all aspects of life, including food security, housing, jobs, and mobility. Notably, the *National Framework of Sustainability* (2008) depicted ecosystem functioning as a fundamental constituent of sustainable development (DEA, 2008). In *Strategies for Sustainable Architecture* (2006), it is identified that as little as 12 percent of the ecosphere's surface is occupied by conservations, reserves, and protected areas (Sassi, 2006).

Therefore, it is critical that further loss of natural habitat, especially in vulnerable areas such as wetlands, is circumvented. Sassi (2006) has specified a need to reinstate lost habitat and increased land area that sustains ecosystems to combat extinction rates (Sassi, 2006:32).

Natural resources and ecosystems, especially within the South African context, are responsible for tremendous economic growth (DEA, 2012). According to the Department of Environmental Affairs (2008), the health of South Africa's biodiversity and general health of ecosystems within the country is steadily declining, with 34 percent of terrestrial ecosystems deemed threatened (DEA, 2008).

The Department of Environmental Affairs describes sustainability as not a single action but as a systematic process that requires a set perception or values that balance environmental, social, and economic issues to cater to future generations (DEA, 2008). To rationalise sustainable

thinking, humans must prioritise the needs of long-term global solutions over short term anthropocentric benefits. Consequently, it can be interpreted as going against primitive human instincts to regard ourselves before others in the fight for survival (Sassi, 2006). Therefore to achieve a sustainable architecture, an integrated approach is required where technology must be compliant to design and not a goal (Sodagar *et al.* 2006). In this regard, technology can be harnessed to enhance design and construction within the ecological environment.

2.4.2 Technology to advance ecologically responsive architecture, and conservation

Advances in design development, such as the Building Information Models (BIM) models, 3D printing, and augmented reality, completely revolutionized architectural design. It is worth highlighting the opportunities that software offers to the rationalization of construction and, consequently, environmental sustainability (Leal, B. and Salgado, M., 2020).

In the conceptual stage, innovative tools can help understand the relationship between buildings and the environment, test constructive features, visualize the design solutions, and combine the study of complex forms (Savignon *et al.*, 2012). The innovation of BIM granted the ability to develop various technologies for project management and construction through 3D models. This development allows for the building's historical information to be stored and contribute to its conservation (Canuto & Salgado, 2016:4873).

According to Cuperschmid (2016), another fundamental educational tool that developed was Augmented Reality (AR), which consists of superimposing virtual images or data in the real world via a camera device (Cuperschmid, 2016). The interaction in the AR environment occurs in a real location with the addition of virtual data, generating a composite view in real-time (Leal, B. and Salgado, M., 2020). However, the term is evolving and can be defined by the *Online Cambridge Dictionary* as "*a set of images and sounds, produced by a computer, that seem to represent a place or a situation that a person can take part in*." (Cambridge Dictionary n.d.). It can be ultimately described as an artificial setting experienced through sensory stimuli (Cambridge Dictionary n.d.)

In the journal titled *Impact of Fourth Industrial Revolution on Architecture* (2020), it is identified that AR environments could serve as an alternative pedagogical approach to learning environments (Leal, B. and Salgado, M., 2020). Similarly, it can be noted that augmented

reality puts forth the notion that technology can lead to a more conscious and digitally enhanced public realm (Champion, 2019). Examples of Virtual Reality (VR) as an educational tool have been noticeable in the fourth industrial revolution. They are seen as an effective means for environmental awareness through virtual environments and simulations.

This invention stems from the concept of expanding upon reality (Leal, B. and Salgado, M., 2020) and could provide an alternative to current zoo typologies and ecological learning centres, that negatively impact the ecological environment by their very construction. Therefore, it can be argued that advances in technology may be utilized to significantly reduce the carbon footprint of built form through the use of smart design and innovative buildings.

Advanced technology for ecological preservation can be displayed in the Natural History Museums, *'Hold the World' Virtual Reality*' (VR) exhibit. It can be perceived to permit people to be unseparated by glass displays and allow for interaction with the virtual environment. In need of a more environmental approach, AR and VR applications can be displayed in initiatives such as *'Every Kid in a Park*,' sponsored by the USDA Forest Service. The program educates people on history, nature, resources, and culture.

In a globally-connected digital era, applications such as this encourage individuals to explore the natural setting and simultaneously unlock geo-triggered, augmented reality (AR) challenges (Alvarado, 2020). A study conducted in the U.S. Department of Agriculture (2020) proved that children who are exposed to nature before the age of eleven are more likely to be considerate of the natural setting as adults (Alvarado, 2020).

Similarly, an exhibit at the Art Science Museum in Singapore implements augmented reality initiatives geared primarily towards marine conservation. The display is called '*Our Ocean Life'* and takes the users on an immersive and interactive experience under the ocean to examine pollution's devastating effects. The hope is to inspire people through technology to evoke a sense of urgency to take action against environmental health issues (Mileva, 2020).

Folk (2020) states that machines can be realised as better for the environment than outdated options. In the article published by Sustainability Times, titled *Industry 4.0 Could Revolutionize Sustainable Architecture* (2019), the opinion of machines as a positive tool for sustainability is reinforced.

The progress gained from the digital development of the fourth revolution can be utilized to reduce resource usage and carbon emission from the stages of manufacturing to reuse. However, borrowing from the perception of Vestberg (2019), the stimulating technologies of the Fourth Industrial Revolution cannot, by any means, be measured as a solution to the complex problem of sustainability and conservation.

According to Soloviy (2019), "*with all the innovation, we must remain aware that technologies require immense quantities of resources, and we should ensure that they don't actually cause even greater resource depletion and mounting emissions.*" (Soloviy, 2019: para. 11). In an *age of life (*1994), it will be essential to alter the technologies of the developed nations and discover ways for them to exist in symbiosis with existing technologies of traditional regions and cultures (Kurokawa, 1994). Therefore, the use of technology will need to be transformed to suit the needs of the context in order to ensure longevity for future generations.

2.5 Conclusion

The relationship between architecture and the natural environment was explored chronologically. From the dawn of civilizations to the fourth industrial revolution, a clear transition from the reliance and dependency of man upon the natural realm can be seen. The timeline depicts an evolutionary development from the dependence on nature to self-reliance and, lastly, to a machine-driven society.

However, perceptions of the environment towards humankind can be seen as shifting back to more traditional associations with the emergence of an era of sustainability-*the age of life* (Kurokawa, 1994). The literature provides more than mere review; this information becomes imperative and more so a blueprint to trace back civilization's steps. By identifying the past inadequacies and errors, man can improve the architecture built, thus changing the relationship between man and nature going forward.

Today amid the Fourth Industrial Revolution and an Age of Life, it is critical to remember that sustainability can only be achieved through conscious thinking and environmental awareness. It is only with mindful belief and sustainable initiative that the current conditions be alleviated to prove that nature, man, and architecture can harmoniously co-exist.

To encourage the association between nature, man, and architecture, a critical understanding of the person-environment relationship should be investigated. The literature will, therefore, investigate a means to mend the relationship between person and place through sustainable, responsive design.

CHAPTER 3: PHENOMENOLOGY: SYMBIOTIC DESIGN FOR HUMAN NEEDS AND ASPIRATIONS IN THE NATURAL ENVIRONMENT

3.1 Introduction

It is imperative that architecture be sensitive to its natural environment so that built form may be realized as an integral part of the natural ecosystem instead of dominating over it.

In an Ecological era, there is a requisite to generate ideas and paradigms for the conservation and protection of natural resources, ecosystems, and species that are endangered in order to counter the effects of industrialization (Dahl, 2016). Architecture should therefore be conceived as more than a human-made 'object' as the implications of the built form have far more significant social and ecological effects on people, place, and human consciousness (Day, 2004).

With the consideration of human consciousness, the following theories, concepts, and principles will be viewed from a phenomenological perspective to uncover the human-environment relationship towards an ecologically responsive approach to architecture. Considering the relevance of context to this research, the theories of place and sustainability will both be investigated through a philosophical lens to understand the connection between man and place holistically. This understanding aids in constructing ecological design philosophies that shift the perception of nature and the development of built form.

3.2 A phenomenological analysis of the human-environment relationship

"We exist in a world, and phenomenology attempts to identify the essential characteristics of that existence, which once understood, provide footholds around which to understand ourselves and others." (Seamon, 1982, p.136)

In its most basic interpretation, phenomenology can be understood as the science of phenomena (Heidegger, 1962). It is referred to as an undertaking that aims to understand the fundamental qualities of human experience and the world in which that experience occurs (Burch, 1989). According to Norberg-Schulz, a phenomenological study attempts to introduce views of spatial experiences. Rather than being viewed as a dimension of perception, these views can be stated

as a dimension of human existence, essential for action in the environment (Norberg-Schulz, 1971).

As a philosophical paradigm, phenomenology promotes the development of patterns, thinking, and principles that focus on fostering an authentic connection between human experience and the world. A philosophical understanding of architectural design needs to acknowledge the relationship between man and the environment in which he dwells. Man is continuously immersed in his world, inclusive of the physical environment. This immersion-in-world will be a primary focus of the phenomenological investigation (Seamon, 1982). The nature of this immersion provides the background for any concerns of environmental fundamentals and interconnections (Seamon, 1986).

According to Heidegger in *Being and Time* (1962), it can be argued that in philosophical terms, the relationship between person and world is either viewed from a realist or idealist point of view. An idealist perspective being that the individual constantly defines and shapes their world. Conversely, the realist perspective builds upon the notion that the world acts on the person, and in turn, the person reacts (Heidegger, 1962). However, it can be noted that both views are representative of the humans disconnect with nature as they suggest that the relationship between humans and the world is separated in either reality (Heidegger, 1962, Seamon, 2012).

In accordance with the work of Heidegger, Edward Relph (1987) agrees that both person and environment should be considered equally intertwined and thought to be reliant on each other to achieve holistic relationships (Relph, 1989). This 'undissolvable unity' (Stewart and Mickunas, 1990: 9) can often be referred to as the term 'Daessin' or 'being-in-the-world' (Heidegger, 1962). For this relationship to be tangible, the necessity for the natural environment as an integral aspect of human life needs to be recognized.

In Genius Loci: *Toward a phenomenology of architecture* (1971), it stated that the everyday 'life-world' could be considered made up of concrete phenomena such as people, animals, plants, and built objects. However, it is understood that it also comprises intangible phenomena such as meaning, feelings, and experiences (Norberg-Schulz, 1971). Supporting the latter notion, Seamon (2012) puts forward that life-world can be considered the aspects and experiences of daily life that people often do not take time to reflect upon (Seamon, 2012).

It is expected that humans and, by extension, architecture, neglect the consideration of the phenomena and experiences that occur daily. This 'taken-for-grantedness' can be referred to as the term '*natural attitude'* (Husserl, 1982). It is because of the natural attitude that "*any life-world is transparent in the sense that it is normally implicit and just happens, grounded in spatial-temporal situations and events which are more or less regular*" (Moran 2005: 9–17). In architectural design, it is mindful of distinguishing the fundamental physical as well as psychological aspects of the lifeworld to provide responsive and meaningful built environments.

3.2.1 Environmental and architectural phenomenology

"Architects must aim to create embodied and lived existential metaphors that concretize and structure our being in the world." (Pallasmaa, 2005: 71)

A phenomenological approach to design offers the opportunity to incite similar psychological reactions as stimulated by people or an external environment (Croome, 2000). Due to this quality, users will need to use their thought when experiencing the built form to provoke human perception resulting in an emotional and analytical component of the natural experience (Manzo, 2013).

In *Phenomenological Aesthetics of Landscape and Beauty* Author, Jóhannesdóttir (2016) argues that phenomenological aesthetics can offer essential insights into environmental values that are often neglected (Jóhannesdóttir, 2016). This display of phenomenological aesthetics in architecture can enable the vision that there is no separation between man and nature or subject and object. The phenomenologically motivated design has the capability to be responsive to all biological components of the context while introducing dimensions, meanings, and perspectives to architecture. According to David Seamon (2012), this approach could be used to interpret architecture and contribute to better environmental design (Seamon, 2012).

A phenomenological interpretation of design is intended towards a consciousness of space to give rise to self-awareness, spatial experiences, the character of space, and ultimately an empathy for other living beings in order to generate symbiotic environments. According to the journal of Environmental Psychology (1982), "*phenomenological studies could have a significant role in identifying, designing and building environments that work ecologically, humanly, and spiritually*" (Seamon,1982, 136).

3.3 A phenomenological approach to place theory

"Place is significant centers of our immediate experiences of the world." (Relph 1976, p. 141). In *Poetry, Language, Thought* (1971), place is described as the locality of human existence (Heidegger, 1971). It can be established by the routines and patterns of the occupants inhabiting the environment (Kjerrgren, 2015). This leads to the understanding that architecture's existential purpose is to transform a site into a place (Norburg-Schulz, 1982). Kjerrgren (2015) states that it is only through place that we as humans begin to identify ourselves and our position in the life-world. The nature of place theory identifies critical design principles that are required to develop sustainable and ecological design philosophies (Dahl, 2016).

According to Norberg-Schulz, place pertains to its own meaning, which is already inherent in the world. It is only through architecture that meaning within a place becomes visual (Norberg-Schulz, 1980). Norberg-Schulz's understanding of place can be interpreted to say that while places are essential for a meaningful existence, meaning cannot be created through architecture but rather become a response or visualization of an environment's essence (Kjerrgren, 2015). Norberg-Schulz's understanding of place can be seen to be highly influenced by the perception of the natural environment. According to Hasa (2016), perception is influenced by past experiences, feelings, or thoughts and can be interpreted from the five senses (Hasa, 2016).

Unlike Norberg-Schulz's approach, which emphasizes natural environments as the underpinning of place, Edward Relph (1976) adopts a phenomenological perspective to reinterpret the person-environment relationship. Relph's take on place begins and ultimately prioritizes human experience, defining places as 'fusions of human and natural order' (Relph, 1976). In adopting a phenomenological approach to place, the emphasis is positioned upon being-in-the-geographical-world but also provides linkages with other aspects of human life and experience. (Seamon, 1982)

> "*Clearly, place has a particular geographical and architectural base; it is a context of activities; it generally has a cognitive identity; it involves various social worlds; it has a history joining past, present, and future. Each of these aspects of place is significant, but in a phenomenological portrait of place they are contingencies and therefore secondary*." (Seamon, 1982:133)

Relph (1976) acknowledges that the meanings associated with places may be rooted in the physical setting, objects, and activities but distinguishes that they are not the property of them

– rather, they are a property of human intention and experiences. It can be noticed that the focus of place has shifted from what the spirit of a place holds to what sense or significance it holds towards an individual or groups (Relph 1976). Despite the differences between the experiential and physical significance, place ultimately provides similar ideologies of generating existentially meaningful spatially defined entities.

Notably, a study done by Nogué Font in Garroxta, a region north of Barcelona, questioned if an aspect of concrete life-world such as the natural environment could possess a phenomenology in its own right, or if the phenomenology of environment exists only as particular individuals and groups experience it (Nogué I Font, 1993). Interviews among various individuals of the area stated that the landscape had specific common characteristics that they similarly experienced, thus labeling it "a thing in itself" (Nogué I Font, 1993). An example of this being that both groups had viewed the area as a "*wild, tangled landscape of gorges, precipices, and forests that invoke a sense of respect and endurance*" (Seamon, 2002:6).

Simultaneously, the landscape that possessed the same notable characteristic was instrumental in arousing different experiences for the individuals based on their unique perspectives. In *Place and Placelessness* (1976), it is said that place is a subjective experience and that the perception of the same place will vary between different individuals (Relph, 1976:44-78). Agreeably, In *Spirit & Place: Healing our Environment* (2002), the thought of place can be deemed as controversial and something which is influenced by perspective but also an essence linked to sense, memory, familiarity, safety, and belonging (Day, 2002).

It was concluded from Nogué Fonts' study that both interpretations of place had existed (Seamon, 2012). Therefore, the environment must be studied and critically construed before built intervention is undertaken. Realizing that environments hold their own phenomenological value will thus guide the research to investigate both the physical and human experienced dimensions of place in order to understand it fully. According to Seamon (1986), in order to examine the natural environment and thus place, three essential themes must be investigated. Respectively, the human-environmental experience, the concrete qualities of the environment, and lastly, the '*larger context of societal and symbolic environments*.' (Seamon, 1986)

3.3.1 Dwelling, place, and the natural environment

Dwelling integrates both places and environments but encompasses experiences beyond them. It represents '*our inescapable immersion in the present world as well as the possibility of reaching beyond to new places, experiences and ideas*' (Seamon, 1986). In an architectural sense, dwelling can also be considered as the goal of architecture. The term 'dwelling' coined by Heidegger means to 'be at peace in a protected place,' which essentially relates to how beings exist in the world (Norberg-Schulz 1980:22). Man dwells where he can *orient* and *identify* himself within an environment *(Norberg-Schulz, 1980).*

Norberg-Schulz (1980:19-20) alludes to Kevin Lynch's (1960) ideas of a spatial structure as a determining factor for human orientation, where concrete things in the urban fabric produce distinguishing imageability in places. According to Lynch (1960), it is the absence of imageability that makes us lost and can be thought of as the opposite of dwelling., to dwell is to have an existential foothold, which is secured through the familiarity of where one is in the world, but also how one communicates with the surroundings (Norberg-Schulz, 1980).

In *Existence, Space and architecture* (1971), Norberg-Schulz's writes about the concept of 'existential space,' which is built upon the term 'dwelling' (Heidegger, 1972). Similarly, existential space refers to the fundamental relationships that occur between man and the environment. It can be further defined as a system of three-dimensional organization of the elements which make up a place (Norberg-Schulz, 1971). 'Existential space' is further explored in *Genius Loci: Towards a Phenomenology of Architecture* (1982) and deliberates the terms of *space* and *character,* which parallel the psychic purposes of '*orientation'* and '*identification'* (Norberg-Schulz, 1979).

Space, as Norberg Norberg-Schulz uses the concept, is not seen as an entity or phenomenon opposite or separate from place, but simply represents the physical elements which define a place". Space thus, becomes a critical component of place which is needed in any built intervention to ensure places are spatially legible and characteristically clear (Kjerrgren, 2015). When visualizing, complementing, and symbolizing the environment through architecture, spatial structures and the character articulated within space are the main defining elements of place.

In *Towards a Phenomenology of Nature* (2015), it is argued nature should be thought of as something that makes our experiences possible. In the understanding of architecture being the

"*concretization of existential space*" (Norberg-Schulz 1980:5), place can be set apart from being more than a meaningful location considering meaning is here interpreted from nature, instead of human feeling (Kjerrgren, 2015) .

Place is not *"a mathematical concept, but an existential dimension*" in that it is something one experiences rather than calculates (Norberg-Schulz 180:10-11). Similarly, Tuan (1976) agrees that space is not a singular entity but can instead be approached as an array of mental constructions, all of which depend on the interaction between the human body and the natural place (Tuan, 1976). Thus, the environment must be considered as meaningful (Norberg-Schulz, 1971), and in response, architecture ought to visualize the characteristics of place to create expressive built environments that assist man to dwell.

3.3.2 Genius Loci toward capturing the character of place

"*The Genius-Loci of a place is never constant, it is forever changing, evolving and fluctuating, hence the integral relationship to time; as life itself is bound by time*." (Dahl, 2016: 37)

Relph interprets the term genius loci as "*the very individuality and uniqueness of places*" (Relph, 1976:48-49). Norberg-Schulz (1980) believes that each place holds its own story of the people and events, either past or present, which become the foundation of experience (Norberg-Schulz 1980). All beings bound to place share the same common experience, which is relevant for the development of ecological awareness and mending the relationships between man and natural ecosystems (Raine, 2001).

The term Genius loci or '*spirit of place'* dates back to Roman times, and it was believed that each individual or being had its guardian spirit determining its unique essence (Rose, 2008). These spirits were understood to accompany each being throughout life (Norberg-Schulz 1980:18). In accordance, the individualistic character of place itself was said to hold its own Genius Loci, which was derived from a supernatural spirit (Jackson 1994:157). According to Norberg-Schulz, it was essential that people developed a good relationship with the genius loci of place in order to secure their survival (Norberg-Schulz 1980:18).

Initially, social identity, history, and the natural realm had been critical determinants of a place's character, and thus, ways of living evolved within them **(**Raine, 2001). In present philosophical terms, the root of genius can be realized as the natural environment or natural

place (Norberg-Schulz 1980). In agreement, Day (2002) states that it is the natural environment that informs a spirit of place (Day, 2002). Norberg-Schulz (1980) goes forth to categorize methods of identifying the natural place in five dimensions, respectively: order, thing, and character, light, and time. These factors all influence the user's perspective, which alters the perception of an environment and, therefore, occupants' natural attitude towards the lifeworld.

"*Thing and order refer to the spatial qualities of the landscape, while character and light relate to the overall atmosphere. Time involves both constancy and change in the landscape, especially in regard to daily and seasonal rhythms of weather, climate, vegetation, and animal life"* - (Norberg-Schulz 1980: 24).

Norberg-Schultz proposes that the standards behind capturing the genius loci of a place are based on four thematic levels. The *topography* of the earth's surface, the *cosmological light* and sky conditions - which can be considered the natural environment-, the *built environment, and* the *cultural* meaning (Norberg-Schulz, 1980:25-32). These elements are constant and need to be carefully considered when trying to uncover and respond to the environment's genius loci. Therefore, a critical understanding of a place's existing factors is pivotal to understanding the site and its meaning buried within before undertaking any intervention.

Genius loci should be used to serve as a guide to inform a sensitive approach to particular features of an environment and simultaneously provide an efficient way of creating a narrative of place to inspire built form (Moore, 2010:57). Often, the genius loci of a place are sacrificed due to economic constraints for architectural development (Pearson; 2005). The natural site, health of ecosystems, and place-bound communities are frequently ignored, resulting in human-made structures that dominate the natural world (Dahl, 2016:7). It is essential to recognize the environments, societies, and activities for conscious design intervention that fosters human thought and subsequently influences the spirit of a place (Day, 2002).

3.3.3 Rooting built form to place – A critical regionalist perspective

Places are qualitatively different from the space or landscape in that they are established within our memories through recurrent encounters and multifaceted relations (Seamon, 1986).

The term Critical Regionalism was initially coined by Alexander Tzonis and Liane Lefaivre in the early 1980s. Tzonis and Lefaivre identified that regionalist architecture is both '*reactive*,' '*liberative*,' and criticizes a universal architectural order (Tzonis, A. and Lefaivre, 1991). The consideration of critical regionalism enhances a more responsive architecture by questioning the genius loci and the very essence of place (Dahl, 2016).

According to Kenneth Frampton, critical regionalism was thought of as a tool to mediate the conflict between universal civilization and the local cultures or 'pe*culiarities of a particular place*' (Frampton, 1983). Taking inspiration from the phenomenological work of Heidegger, Frampton's (1981) philosophies can be described as "t*he moods, emotions, and contextual layers of meaning to the act of perception*." (Mullgrave 2011, 101) Frampton's understanding of Critical Regionalism can thereby be perceived as an '*attitude'* instead of a '*set of motifs*' (Moore, 2001).

Its principles are not to revive older vernacular forms of architecture but rather to question how humans can return to traditional design while still taking part in '*universal civilization*' or modernization (Frampton 1981). Similarly, In *the Thinking Hand*: *Existential and Embodied Wisdom in Architecture* (2009), it is stated that the dialectic between modern and local techniques could allow for a more responsive architectural design (Pallasmaa, 2009).

Therefore, it is only in identifying the people, buildings, techniques, and materials within an area that the genius loci be appropriately captured. The basis for designing with a regionalist approach stems from architecture that reflects a specific place's identities and cultures (Frampton, 1983). Built intervention here serves to attempt to accentuate a sites' natural essence to uncover its meaning. (Kjerrgren, 2015). What is now present has been formed and therefore informed by the past. This importance of our history can be seen in *The Shape of Green* (2012), where it is implied that "*architecture embodies humanity's relationship to the earth*." (Hosey, 2012:118).

Critical regionalism formulates the foundation for bounding architecture to place (Frampton, 1983). "*In terms of traditional societies and vernacular architecture, there appears to be solid*

evidence that people often consciously constructed human-made environments in tune with the natural site as well as lifeworld needs." (Seamon, 1982: 131). Therefore, a place bound architecture will allow the built human-made world to respond directly to the natural world. Critical Regionalism manifests more along the lines of sustainable, environmentally conscious architecture (Frampton, 1983).

In the Aesthetics of Architecture, (1979), Roger Scruton mentions that all built form begins in their vernacular style by responding to the climate and setting. Therefore, it is fundamental that architectural design is a truthful representation of the environment in which it exists. Although modern approaches may sway the material choice, ultimately, the building is dialect until the decorative styles are applied (Scruton, 1979).

Modern architecture has been portrayed as something that neglects or alienates occupants by producing generic, utilitarian buildings (Day, 2002). According to Pallasmaa, modern architecture can be seen as '*ocularcentric,'* which is specified to be detached from social and mental associations (Pallasmaa, 2005:22). This perspective reinstates that the world is seen as a meaningless visual journey and not a sensory experience. Architecture thereby quantifies as the art of place-making in which we relate new places to the ones already there (Day, 2002: 10).

According to Peter Zumthor, to create the conception of place, resources, and materials that are ingrained in time and context are highly pertinent (Zumthor, 2010). Dahl correlates by adding that the use of materials in construction is essentially the connection between man, nature, and architectural design (Dahl, 2016). It is a well-known fact that materials should naturally adapt to environmental conditions throughout their use. The ability of adaptive use materials should be highlighted and celebrated through architecture (Dahl, 2016).

It is said in *Touch this earth lightly* (2001) that the use of materiality that fails to respond to the natural environment are considered 'static' and by no means bound to the context to provide place identity. (Murcutt, 2001). The preconceived notion is that buildings would conquer over time if they did not show any weathering attributes or deterioration (Weston, 2003). Therefore, the use of local materials intrinsically connects built-intervention to place by bringing out the genius loci of both the built and natural settings.

The materials implemented in construction should allow the building to be responsive and simultaneously "speak for themselves" (Semper cited in Weston, 2003:60). The use of

materiality in built intervention for more authentically responsive environments will be explored further in Sustainability theory and the precedent studies.

3.4 Conclusion

The research of phenomenology and place have provided methods of analysing environments as a primary concern. This chapter focuses on developing consciousness of place, sensory experiences, and interactive environments that influence perception. Therefore, the theoretical framework proves useful in analysing the human-environment relationship and critically understanding the spirit of a place to producing a responsive design. Key findings included a double-sided approach to place theory by considering place as an entity on its own and place in relation to human experience. From here, the theory of sustainability will be explored to further understand the spirit of place and manifest theoretical framework into responsive design principles.

CHAPTER 4: SUSTAINABILITY AS A MEANS FOR RESPONSIVE DESIGN

4.1 Introduction

The first step towards sustainability may be seen as awareness and empathy towards the environment. With the state of environmental health continually degrading, a new perception of living in the world needs to be constructed. In accordance with Albert Einstein in an article titled '*Atomic Education Urged by Einstein'(1946),* it is critical to acquire a significantly new manner of thinking if humankind is to survive. (Einstein, 1946: 11).

To design sensitively, it is significant to understand the systems or metabolism of a particular place (Van Der Ryn and Allen, 2013). Therefore, the metabolism of a site will consist of the energy, materials, waste input, and output flows. This consciousness in architecture is imperative to creating symbiotic environments. In *Design for an Empathetic World* (2013), Van Der Ryn and Allen deliberate over the 'enormous' impact a simple home has on the surrounding ecosystems. The existing site may have been a forest, grassland, or wetland. Each contains its own metabolic flows and subsequently fosters homes to smaller animals or organisms undergoing their own metabolic processes (Van Der Ryn and Allen, 2013).

This entire ecosystem is disrupted or destroyed through the built intervention. Natural resources are depleted. Coal and gas are used for heating, cooling, and anthropocentric comforts (Van Der Ryn and Allen, 2013:58). For construction purposes, trees are cut, steel, concrete, and glass are manufactured in factories to provide materials that further alter a site's natural metabolism.

> *"While believing a flower has the same rights as a human may seem radical, it simply represents one extreme of a sliding scale of values that is constantly shifting…Today, we know that dolphins communicate with one another, we know that animals suffer stress, we know of numerous animals that use tools and others that mate for life. In future, as we understand more about animal behaviour, we may all come to accept some or all animals as being equal to humans and deserving of equal rights." (Sassi, 2006: 12)*

4.2 Designing ecologically for an empathetic world

The concept of ecological architecture emerged in the 1970s (Day, 2002: 89). Ecological design sets out to be not only technologically sustainable but also a positive influence on the environment (Yeang, 2014). Placing ecology in the foreground of the composition provides specific ways to minimize energy, materials use, reduce pollution, preserve habitat, foster communities, improve health, and provide beauty. Thus, it offers a new way of thinking that strives to demonstrate how architecture can aid in the conservation and become an integral part of the natural environment (Yeang, 2014).

According to Van De Ryn and Allen (2013), it is suggested that all architectural design should be human-centered to be empathetic (Van Der Ryn and Allen, 2013). Facets, such as the physical, emotional health, and the connection to the earth, should be thoroughly considered regardless of the economic, social, or discriminatory factors. Empathetic in the context of this research means to provide compassion to all living things. Therefore, to design empathetically is to prioritize the quality of life for both human and non-human nature.

It is only through architecture that the truth of places is materialized, allowing the natural setting's experience at a deep transformative level. The use of sustainable, ecological, and empathetic architecture should all focus on reconnecting buildings to their natural place so that nature can be directly experienced and, subsequently, celebrated to raise public awareness. To visualize architecture as a symbiotic process, understanding the fundamental need for connection between man and nature should be carefully deliberated (Dahl, 2016).

It is important to recall that human dependency on nature is critical. Yet, nature's survival is entirely independent of human beings (Van de Ryn, 2013). According to Sassi (2006), ecological economists believe that it would be impossible for people to replace all the services nature provides. The rise in the value of nature's services rises as quickly as their availability decreases.

Architects need to not only reduce resource consumption and waste in design but create regenerative, living systems. Structures can be made whole through design that incorporates life-enhancing technologies that include essential elements such as sun, water, plants, healthy landscapes, and clean air wherever possible.' (Van Der Ryn and Allen, 2013:48).

In *safeguarding our common future* (2000), the terms of anthropocentric, non-anthropocentric, or eco-centric sustainabilities are referred to. In an eco-centric or non-anthropocentric perspective, which is the non-dominant view of the world, the emphasis is placed on seeing the earth as a whole (Sassi, 2006). This view encourages the value of the surroundings and all living beings in nature. Eco-centrists do not compete with non-human nature, which is viewed as an *object* while human is the *subject.* Eco-centrists exist in total opposition to an anthropocentric view. Dejectedly, it is noted in *Strategies for Sustainable Architecture* (2006) that the closest example of a non-anthropocentric view is only conservation groups that dedicate individuals' time and money to protect natural environments. Unfortunately, most anthropocentric viewpoints may claim to protect the natural environments so that humans can remain to benefit from them (Sassi, 2006).

Stefanovic goes forth to criticize both anthropocentrisms as well as non-anthropocentric as they both 'assume the dualism of subject and object.' In line with Heidegger's being-the-world, thinking in terms of 'subject' and 'object' is not seen as the primary way of being between human and nature, as both are part of an integral system. It is through being-in-the-world that we start to find meaningful relations with others in the environment. In conclusion, each individual's role is to consider themselves as part of a meticulous system that is equally responsible for the natural resources and well-being of all-natural beings. Only once this mindset is imparted can humankind fully achieved empathetic and sustainable design.

4.2.1 Sustainability as a guiding design philosophy

"*It is useful to distinguish between different normative views of sustainability, recognizing that there are multiple sustainabilities which decisively need be defined quite precisely for particular issues and groups*" (Leach *et al.*, 2010: 42).

Extensively stemming from a primarily non-anthropocentric view, Paolo Sassi (2006) emphasizes the ideology of sustainability as, first and foremost, contradictory thinking to human instinct, which prioritizes future resources and the wellbeing of the natural world over themselves. The first step towards sustainable development is to determine the desired type of relationship with the environment, and secondly would be to figure out how to achieve it (Sassi, 2006). It will require scrutiny of shared traditions and methodologies in the hope of conscious, place-responsive design.

Unlike directly experienced environmental issues, sustainability issues also emphasize the impact of actions on humans and environments in the future. As infamously stated by the *Brundtland Report*, sustainability concentrates on the progress that attains the present's needs without negotiating future capacity (Brundtland, 1987).

"*Sustainable thinking, which is altruistic and long term, requires reasoned and sophisticated thought processes that involve high levels of abstraction and are underpinned by an understanding of complex interconnecting networks*" (Sassi, 2006:11).

In this technological era, sustainable development becomes more than a technical issue. It is also, in fact, a philosophical matter. In *safeguarding our common future* (2000), Ingrid Leman-Stefanovic stressed the importance of bridging the gap between philosophy and sustainable architectural concerns. Borrowing from Heidegger, Stefanovic articulates that a phenomenological insight could lead to an environmental understanding that highlights the genius loci and provide a sense of *being in the world* (Leman-Stefanovic, 2000).

A phenomenological approach to sustainable growth rethinks the taken-for-granted view of the life-world. It prioritizes the conservation of natural resources consciousness development to fulfill human needs at a local scale in order to sustain the earth (*Leman-Stefanovic, 2000).*

Stefanovic does not seem to disregard quantitative indicators or sustainable development factors but views them as only the '*tip of the iceberg'* (Leman-Stefanovic, 2000). This philosophical take on sustainability allows for inquiring background information and plays a role in developing future design principles accordingly. It is through this methodology that we see the world "*not as merely quantifiable empirical data or as a mere social construction, but rather simply there in the experience of connectedness.*" (Maly, 2001). Like Heidegger's work, a phenomenological way of thinking constructs opinions dealing with humans' relationship to their natural world, which is primarily not considered calculated, rational, or subjective in most built form.

The theme of sustainability in architecture revolves around the consciousness that the building is not considered an individual entity but rather thought of as an entire life cycle from design, site selection, materials, construction, and eventually decommissioning (Gunnell, 2009). It takes heed to the ecological footprint by mindful usage of innovative technology, materials, energy, and built space impacting the ecology. The notion of sustainability in architecture is to apply different strategic interventions to re-orientate the human development path in a more sustainable manner (Leman-Stefanovic, 2000).

In the book *Strategies for sustainable architecture* (2006) Sassi, suggests that the main aims for sustainable architecture are to prioritize construction that minimizes the impact on the natural landscape and, secondly, to attend to both the physical and mental wellbeing of the occupants (Sassi, 2006:9). Similarly, sustainable architecture aims to reduce energy and waste within the design while considering the built form as a living, organic system.

Sustainable buildings can also be seen as education vehicles to promote environmental awareness to the occupants and public. From construction to completion, the structure can stand as a way of educating locals or those interested. The completed building can also be seen as a 'demonstrative tool' to display effective design strategies (Sassi, 2006).

4.3 Sustainable strategies for ecological design

In *Sustainable Ecology, Architecture, and Planning* (2007), Daniel Williams alludes that a place becomes improved because of sustainable design (Williams, 2007). The building sector is commonly associated with burning fossil fuels for construction and operational purposes. It is determined that the word-wide building industry contributes 30 percent of the global CO2 emissions (IPCC 2001).

According to Sassi, all buildings require operational energy, which is the energy used to provide electricity for appliances, lighting, and hot water. Therefore, a zero-energy building does not exist; however, low energy buildings do (Sassi, 2006).

Designs that utilize sustainable energy sources require little to no fossil fuels to operate while still providing a healthy quality of life for occupants (Williams, 2007). With regards to energy reduction, sustainable development allows users of the building to "*maintain and, if possible, improve their quality of life while producing the least possible amount of CO2 emissions*." (Sassi, 2006:204) By designing responsively, sustainable architecture can renew and add to the environment's quality by including passive air and water purification (Williams, 2007).

In evaluating the energy usage for environmental impacts, the building's energy usage needs to be assessed foremost. Secondly, the building design alternatives need to be modified to reduce the CO2-emitting energy sources. Energy almost always varies according to climate and geographical location (Sassi, 2006).

While a sustainable design may vary from one temporal setting to the next, the fundamental principles can be universal and applied to all locations. To create a sustainable structure, the design of the building needs to follow strict energy efficiency principles along with passive design strategies-. Passive design strategies primarily affect spatial design, and therefore need to be considered at the beginning of design development (Sassi, 2006).

As stated in *Strategies for sustainable architecture* (2006), these principles include, "*orientating the building in relation to the sun, the wind and the site characteristics; insulating the building and providing heat storage according to climatic needs; integrating systems to passively cool and ventilate the building; and providing appropriate natural light to minimize the need for electrical lighting*." (Sassi, 2006). Accordingly, the occupant's needs should be met.

With regards to heating, and thereby the reduction of auxiliary heating, buildings should be constructed to harness solar heating through passive design means. Solar radiation allows for heat to be retained within a building, reducing energy consumption. Passive principles to influence heat reduction include the orientation of openings to the Northside of the building to "*allow maximum solar radiation to enter the building, and create a well-insulated and airtight building envelope that will retain heat within the building*." (Sassi, 2006: 206).

According to Williams (2007), a sustainable site analysis should commence with an investigation of the sun and its influence on the region, the community, and the site (Williams, 2007). Paolo Sassi (2006) talks about the '*durial range*,' which can be explained as the average difference between the maximum and minimum temperatures of a given day. If this is large enough, cool night temperatures may be subjugated (Sassi, 2006).

By the addition of a dense material called a thermal mass, heat is absorbed during the day and slowly cools down. However, thermal mass can be used to release heat daily or even seasonally. In humid climates such as South Africa, passive methods of heating and cooling may not be adequate. In this situation, other strategies such as natural ventilation or technological aid may need to be employed.

For the reduction of water usage and pollution, it can be seen that three main approaches need to be carefully considered. Sassi (2006) identifies that the need for freshwater should be reduced, the means of a secondary source of water should be implemented, and lastly, the disposal of black/grey water has to be well-thought-out.

The combined use of all three principles results in the building becoming water autonomous. According to Williams (2007), sustainable design efforts differ from standard methods and could improve local energy means, establish alternative green power use or invent new means entirely (Williams, 2007).

In noting that sustainable development acknowledges the future needs, materiality should be 'used with care' (Sassi, 2006). When using materials in large quantities, resourcing impact on the environment should be a priority. It is advocated that the use of renewal materials be applied to design. These are materials that regenerate or are *biodegradable* (Sassi, 2006). In addition, the use of plants also drastically influences the cooling of a building by lowering the ambient temperature. In *strategies for sustainable design* (2006), it is said that the evaporation of plants also cools the environment by reflecting heat into the atmosphere. The combined cooling and shading effects of vegetation are assumed to save up to 50 percent of building air-conditioning costs (Foster 1994).

Green roofs are not a sustainable design principle; however, it contributes to reducing the environmental impact in various ways (Sassi, 2006). It aids in stormwater run-off, provides insulation, and reduces noise pollution. The evaporation caused by the plants also aids in the reduction of smog and dust. For conservation, green roofs are generally used to introduce a natural habitat on-site to sustain wildlife. These roofs are called 'brown roofs' and are typically constructed with existing seeded soil found on site (Sassi, 2006).

In *Building Green: A Guide to Using Plants on Roofs, Walls, and Pavements* (1997), it is stipulated that certain types of plants be used to attract wildlife. (Johnston and Newton, 1997) An example in *Sustainable Ecology, Architecture, and Planning* (2007) used the local, indigenous moss to create a self-maintaining living roof with no expense (Williams, 2007).

The above principles align with the goal of sustainability and contextually appropriate design. They are considered as a universal guiding system for achievable invention. By including these principles, they will enhance the overall livability and comfort of the user while benefiting ecosystems' well-being.

Examples of sustainable design strategies

Figure 6: Pinakarri cohousing community. Source: (Crabtree, Grimstad, McNeill and Perry, 2019)

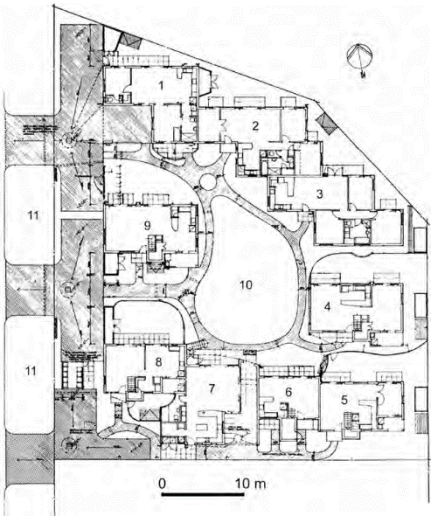

Figure 7: Layout of cohousing community. Source: (Crabtree, Grimstad, McNeill and Perry, 2019)

Pinakarri Cohousing in Western Australia demonstrated sustainable design at its simplest and most effective form. These buildings were intended to be self-reliant on auxiliary heating and cooling methods to provide comfortable living conditions throughout the year. Facing mild climates, the need for insulation is minimal, with only roofs requiring insulation. *According to Sassi (2006)," the building fabric is sufficiently insulated to retain the heat generated through internal and solar heat gains to maintain comfortable internal temperatures."* (Sassi, 2006: 212).

The orientation of each unit had been carefully considered to maximize passive cooling and heating. Larger openings were strategically positioned on the north façade to capitalize on natural lighting and heat gain. In comparison, smaller openings were placed on the south side for spaces that do not require much lighting. In addition, thermally insulated tiles are used for flooring to retain heat. The houses' orientation shows thoughtful consideration of solar impact and displays a review of wind patterns that enable cooling. It revealed that even a slight breeze could be exploited to allow the cooling of a building in more humid climates. (Sassi, 2006).

Figure 8: The Greenwich Sainsbury's store-innovative use of daylighting. Source: (Chamberlain, 2008)

The Greenwich Sainsbury's store in Greenwich peninsula London displays a successful use of daylighting. The entire building is considered one of the leading food stores and serves over 1300 new homes as well as an existing community. Typically, supermarkets are known to rely on artificial lighting; however, the store has been designed with the maximum use of natural lighting. In addition, it had applied various heating and cooling strategies resulting in a reduction of energy by 50 percent (Sassi, 2006). Through the implementation of north-facing high-angled roof lights, the building effectively makes use of natural daylighting. The building is not solely running on daylighting as general lighting can is seen installed in certain areas. However, these lights are energy-efficient lights such as T5 fluorescent tubes, compact

fluorescent light bulbs, and CDM metal halides. The utilization of North lighting provides diffusion lights that do not degrade the merchandise (Sassi, 2006).

Figure 9:Thurgoona campus. Source : (McInerney, 2001).

Figure 10: Sustainable design strategies applied at Thurgoona Campus, Albury-Wodonga. Source: (Australian Architecture Association, 2019).

An exemplary example of water energy efficiency is demonstrated in *Thurgoona Campus,* located in Australia. The building used multiple strategies such as minimal main water usage, rainwater harvesting, and composting toilets to treat black water. Rainwater is further harvested and passed through waterways into the nearby wetlands, where the soil purifies the water. The water is then pumped and stored in a reservoir by using solar-powered pumps and windmills. During dry months water is also released from the wetlands to maintain systems.

4.4 Conclusion

In this chapter, sustainability has been explored philosophically and structurally. The research has investigated various empathetical, ecological, and sustainable principles to ensure that architectural design may be considerate as well as responsive to its environment. It was evident that architecture is most sustainable when it is contextually receptive. Therefore, understanding the natural setting before applying innovative strategies is fundamental to the design of conductive structures.

This secondary data has been relevant to the human-environment relationship, either through associations directly related to design or through experiential factors that raise ecological awareness and contribute to the human-world connection. Information achieved will be pivotal

in generating design philosophies that aim to understand the natural environment and create mutually symbiotic places for all occupants.

The chapter aimed to display an ordered demonstration of a theoretical framework being truthful to the nature of places, experiences, and technology. The literature intends to relate to a broader pattern of underlying structural design strategies that depends on the natural setting. It becomes evident that a primary point of union between theory and practice lies in architectural design. Therefore, the following chapter will critically analyse precedents studies through a theoretical lens to investigate how various design strategies are implemented in architectural schemes globally.

CHAPTER 5: PRECEDENT STUDIES

The precedent studies will critically analyse various architectural built forms relevant to the research topic. All precedents are evaluated through the theoretical framework and chosen for reasons relating to program, context, responsiveness, or sustainable design innovation. The following buildings were selected from a local and global context to understand theoretical applications and design strategies. The precedent studies thereby act as a guide to developing built form that creates narratives of ecological awareness.

5.1 uShaka Marine World

Architects: Urban Edge Architects

Construction date: Completed 2004

Client: The client is a non-government, non-profit company called The South African Association for Marine Biological Research (SAAMBR) and the main headquarters lies within the uShaka marine world.

Figure 11: Aerial view of Ushaka Marine World. Source: (Urban Edge Architects, 2004)

5.1.1 Concept and Locality

uShaka Marine World is a 16-hectare water park located in Durban, KwaZulu-Natal, South Africa, on a land strip between the beachfront and the harbour. The opening of the park on the 30th of April 2004 marked the first phase of Durban Point's redevelopment. The park is seen as an addition to the city's *Disneyfication* process (Bellingan, 2008)

Figure 12: Ushaka Marine World locality map. Source: (Author, 2020)

The marine park was created to serve as entertainment, conservation, and a tourist destination for South Africa. The development integrates both saltwater and freshwater, lush vegetation, natural materials, and indigenous African imagery. uShaka Marine World now serves as an icon that symbolizes the history of a multicultural land.

5.1.2 Justification of the Precedent

This precedent was selected to provide programmatic insight to establish the spaces required to design an ecological conservation centre. The precedent will allow in understanding the research institute and provide knowledge on how to form similar areas.

The facility outlines many compatible activities essential when designing for the proposal for the research and wildlife conservation. Simultaneously, it will help display a phenomenological design approach and criticize many regional design strategies applied to the design.

5.1.3 Facility overview

The facility comprises eight sections, each of which falls into conservation, research, and entertainment categories. These sections are:

- uShaka Sea World
- uShaka Wet 'n Wild
- uShaka Sea Animal Encounters Island
- uShaka Beach
- uShaka Village Walk
- uShaka Kids World
- uShaka Dangerous Creatures
- Chimp & Zee

Figure 13: Ushaka Marine World zoning. Source: (Xinhua, 2017)

uShaka Sea World is the only facility along the KwaZulu-Natal coast that possesses specialized facilities for the care and rehabilitation of stranded marine animals. The focus on animal welfare is holistic, including physical and physiological well-being (Bellingan, 2008). An experienced team works in the specially designed rehabilitation centre where many marine-life are rescued, rehabilitated, and released or re-homed, as prescribed by the relevant government authority. A similar approach will be applied to the proposed typology in St Lucia, dealing with the endemic species within the area.

Sea World, located at the centre of uShaka Marine World, comprises a large saltwater aquarium and various performance stadiums. This facility also offers educational opportunities to the public utilizing tours, interactive activities, classrooms, and research libraries for marine life education. These programs are provided by the Oceanographic Research Institute (ORI).

Critical facilities are required to prepare food for the animals, and regular water testing is crucial for the park to thrive. These are done in high developed laboratories run by a team of specialized technical staff. The healthcare of marine life is of the highest priority and is vitally dependent on new seawater that flows through pipes below the uShaka pier. The water is then pumped from the ocean through a network of sand filters, protein skimmers, and biological filters.

Retail, food, and beverage outlets, located close to the main entrance of uShaka, holds great importance in the marine world as a high source of income. Similarly, uShaka beach is open to the public for windsurfing, beach rugby, jet skiing, etc. The advantage of having this beach location is an immense opportunity for tourism activities, which increase economic development.

A summary of the facilities include:

Entertainment	**Research**	**Conservation**
Restaurants, bars	Aquariums	Laboratories
Retail stores	Dolphin/seal stadiums	Indigenous wildlife
Water theme park	Snorkelling, diving	Water filtration systems
Ushaka beach	Classrooms, Research library	Rehabilitation and release program

Figure 14: Table showing break down of spaces at uShaka Marine World (Author)

5.1.3.1 Spatial Arrangement/ Program

Some of the major spatial requirements in uShaka Marine World may be adapted for the proposed ecological conservation centre in St Lucia. These spaces include:

Laboratories

There are various laboratories within the ORI, such as preparation rooms, microscope laboratories, genetic microbiology laboratories, and wet labs. These are all directly involved with ecological research and are supervised by a laboratory manager (Bellingan, 2008). Rooms such as preparation rooms need to be well ventilated for large amounts of chemical values being stored. However, some of these labs are sub-standard, with issues relating to ventilation and inadequate spaces (Bellingan, 2008).

Research offices and support facilities

The marine park's research building comprises private and open planned offices, computer rooms, Geographic Information Systems (GIS) room, meeting rooms, administrative facilities, and a kitchen for staff (Bellingan, 2008).

Library

The library contains a wide range of journals, slides, maps, and books. One of the library's main issues is that it does not have a multitude of spaces, such as quiet reading areas for individuals or larger social rooms for groups (Bellingan, 2008). There are also issues relating to storage capacity within the library that should have been addressed before construction. The proposed facility in St Lucia will not need an extensive library as it is more focused on technologically advanced methods of learning.

Research Aquarium

One of the essential facilities at the SMMBR is the research aquarium. This area is used to conduct experiments for study purposes. These include long or short-term tests on coral and saltwater. Additionally, sensitive marine life is held in specialized tanks within this facility. Daylighting in these spaces is pivotal for the growth of certain species (Bellingan, 2008).

Education and Conference Centre

"This accumulation of knowledge is futile if the findings are not propagated to as wide an audience as possible" (Bellingan, 2008: 69).

The educational centre is used as a '*living museum'* targeted towards a more experiential involvement. These facilities are targeted towards students and teachers. This area contains classrooms, conference rooms, and an experiential laboratory where children can have a first-hand encounter with smaller marine life. One of the issues with the experiential laboratory is the lack of ventilation. Currently, this space is purely mechanical ventilated.

Staff Facilities

There are offices and board rooms in the educational centre. This is where staff and employees prepare for programs and create educational posters. Additionally, there are meeting rooms for discussion and management purposes.

Rehabilitation Facilities

Most mammals or reptiles in captivity are brought in as rescued and are released once recovered. If these animals are unfit to be reintroduced into the wild, they are kept and cared for by the marine institute or re-homed. These spaces consist of specialized tanks, cages, and rooms catering to both marine and land wildlife. These areas are custom made depending on what type of species are contained.

Rooms for veterinarians, such as operating rooms, storage, recovery, quarantine, and observation rooms, are strategically designed. It is fundamental that these spaces, in particular, are well ventilated, large enough, and receive adequate daylighting for many species to thrive. In uShaka, these spaces tend to be subpar (Bellingan, 2008)

Entertainment Facilities

Apart from the research, conservation, and educational facilities, uShaka boast numerous bars, restaurants, retail stores, exhibits, and recreational activities. However, the proposed typology does not intend to add many recreational activities as its primary focus will be on research and conservation.

The precedent offers excellent insight into the operating of the research institute. From this, it is clear as to what spaces may be required for such a facility to function at an optimal rate. Application of this program to similar typologies is vital, considering they are site responsive and contextually appropriate.

5.1.4 Theoretical underpinning and design considerations

- A phenomenological approach: A unique sense of place

The park's design aims to create an authentic experience for the user, which binds the built form to the context. The play on sensory design elements allows for an eminent relationship between the natural context of the land and its people's multicultural history, creating a unique sense of place.

Figure 15: Village walk at uShaka Marine World (Author)

uShaka Marine World village walk was designed to exemplify a market-like environment, imitating a village's structure. This generates a distinct representation of a modern adaptation of the set context. The arrangements are designed to house various shop frontages placed along with complete 'streetscape' scenes. These structures vary in height and size to allow for a range of diversity in the design, representing a typical village.

Similarly, the aquarium layout shows irregular organic shapes that subtly guide the user's movement through space. The journey is curated to be reminiscent of a walk around a village with various twists and turns. Refer to figure 26

Figure 16: Aquarium layout displaying a village setting. (Author)

Figure 17: Cargo Hold Restaurant at uShaka Marine World. (Author)

Another notable design element and a focal point is a 1920 era cargo steamer shipwreck lodged between the park's rocks and lagoons. This life-sized ship was repurposed to form the aquarium entrance into the water park, creating a unique, enigmatic experience for users. The shipwreck still retains many of its past amenities, such as wooden decking, 1900s electrical fittings, and even a cannon. While holding such antiquity, the ship can stand with elegance while acting as a landmark for contextual history and providing a sense of human endeavor for the users.

Figure 18: Interior of Cargo Hold Restaurant at uShaka Marine World (Author)

The design of the marine world enables users to be immersed in marine life throughout the park. Restaurants are surrounded by large glass aquarium panels to allow users to experience the marine world even while dining.

- *Place* and Materiality

The use of various traditional African artwork around the walls and textured pebbled floors gives users a sense of place and historical significance. The implementation of vegetation, color, and natural materials such as wood and rusted steel, create an intuitive experience to submerge the individual into the South African context.

However, while attempting to label itself as a theme park (Bellingan, 2008) that is authentic to the place, the design and materials are not accurate representations of local architecture. Throughout the scheme, there is a heavy application of typically *African* forms and materials, imitations of natural resources (Bellingan, 2008). Examples include air-conditioned, flat-roofed, concrete enclosures covered by a false thatched roof (Bellingan, 2008). Correspondingly, many wooden columns are merely timber clad steel columns.

Figure 19: Entrance of Ushaka Marine World. Source: (Daga, 2018)

- Sustainability

The research institute's original intention was to provide a *green* building that represented sustainability and conservation research. This has not been the outcome of that aspiration due to design decisions. It can be seen that the research facility, in particular, demonstrates a lack of responsive architecture. An example of this is displayed through the fact that there are no openable windows within the research building (Bellingan, 2008). As a result, the entire facility has to rely upon air-conditioning. From an economically sustainable view, it can be observed that the Marine park could have benefited from using more passive design principles to combat ongoing expenses.

Similarly, there is a lack of empathetic design, which is seen by insufficient habitat spaces. Many reptile enclosures are too confined and could be jeopardizing the growth and safety of species. In accordance, the shortfalls of the animal's enclosures should have been addressed in the conceptual phase to ensure humane and empathetic design.

There is also a minimal effort of social sustainability within the construction of the research facilities. The building does not provide any areas which catered to relaxation and socialization. An attempt at a socialization space can be exhibited through a minuscule staff lounge for elderly volunteers. This lounge was only recently executed and was originally a storage space (Bellingan, 2008). It is crucial to consider social areas when designing research spaces, as there is evidence to support that researching in isolation often leads to poor mental health (Hansen, 2016). Contrarily, there are dozens of areas designated for interaction and socialization throughout the park.

5.1.5 Conclusions

As a programmatic precedent, the facility provides excellent insight into the spatial requirements for a conservation facility. The program at the Marine world display spaces that will be necessary for the proposal at St Lucia.

The park proves to be successful in enabling a positive user experience through a multisensory design, which is enhanced by the consideration of materiality, light, texture, and nature, all of which contribute to the unique sense of place. However, it can be noticed that there is a lack of an authentic connection to place because of the false materiality and facades applied.

The design does not represent a fully sustainable model, but it does display a philosophical sense of sustainability through environmental awareness. The shortcomings of the structure are most evident through the minimal effort put into standard passive design consideration. The use of a truly sustainable model would have given more significant meaning to a facility that symbolizes conservation.

5.2 Siyabonga Tourist Centre

Architects: CNN Architects (Pty) Ltd, Durban

Construction date: completed in 2004

Client: Lubombo SDI / Tourism KZN. All schemes in the area are commissioned by the iSinmangaliso Wetland Park (IWP) Authority and conjointly sponsored by SANRA and KZNTA.

Figure 20: Siyabonga Tourist Centre. Source (KZNIA, 2005).

5.2.1 Concept and Locality

Figure 21: Siyabonga Tourist Centre locality map. Source (Author, 2020)

The Siyabonga tourist centre is located within the Greater St. Lucia Wetland Heritage Park, 225km from Durban. The project was commissioned by the Greater St. Lucia Wetland Park Authority. It was jointly funded as a part of the Government Poverty Relief by the KZNTA and SANRA.

The tourist centre is designed to form a gateway into the park. It is dedicated to the users' experience of the wetlands, cultural and ecological heritage. The development was designed around the local context and attempted to articulate the interrelationship between architecture and nature. The building was created as an organic response to define the personality of the place. It employs simple details that bring awareness of the local materials and the natural world.

5.2.2 Justification of the Precedent

The precedent was selected for its contextual similarity as it is located within the iSimangaliso Wetland Park. It provides a similar basis for designing alongside the local and environmental factors that influence the development. The precedent proves an authentic connection to place, which is evident in its design. Therefore, it is beneficial to examine how architecture has been contextually responsive to express *genius loci*. The development also follows the iSimangaliso Wetland Park authority criteria, which would be the same client as the proposed facility. The Siyabonga Tourist Centre also serves as a landmark for the area; similarly, the proposed typology should act as a catalyst or icon for a new sustainable model.

5.2.3 Facility overview

The facility includes exhibition areas, a restaurant, and a ferry jetty. Additionally, the estuary forms a natural backdrop for the amphitheater, and the Park authorities temporarily occupy a multi-purpose area, which is juxtaposed to the central courtyard. The Siyabonga Informal Craft facility was established along the estuary's edge by the park authorities to benefit the indigenous people who volunteered to be relocated from the Dukuduku forest due to its sensitive ecology.

The informalized ferry node replaces a previously disturbed site located along the main access routes between the St Lucia Village and the community. The development provided an opportunity to rehabilitate the existing landscape and serve as an economic and cultural development catalyst.

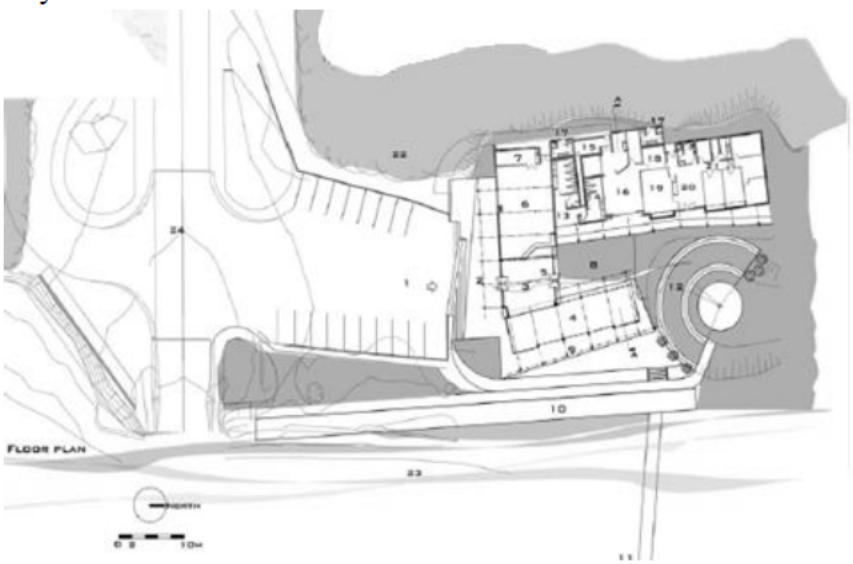

Figure 22: Siyabonga centre floorplan. Source (KZNIA, 2005)

5.2.4 Theoretical underpinning and design considerations

- Phenomenology

The building has multiple ramps, steps, and levels which lead to the entrances. The use of a raised building is a preventative measure against flooding and can be seen to have a phenomenological impact on individuals. These steps and ramps are representative of the structure growing naturally out of the earth. Similarly, the large, planar formed decks surrounding the building are seen as an architectural expression reminiscent of the estuary's tranquil flat plane (KZNIA, 2005).

Figure 23: Image showing raised platform and ramp structures. (Author)

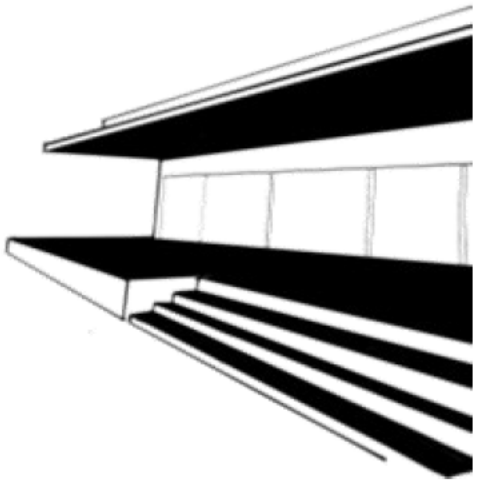

Figure 24: Figure 24: Image showing large, planar formed decks. (Author)

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- Place and Materiality

The building is meant to represent the cultural and ecological heritage of the iSimangaliso. The architecture itself responds in a regionalist approach by implementing various design principles centered around the theory of place. The spirit of place is captured through the form and materiality of the built structure. Thus, the development acts as a narrative that interprets the environment's colours, cultures, texture, and materiality (KZNIA, 2005).

The building is made of concrete, aluminum roof structures, bamboo, and large timber. The excessive use of wood is displayed vigorously throughout the design. Wooden elements can be seen on both the exterior and interiors in forms such as cladding, ceilings, window frames, and shading devices. The bamboo frames and wooden structures are intended to be in unity with indigenous people's typical wooden dwellings common to areas such as Duku and Khula village. Additionally, expansive timber decks are parallel to the estuary and attach to a pier

running into the river. These structures seem to form part of the landscape and are directly responsive to the spirit of place with their given materiality. The timber used for construction is locally sourced from the resident mill, which provides large quantities of saligna timbers. The use and reuse of local materials also align with a critical regionalist approach and a sustainable design strategy.

Figure 25: Image showing the extensive use of wood around the building. Source (Choromanski, n.d.)

Lastly, the place stands as a cultural hub that preserves the traditions of the people and place. The merger of culture and architecture is displayed through the use of interactive mural walls. Liquid stone pots create a visual screen while maintaining the character of the place. These walls are more than merely decorative as it aims to engage and enhance the connection between the built form and the individual. The use of merging culture within architecture thereby assists in the overall user experience through tactile interplay.

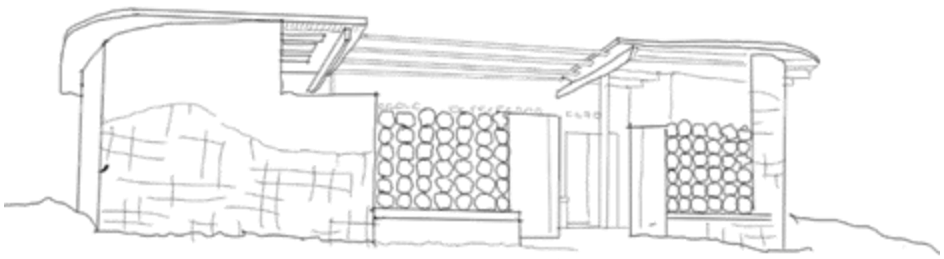

Figure 26: Sandstone pots forming a mural wall and screen (Author)

- Sustainability

Considerations towards environmental sustainability through technical advancement were not paramount, but a substantial effort has been made regarding passive cooling strategies and local materials.

There are large overhangs used to filter the harsh African sunlight. These overhangs were constructed by aluminum roof planes and a framed timber structure that projects beyond the structure's walls to protect from the coastal elements.

The roofs are tilted toward the estuary and contain clerestory windows, allowing adequate amounts of daylight to enter the building. These openings also contribute to airflow moving through the building and simultaneously allow heat within the structure to escape.

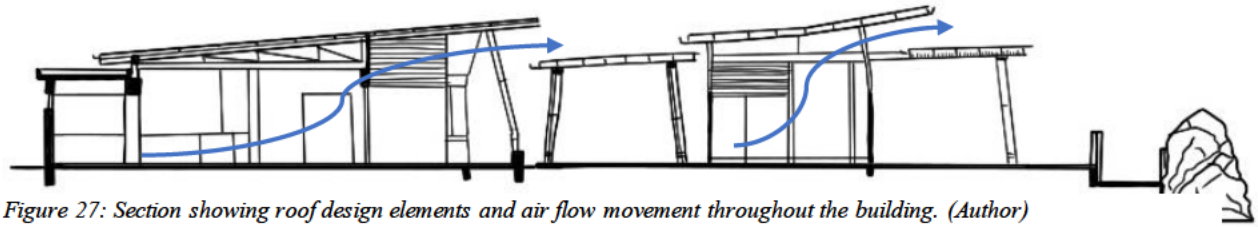

Figure 27: Section showing roof design elements and air flow movement throughout the building. (Author)

The comprehensive implementation of glass windows and doors solves issues of daylighting and natural ventilation and creates a connection to the natural environment. This design strategy, in turn, reduces expenses related to air-conditioning, mechanical ventilation, and artificial lighting

The building, in general, is designed in a U-shape and is linear in width. The use of linear structures is an excellent passive design method as it allows for adequate daylighting and ventilation to enter. It is also noted that the building is consistently only a single story to ensure the mangroves skyline is preserved by the highest point of the roof sitting below it (KZNIA, 2005)

This linear scale of the architecture is continued through the timber decks and canopies surrounding it. It is strategically designed to allow dining and viewing decks that have panoramic views of the estuary. This construction technique similarly provides maximum frontage for foot traffic around craft areas.

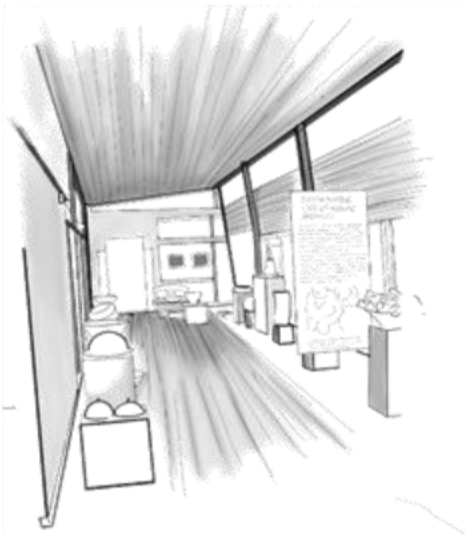

Figure 28: Image displaying how clerestory windows facilitate light into the interior of the building. (Author)

The central courtyard utilizes these rectilinear volumes to articulate spatial volumes and allow the natural landscape through the development centre. Courtyards are also listed as a standard passive design principle that allows for maximum cooling and ventilation within a structure.

Considerations towards socio-economic sustainability were made through the inclusions of the locals in all phases of development. Community members were trained in construction, operational involvement, crafts development, and sales. Local contractors were also employed during the construction and development phases. The place currently represents the diverse and cultural background of St Lucia and can be seen as a hub for tourists, local traders, and environmentalists alike.

Figure 29: Craft market area (Author)

5.2.5 Conclusions

Although the simple rectilinear form does little to blend with the context, the structure acts sensitively by not dominating the area and ensuring the preservation of the mangrove's natural skyline.

The facility makes special consideration with materiality to conserve the sense of place and, similarly, relate to the dwellings within this setting. There is also a strong sense of place created by using local culture (sandstone pots) in the building façade. These principles all help in creating an authentic connection between the user, building, and environment.

Many passive design strategies have been implemented that have aided in social, economic, and environmental sustainability. However, it could be beneficial to investigate more technological enhancements to ensure the building is more empathic to both users and the environment.

The overall design bears merit to consider in terms of contextual application and passive sustainable design. The proposed ecological conservation facility will also be a landmark for the area and thus needs to be built from the foundations set by this precedent.

5.3 El Humedal (The Wetland): Science Centre

Architects: TAAR / Taller de Arquitectura de Alto Rendimiento

Construction date: 2014

Client: Private Facility

Figure 30: El Humedal. Source (Gamo, 2013)

5.3.1 Concept and Locality

The facility was designed in Valle de Bravo, Mexico, by Taller de Arquitectura de Alto Rendimiento (TAAR). El Humedal, also known as The Wetlands, is an architectural design built on zero waste and net-zero energy consumption principles. Net-zero energy consumption means that the structure generates all resources needed to operate internally (El Humedal / TAAR / Taller de Arquitectura de Alto Rendimiento, 2018)

Figure 31: Locality of El Humedal. (Author, 2020)

According to TAAR, the project is a way for architecture to redefine the association between humans and the natural environment so that the relationship becomes mutually symbiotic in all facets (Block, 2018).

5.3.2 Justification of the Precedent

The precedent displays innovative and sustainable architectural design while authentically representing the place. The facility's architecture responds sensitively to the site. Consideration of local cultures is evident through design. Like the design of the proposed facility in St Lucia, the precedent demonstrates technological advancements that help orchestrate symbiotic environments for humans and ecosystems. Design principles gathered from this precedent will be crucial for generating sustainable structures.

5.3.3 Facility overview

The development is a private botany research facility. The primary objective of the centre is to develop natural products that are sustainably acquired from the forest. The centre researches, documents, and analyses all surrounding forests' characteristics to obtain information about the benefits of local ecosystems and resources.

The scheme consists of the leading research complex, surrounded by edible forests, organic orchards, and constructed wetland systems that vary into several ponds. Apart from the laboratories, the main building has seed cellars used for storing specimens, wine cellars, adaptable workshop spaces, offices, and bathrooms (Dezeen).

An adjacent building towards the South of the site encompasses a greenhouse and maintenance warehouse. The water treatment plants, along with parking, are both located underground. (Dezeen).

5.3.4 Theoretical underpinning and design considerations

El Humedal was selected as a precedent for its immaculate display of sustainable technological innovation. While phenomenology and place theory is evident in the facility's design, the focus will primarily be on sustainable development.

- Phenomenology

The site sits in a lush, biodiverse context. To align with the natural setting, the architecture of the research facility merges with its surrounding environment.

Figure 32: Open corridors enabling as social spaces. Source (Gamo, 2013).

Vast open corridors act as social spaces that encourage a direct connection with the natural environment. According to TAAR co-founder Carlos Ruiz, porches serve as a unifying element between rooms that 'force' people to generate a bond with the exterior space (Block, 2018).

Similarly, large windows in laboratories and workspaces open the interior room to the external environment. This creates an immersive design experience that enables the user to exist within nature.

Figure 33: Large windows in research spaces to promote productivity. Source (Gamo,

The use of natural raw materials significantly influences the phenomenological experience of the design. Local materials for finishes and fixtures, such as timber and stone, are applied to create a sensory journey. The use of local materials with exposed tectonics demonstrates a built form that is authentically bound to its place.

- Place and Materiality

The facility is a reflection of a place-based design that considers local cultures. The architects of the research centre had stated that the inspiration for the design had come from the Mazahuas people's architecture, who is a pre-Hispanic culture living in Valle de Bravo.

Figure 34: Fixtures and textures imitating natural elements. Source (Gamo, 2013).

The use of two fundamental principles from the Mazahuas people has been employed for El Humedal. These include wooden pitched roofs for rainwater harvesting, stone walls, and soil bricks to produce thermal mass (El Humedal / TAAR / Taller de Arquitectura de Alto Rendimiento, 2018). However, more contemporary elements drawn from local architecture such as colonial-era patio houses and Mexican plazas were applied for the research units' layout.

Figure 35: Wooden roofs adapted from the Mazahuas people. Source (Gamo, 2013).

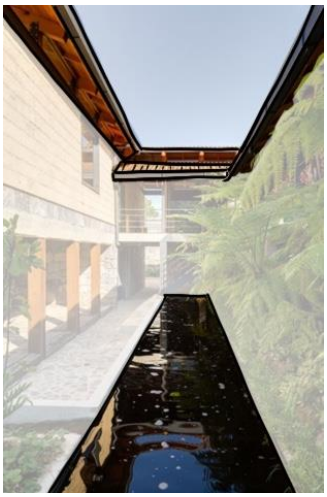

Figure 36: Roof water harvesting and collection pit. Source (Gamo, 2013).36

Figure 37: Local materiality displayed through architecture. Source (Gamo, 2013).

The use of responsive architecture can be seen through the stilts and steel beam constructions over the wetland pools and natural land. Many materials are raw, local, or recycled, thus harmless to the environment (El Humedal / TAAR / Taller de Arquitectura de Alto Rendimiento, 2018). Examples of recycled materials are the indoor and outdoor decking, made using plastic fashioned from 100 percent recycled materials.

Figure 38: Stilt foundation to avoid flooding. Source (Gamo, 2013).

Local materials such as oak wood and pine were used for the structure's mainframes and roofs. Similarly, bricks used for walls were made from local volcanic soil, while volcanic rock and terrazzo were used to create flooring and work surfaces.

- Sustainability

According to the TAAR, the project is a development that is conscious of the consumed and produced resources. El Humedal was conceived under the no-waste and net-zero principles, which means the structure makes 100% of the resources it needs to operate. Similarly, stemming from the no waste concept, the project intends to generate valuable resources from waste products.

"*The common waste conception is flawed because it's perceived as something that we don't want; the challenge was to think of it as a valuable resource. All of this implies a new way of living, understanding our evolutionary potential with nature."* (Block, 2018: para.10)

5.3.4.1 Sustainable strategies:

The projects use of innovation and sustainable design is displayed through the following features:

- Recycled & Salvaged Materials: The use of recycled materials further aids the zero-waste concept. Materials are locally sourced or obtained directly from the site. This reduces costs and minimizes impact on people or the environment.

- Bioclimatic Design: Passive design strategies are utilized for cooling and natural daylighting. These design principles, in turn, lower energy reliance and thereby cost efficiency. The utilization of local materials further maximizes the heating and cooling effects of the built form to ensure thermal comfort during hot and cold months.

- Sewage Water Treatment and Compost Toilets: Blackwater and sewerage are transported through biologically powered treatment plants that simultaneously generate compost from a combination of human feces and pruning's from the forest.

- Rainwater Harvesting: There is a total of 130,000 liters of rainwater harvested for internal use within the building. The water is treated, stored, or used for irrigation purposes.

- Photovoltaic Panels: The use of photovoltaic panels generates all the electricity needed for the building to operate. This strategy removes dependence on non-renewable sources of energy, protecting the environment but also securing economic sustainability. The building also makes use of LED lighting, the more environmentally sensitive alternative, where necessary.

- Thermosolar Water Heating: Thermos-solar panels are installed to generate additional energy to warm water as required. There are also smart low consumption showers within the research facility to minimize water usage.

- Constructed Wetlands: The structure is built on and around the constructed wetland. These wetlands are used as water purification systems. Simultaneously, these constructed wetlands or aqua gardens help create habitats for surrounding wildlife. The wetlands also help with passive cooling through evaporative cooling techniques.

- Permaculture & Edible Forest Landscape: El Humedal features an edible forest and an organic orchard, which is used for research purposes as well as to form natural habitats. The plants within these gardens also provide sufficient shading and cooling for users.

Figure 39: sustainable design principles applied to El Humedal. Source (Author)

5.3.5 Conclusions

The analysis of El Humedal displayed the execution of innovative design principles in built structures. Many of the design strategies used for creating this no-waste and the net-zero system will be implemented to the proposed design in St Lucia to ensure sustainability. These principles are vital in ensuring that architecture is empathic, symbiotic, and ultimately sustainable. El Humedal provides an innovative modernized view of sustainable design. It boasts a successful, functional, and aesthetic design that actively defies generalized associations regarding the inherent primitive qualities often feared around regionalist design.

5.4 Conclusion to precedent studies

The precedents were strategically selected to provide a comparison to local, national, and international facilities. Each precedent was analysed for its phenomenological approach to design, its response to place, and its use of sustainable principles.

Through this evaluation, it was clear to find both advances and setbacks within the schemes. By comparing the various facilities against the same critical factors, it becomes apparent that international facilities' standards are bounds ahead of many of the South African facilities. Many design principles were noted and will be employed in the proposed conservation center in St Lucia.

Conversely, the precedent studies have highlighted many gaps missing between theoretical framework and architectural built form. These gaps will be translated into opportunities as it identifies areas for improvement for the proposed facility's enhanced design.

CHAPTER 6: A DESKTOP STUDY OF ISIMANGALISO WETLAND PARK / ST. LUCIA

Figure 40: iSimangaliso Wetland Park. Source (Marty, 2017).

6.1. Introduction

Through various literature and precedent studies, it can be observed that ecologically responsive architecture is most successful when the place and people within the environment are recognized. To adequately address the primary research question of *how natural ecosystems can influence responsive built form*, the desktop study will investigate Isimangaliso wetland park's specific setting.

The Isimangaliso wetland park area is analysed through a theoretical lens to identify the spirit of place and, thereafter, provide a responsive resolution to the research problem. This desktop study is pivotal since no two sites are the same, and different communities have varying relations with the natural environment (Dahl, 2016).

In order to understand how Isimangaliso had developed into an ecologically receptive community, historical, social, and cultural aspects of the area were recollected. This information becomes crucial to understand the various characteristics of the region. The desktop study examined the immediate context and surrounding rural areas to grasp the place's essence.

It becomes clear that the natural environment of Isimangaliso has influenced the materiality of the built form of the area, leading to a unique sense of place. The researcher will examine materials and construction methods through a critical regionalist approach to determine how

the local architecture captures the environment's character. Through a phenomenological perspective, local cultures and building methods are evaluated to inform a sensitive and holistically responsive design. Lastly, the investigation will explore areas of sustainable development to gauge possible gaps for future growth.

The vast natural ecosystems of iSimangaliso are fundamental to the socio-economic development of the area. Therefore, the topography, fauna, and flora of the context were evaluated to ensure that architecture may respond appropriately. In this situation, it is essential to understand how nature has positively impacted the lives of surrounding communities.

"*There are few places on this planet that inspire and encourage sustainability in the way that iSimangaliso does*." (iSimangaliso Wetland Park, 2017: para. 9)

6.1.1 Limitations of the study

A desktop methodology of data collection was employed to obtain contextual data. Due to the Covid-19 pandemic, it was not possible to visit the area of iSimangaliso wetland park to get first-hand insight. The study collected all information and imagery from online sources, such as journals, articles, photographs, videos, and satellite imagery.

The most significant limitation was the inability to visit the site and collect first-hand data. For this reason, it was not possible to gain an intimate understanding of the environment. Certain aspects, such as investigating various terrain and people-place interactions, were challenging but not unobtainable. Information on the area was available through online sources. Research of the region had also allowed for insight into how people used the natural environment to improve their quality of life.

The inability to access the location prohibited interviews questioning how local people felt about conservation and the built form. Lack of primary information has been compensated for with facts collected from online databases. Similarly, these sources made it possible to see the challenges surrounding communities currently face. Online material had allowed insight into how people use the land to deal with social and economic problems.

Vital information for developing an ecological conservation facility was achieved through the analysis, regardless of its challenges. All information sources have been acknowledged and referenced.

6.1.2 Location of iSimangaliso Wetland Park

The iSimangaliso Wetland Park (IWP) or formerly known as Greater St Lucia World Heritage Park in KwaZulu-Natal, South Africa, is a state-led development plan for conservation (IWPA 2008: 3) as well as a UNESCO World Heritage Site (Hansen, 2014)

The area is located on the North East Coast and stretches adjacently along with Kwa-Zulu Natal's inland areas. iSimangaliso now consists of sixteen previously independent parcels of land into one protected area, covering an approximately 324,441-hectare area (IWPA, 2017: 5). The park runs three nautical miles into the sea and stretches between 1 and 55km inland, encompassing the Lubombo Mountains and finally narrowing out towards the north and south (IWPA, 2017).

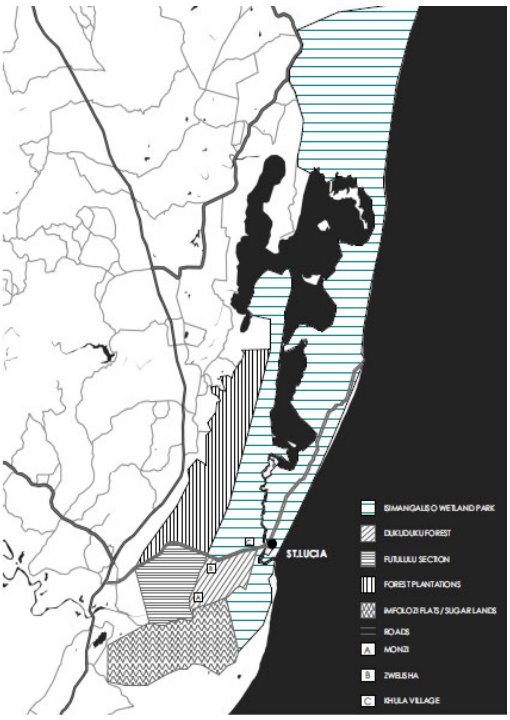

Figure 41: iSimangaliso zoning map. (Author)

The park itself includes diverse endemic species of flora and fauna amid varying landscapes. The IWP aims to be a new model for protected area development and conservation management (IWPA, 2017). According to Hansen, the IWP strives to convey that natural environments can provide a synergy between conservation and sustainable development' (Hansen, 2014)

While the park is listed as a heritage site based on its natural resources, the world heritage convention act enforces that all cultural and historical value be preserved, supported, and promoted. (IWPA, 2017). The park is representative of a post-apartheid protected area in Kwa-Zulu natal. Therefore, iSimangaliso equally intends to benefit socio-economic development (IWPA, 2017).

6.1.3 Accessibility and formation

The IWP is accessed through various transport networks. The nearest airport locations are the international airport of King Shaka in Durban, and the closest regional airport being the Richards bay airport. There are many tourist travel options from either of these hub locations, with accessible transport services available at request.

The park's gates are accessible through two major tarred roads – the N2 and the R22 mainly. Travelers will pass many significant towns, such as Mtunzini and Kwambonambi, which will lead to the southernmost Park entrance, located in Maphelane. Taking the N2 turnoff at Mtubatuba will lead to the main town of St Lucia and nearby tourism destinations.

Other than the main roads, which are the R22 and the N2, the region's infrastructure is poorly developed. This underdevelopment limits access to specific zones and towns. Rail and air-flight use is restricted within the park boundaries due to limited access and services provided (IWPA, 2017).

To conserve the integrity of the wetland park, There are restrictions implemented regarding certain activities that may occur listed under a three-part zoning strategy:

- A low-intensity zone – allowing for foot entry only.
- A moderate-use zone – for vehicle entry and usage of campsites.
- A high-intensity zone – includes roads, educational facilities, guided walks, and accommodation.

A total average of two million tourists visits the iSimangaliso Wetland Park annually through any of the ten main park gates. The public can enter as day visitors or as overnight guests using the various accommodation or camping facilities. The town of St Lucia poses as one of the leading accommodation attractions for most guests.

6.1.4 Towns and services

Most of the parks' built area consists of dispersed rural houses. This results in the distribution of electricity and water services problematic.

Many houses in rural townships do not have electrical and sewer connections; however, recent measures have been used to ensure that clinical facilities in these areas receive electrical

energy. The few and fortunate nearby settlements are provided electrical through Eskom. The need for electricity is still considered imperative as many districts rely on gas, wood, candles, and paraffin (IWPA, 2017).

The water supply is also believed insufficient, and there is concern over the incapacity of water supply to handle future demands (IMP, 2017). Many communities currently obtain water from shared standpipes. With the minimal piped water in the contextual area, the lack of proper sewerage systems also becomes a critical issue.

There is an observable change between access to these essential services between the rural and more developed areas in iSimangaliso, with most intervention or infrastructure being towards the park's south sectors.

There lies a critical need for development in rural towns with excessive poverty levels, high numbers of neglected orphaned children, lack of essential services, lack of sanitation, lack of infrastructure, and increased HIV/AIDS rates (Hansen, 2014). All of these factors greatly influence the progress and vulnerability of communities.

6.1.5 Topographical analysis

The park exemplifies a merger of landscapes containing biological systems that function without external interference. There is a spectrum of landscape diversity ranging from rocky terrain comprising woodlands, grasslands, and forested areas to wetland and freshwater ecosystems, encompassing swamps, salt marsh, mangroves, swamp forests, and riparian forest habitats (IWPA, 2017).

iSimangaliso can be made up of these five central biological systems (Bellingan, 2008). These systems are:

The Eastern Shores: This comprises dunes and forests along the coastal regions of the reserve. These form diverse biomes networks that act as a barrier between the St Lucia Lake and the Indian ocean. The dunes formed due to 'coast-parallel prevailing winds' and have become a prominent feature of the landscape (Ramsar, 1998: 11).

The Estuarine System: This is composed of the Lake St Lucia, which is the most extensive, most complex system in the world (Bellingan, 2008). It spans 85km long and hosts habitats to a wide range of hippopotamus, reptilian, bird, and crocodile species (IWPA, 2017). This area is made up of sedimentary rocks that contain rich fossil remains (Bellingan, 2008).

The Swamp System: The Mkuze swamps form on the northern end of the lake and consists of immense reedbeds and waterlilies. Its extent also reaches the Mfabeni swamp forest. Similarly, to the south of the park lies the Mfolozi swamps. These swamps had originated by sedimentation of the upper reaches of a flooded valley of a lagoon (Ramsar, 1998)

The Western Shores: These are the driest areas of the ecosystems (Bellingan, 2008). They are made up of vast savannahs and dry, sandy thornveld areas (IWPA, 2017). The western shores have geology made up of Cretaceous rocks, which are superimposed by the sedimentary rock in the form of relict beach-dune ridges covered by dune sands (Ramsar, 1998).

The Marine System: The final ecosystem is the marine areas along the Indian ocean's coastline. These areas are comprised of beaches and coral reefs along the sea (Bellingan, 2008).

Each system has its diverse species of flora and fauna. Therefore, it is pivotal to fully understand the location's ecosystems to comprehend the context and generate an empathetic design.

Water Bodies and Systems

The main types of water systems within the area are estuarine lakes and freshwater lakes. The estuarine is made up of lake St Lucia while freshwater lakes are north and south of Bhangazi.

Lake St Lucia is considered the most extensive lake system in the African continent. It spans depths of 1 meter deep and is calculated to be 36826 ha (Ramsar, 1998). The lake's water is said to be high in saline content, and only certain areas of the estuarine are fed by freshwater inputs (Ramsar, 1998).

The freshwater lakes are located in depressions closer to the shoreline of Bhangazi. Water for these lakes is received from limited catchment sources and replenished by groundwater supplies. According to Ramsar (1998), these water sources are deficient in nutrients because of their substrate's sandy leached nature (IWPA, 2017). Therefore, development in these areas is restricted.

6.1.6 Climate

The park typically experiences a subtropical climate with hot, humid summers and dry, moderate winters (Bellingan, 2008). Most rainfall occurs within the summer months, with the annual average precipitation for the area being 1200mm (Bellingan, 2008). It is also noted that there is significant flooding that results from additional rainfall caused by tropical cyclones. The winds are generally parallel to the coast, moving from north-east or south-west (Ramsar, 1998)

6.1.7 Ecosystems

There are fifteen interlinked ecosystems within iSimangaliso, which provide vital habitats for large amounts of endemic species. It is quite a rare occurrence to find each distinct ecosystems in a particular area within South Africa. These ecosystems are grouped into three general biomes, categorized as terrestrial, marine, and aquatic. The figure helps display the breakdown of each of these ecosystems within their respective biomes.

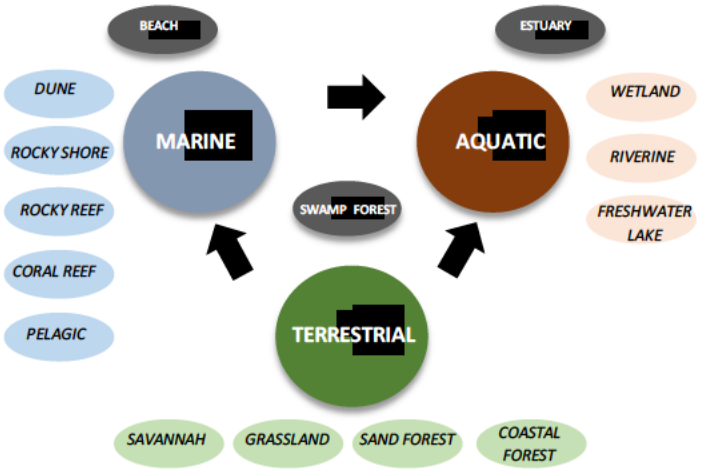

Figure 42: Types of ecosystems in iSimangaliso. (Author)

The world heritage site encompasses the St Lucia estuary system, surrounding swamps, woodlands, grasslands and dune forests, beaches, offshore marine environments, and coral reefs.

These offer essential habitats for diverse species from Africa's seas, wetlands, and savannas. Some endemic fauna includes large populations of nesting turtles, aggregations of flamingos,

hippopotamus, and crocodiles. The St Lucia system supports over 350 bird species and is the most critical breeding area for waterbirds in South Africa, with at least 48 breeding species recorded.

- 6.1.8.1 Flora

The area boasts 2180 recorded plant species, 46 endemics, and six recorded mangrove species. The mangroves function as part of an ecosystem, forming habitats for animals who depend on them to complete their life cycles. However, the interaction of significant floods and coastal storms in these environments fuels a process of continuing ecological change (Dimensions, 2020).

A few of the indigenous trees include:

- Dune sweet thorn
- Coast red Milkwood
- White Milkwood
- Cape Ash
- Bush Tick-Berry
- Buffalo thorn
- Coast Strelitzia
- Thorny rope Flat Bean

- 6.1.8.2 fauna

Of the terrestrial fauna that occurs in southern Africa, iSimangaliso has;

- 22% of the Insectivora (insects)
- 32% of the Chiroptera (bats)
- 51% of the Carnivora (flesh-eating mammals)
- 53% of the Artiodactyla (animals with hooves)
- 21% of the Rodentia (rats, mice, porcupines, and other rodents).

iSimangaliso is renowned as the wealthiest mammalian conservation area boasting 115 mammal species (iSimangaliso Wetland Park, 2020). Some of the wildlife includes Genet, Porcupine, Leopard, Lion, Spotted Hyena, Brown Hyena, Wild Dog, Giraffe, Buffalo, Warthog, Wild Bush Pig, white and black Rhinoceros, and Zebra. The humpback whale is the largest mammal found in the area.

In addition, there are 53 recorded species of snakes. Lake St Lucia has no less than 1 200 Nile crocodiles, conceivably the largest South African population. The crocodiles are vital predators within aquatic systems in the park, and human safety should be indispensable to the design of built form along the water's edge.

Lastly, at least 129 species of coral, with more than 80 percent of South Africa's fish species found within the coral gardens and reefs in the protected area. These reefs create an optimal breeding ground for several marine species.

- 6.1.8.3 Endemic species

There are approximately 467 species of wildlife that are at serious peril of extinction. Additionally, 11 endemic species reside within the area, and 108 endemic species native to South Africa are found in iSimangaliso. Thus, it is evident that the park is home to many diverse ecosystems that provide habitats for numerous endemic or threatened species.

Lake St Lucia and its associated wetlands form one of the essential refuges on the Southern African sub-continent for many migratory waterfowl and wetland birds. (iSimangaliso Wetland Park, 2020). It is one of the principal avifaunal breeding areas in South Africa, as 339 birds are known to be breeding in the park. The region also contains four South African endemic bird species (iSimangaliso Wetland Park, 2020).

6.2 People and place: Identifying the spirit of St Lucia

6.2.1 History and Context

The iSimangaliso was previously known as Saint Lucia. The area was populated by an extensive number of wildlife such as hippos and elephants. The land was inhabited by the Nguni tribe centuries ago (Khuzwayo and Vorwerk 2006). It is believed that these communities were the ones that had created an authentic connection with the spirit of place (Bellingan, 2008). Historically, the land is said to have not been significantly occupied by large settlements or had any man-induced land disruptions, even though it had been used frequently by people (Bellingan, 2008).

Things had started to shift with the forced removals and evictions of indigenous people, the extensive hunting of endemic species, and the site becoming a missile launching area. The natural environment or *wilderness* was regarded as places to gather resources or treated as poaching areas for sport. With game numbers dwindling, parts of St Lucia had been classified as a Game reserve in 1895 (Perissinotto, Stretch & Taylor, 2013).

The park was later aided by the government, allowing it to be recognized as a significant protected area and named the Greater St Lucia Wetland Park in 1999. It had been documented as South Africa's first heritage site. In 2000 regulations published in the Government Gazette No. 2177 had stated that the individual protected areas be merged into a solitary proclamation of 325 000 ha land that ranges 230km southwards from the Mozambican border (Dimensions, 2020).

In 2007, the conjoined conservation areas were officially renamed as iSimangaliso Wetland Park, which means *Secret* or *Miracle* in isiZulu (Bellingan, 2008).

6.2.2 Social injustices in St Lucia

With forced removals incapacitating indigenous communities for years, local people could not claim their land resources (Skelcher, 2003). Land claims from the people who were forcibly removed during apartheid had been a difficult task for the new managing authority. However, an agreement was made stating areas would be conserved and claimants compensated (Dimensions, 2020).

The iSimangaliso Park falls under the boundaries of the uMkhanyakude District Municipality. According to the iSimangaliso wetland park authority (IWPA), the uMkhanyakude region and surrounding areas host some of the most poverty-stricken communities in South Africa (IWPA 2008). In the iSimangaliso management plan (IMP), it is said that 80% of the people in the and around the park are well under the poverty line (IWPA, 2017).

A community survey conducted in 2012 by the uMkhanyakude District Municipality stated that the district encompasses approximately 114,973 households (Hansen, 2014). There are six small towns in the park boundary (uMkhanyakude District Municipality, 2011/2012), and the area accounts for high cases of underdevelopment, HIV/AIDS, and lack of employment. The

communities in this region rely heavily on their natural resources for their daily living and revenue (uMkhanyakude District Municipality, 2011/2012).

According to Hansen (2014), the Juncus Krausii plant is a staple utilized in local communities. This plant is also known as 'ncema reeds,' to construct mats and traditional vernacular structures. The reed is employed for daily usage and sold to gain an income (Goge, 2020). Therefore, the use of this reed contributes to sustaining the lives of the local communities and contributes to the region's development.

Figure 43: Juncus Krausii plant. Source (South African National Biodiversity Institute, 2006)

Figure 44: Juncus Krausii plant cultivation in rural communities. Source (South African National Biodiversity Institute, 2006)

Similarly, the Marula tree (Sclerocarya birrea) and ilala palm (Hyphaene coriacea) are considered valuable and protected plant species (Hansen, 2014). These plants are used to produce alcohol and "ubuganu," a term for beer. According to the IWPA (2019), the Marula tree is widespread and is a preferred species to plant when undertaking greening efforts. There is a celebratory day of the Marula plant called the Umyathi Marula festival. This cultural commemoration involves local people making traditional beer, dancing, and singing.

Figure 45: ilala palm plant species. Source (South African National Biodiversity Institute, 2004)

Figure 46: (Sclerocarya birrea) Marula palm species. Source (South African National Biodiversity Institute, 2004)

Figure 47: Marula festival in iSimangaliso Wetland Park. Source (iSimangaliso Wetland Park, 2019)

Similarly, fishing in coastal areas and land cultivation for cattle grazing play a significant role in the region's socio-economic development. Many communities rely upon these resources to fund their necessities. However, there are concerns raised by the IWP, which focuses on the pressures on extensive resource usage within the park. The claims stated that the parks' resources are depleting near communal areas (IWPA 2008).

The IWPs intention of accepting a view of *intergenerational equity* means that conservation and equity ideas may vary based on the people's normative perspective. Where to one person, the intergenerational equity is reached through conservation for future wellbeing, and to another, it is achieved through the improvement of current conditions of living (Sen 2009). Hansen (2014) states that "*the World Heritage Convention Act and the IWPA adopt the goal of recognizing intergenerational equity with a level of priority that is not the same for municipalities or tribal authorities*" (Hansen, 2014:59).

Hence, the decisions and actions undertaken for the IWP are greatly influenced by the people's normative perspective. Thus, different communities and groups are identified, and each may have its unique limitations or benefits of resource access.

The IWP can be seen to include the local people through various strategies. Environmental conservationists run the park's protection, and local people are considered the constituents or beneficiaries of the land (Hansen, 2014). Nonetheless, in this setting, socio-economic development is restricted to a '*model based on ecotourism.'* (Hansen, 2014: 49)

6.2.3 Methods of construction and materiality in the settlements

A range of architecture is displayed throughout iSimangaliso, from more traditional construction methods in undeveloped areas and rural townships differing to the more modern developments near the town of St Lucia.

Rural settlements situated along the park, such as Khula Village, Mtubatuba, and KwaNibela, are highly underdeveloped. Many people in these communities are unemployed. As with most informal settlements, homes and structures are usually self-built using vernacular construction techniques that utilize locally sourced materials.

Some examples of vernacular architecture include using stick and mud structures for housing. The sticks are tied together using reeds from which are abundant near rivers. These materials are then packed with mud and left to dry. These types of constructions are currently found in towns such as Mtubatuba and Khula village.

Figure 48: Photograph of a house made of sticks, reeds and mud in the Mtubatuba village. (Kitamu, 2018).

Although many of the populations' developments have a lot to do with economics, traditional building techniques can be seen as notably evolving. Many structures have combined modern construction methods, creating a hybrid model mixed with vernacular architecture. Concrete block structures mixed with mud and stick buildings have become a well-known find in multiple rural settlements in iSimangaliso. The concrete is locally constructed by combining sand and water from the nearby rivers (Dahl, 2016). Subsequently, these houses are erected using mud as a binding material.

Figure 49: A photograph in the nearing town of Khula village displaying a hut made from concrete blocks, as well as an adjacent hut made from seamless thatch. Source (Martins, 2014).

Figure 50: A photograph in the Mtubatuba district demonstrating a hybrid hut model constructed from clay bricks and thatch material. Source (Kitamu, 2018).

Figure 51: A photograph in the nearing town of Khula village displaying a hybrid model with a mixture of a mud and reed construction attached to a concrete block structure. Source (Mapio, 2018).

Thatch is widely used in these rural communities and within the central town of St Lucia. Accordingly, many housing constructions built in the Mtubatuba area are constructed with thatch roofs. Some thatched roofs are seen as emerging from the ground to blend architecture with the landscape seamlessly. The thatch is sourced locally and is a traditional construction method. These local materials can be seen as an act of binding architecture to place.

Figure 52: Photograph depicting hut made of seamless thatch construction to blend with the ground. Source (Kitamu, 2018).

Figure 53: Image showing the materials of grass and plants that are used extensively throughout the Mtubatuba area. Source (Kitamu, 2018).

Figure 54: Process of thatch roof construction. The grass is harvested and dried in the sun before being put into bundles to construct roofs. Source (Author).

Figure 55: Image displaying the use of steel in the nearby area of Mtubatuba. The steel is gathered and reused from neighbouring areas. (KITAMU, 2018)

It is evident that traditional circular designed housing remained popular, even though its materiality had evolved from reeds and sticks to concrete and brick. This display of innovative design had allowed for a step towards a more durable built environment. The more modern construction attempts included hybrid models involving circular forms and corrugated steel roofs, usually reused from surrounding areas.

Even modern structures such as the Siyabonga craft centre and similar tourist facilities still retain some fundamental aspects of place with their choice of materiality. This architecture approach shows that the establishments, communities, and individual members are well habituated with traditional materiality,

construction, and genius loci. Therefore, it is vital to celebrate vernacular architecture techniques to preserve local traditions, the spirit of place, and empower local laborers.

6.2.4 Cultural heritage

There is a long history of cultural significance that is intertwined into the fabric of iSimangaliso. According to Hansen (2016), the forced removals' events are still fresh in the people's living memory, and therefore specific sites have cultural significance and meaning to land claimants. The region now memorializes the land claimant's loss of properties, preserves remnants of two world wars (flying boat base camp), and contains an active military site.

Apart from its colonial influences, there is evidence of land habitation that dates back to the stone ages. There are numerous artefacts, palaeontology sites, and historical landmarks scattered throughout the topography. According to the iSimangaliso Management Plan (2017), '*the land encompasses historical buildings and jetties, graves, fish traps, shipwrecks, landscapes, natural features, and more intangible resources such as places, oral traditions, and rituals*' (IWPA, 2017: 1).

Similarly, there are significant cultural events tied to the history of the Thonga people. The Thonga are among the early tribes that inhabited iSimangaliso and the surrounding areas (iSimangaliso Wetland Park, 2020). Some of these cultural events include the earliest recording of wildlife conservation and the battle of eTshaneni, which took place in the uMkhuze River Gorge.

There is also a living tradition of oral histories, practices, and indigenous knowledge systems. Examples of fishing traps in Kosi Bay are stated by Ramsar (1998) as an activity and criterion of protected living history (IWPA, 2017)

6.2.5 Economic Activities

Two leading economic functions primarily occur in the area. These are both agriculture and tourism.

- 6.2.5.1 Tourism

As evidenced by the numerous accommodation facilities in the form of cabins, hotels, lodges, and camping areas, tourism opportunities occur throughout the park. There have been talks of the redevelopment of existing accommodation to keep up with market trends and increase

tourism. Currently, the tourism sector of iSimangaliso contributes towards 0.06% of South Africa's tourism GDP and provides 7000 jobs for people within surrounding communities (IWPA, 2017).

Similarly, traditional craftwork such as beads, carvings, and ornaments stand allocated along busy streets in St Lucia's town, forming informal and formal trading spaces. The three central high-density nodes are St Lucia, Sodwana Bay, and Cape Vidal. The rest of the areas are zoned as low-density development areas except for wilderness areas, which restrict all development.

- 6.2.5.2 Agriculture

The use of commercial and subsistence farming is both predominant in the uMkhanyakude District. Large numbers of households practice homestead-based agriculture for food production. Commercial agricultural practices within iSimangaliso have been recognized in the 'Integrated Development Plan as one of the two main economic sectors' (IWPA, 2017).

Near the tourism sector, the type of agriculture produced is primarily for commercial purposes. This includes timber, sugarcane, and pineapple farming (IWPA, 2017). Production of these crops promotes casual labor and sales for economic development.

To the north of the park, there is a variety of farming. This ranges from home-based agriculture to cattle farming. However, the land is notorious for having poor nutrient soils, unfavorable rainfall, lack of water services, and high proximity to towns and markets. Although livestock farming is dominant in the northern sectors, cattle remains valuable for cultural practices such as social status, ploughing, bridal wealth, and communicating to ancestors (IWPA, 2017).

6.3 Identifying a *sense of place* for iSimangaliso

As discussed in place theory, a sense of place will be perceived differently by each individual. The area has been identified for its individualistic *sense of place* and is safeguarded by its diverse groups, values, and cultures (iSimangaliso Wetland Park- History, 2020).

A review panel appointed by the government had set out to identify what *'sense of place*' iSimangaliso had embodied to debate the area's future. Their findings had concluded that the land has a *'unique'* and *'special'* character (IWPA, 2017). Further research stated that the area

is seen as precious by varied groups, including conservationists, learners, and the people forcefully removed from the land. (iSimangaliso Wetland Park- History, 2020).

6.3.1 iSimangaliso: Embodying '*Wilderness.*'

Wilderness can be referred to as a concept taken on by iSimangaliso. In this context, wilderness is adapted as a concept for healing and calming environments. However, this conceptual notion has changed through time and cultural perceptions. Historically, most, if not all, cultures had seen nature as a place of danger and hardship (iSimangaliso Wetland Park- History, 2020).

In African cultures, the wilderness was denoted as the place that spirits and ancestors dwelled. In some cultures, young men were sent in isolation into the wild as an initiation practice (iSimangaliso Wetland Park, 2017). It was not regarded as a place for relaxation. (Cousins, 1998). To indigenous people, the wilderness remained perceived as harsh lands where people did not farm, live, or gather.

Similarly, in western cultures and biblical representation, man was given dominion over nature. It is supposed that the European settlers who had colonized South Africa have adopted these ideas by attempting to manipulate wild nature (iSimangaliso Wetland Park, 2017). They had viewed all people inhabiting the wildlands, from hunters to farmers, as less human than men (iSimangaliso Wetland Park- History, 2020).

Due to colonization and industrialization in the 19th century, the definition of wilderness has once again changed (iSimangaliso Wetland Park- History, 2020). It has now been accepted and adopted as an escape from the overcrowded and developed environments. Studies have solidified that natural environments positively impact human beings' quality of life and relationship with others (IWPA, 2017). While wilderness areas usually do not bring in much income, there is prodigious value and achievement from these spaces. Knowledge, preservation, experiences, culture, tradition, and job opportunities all can be seen as a sense of healing in this readaptation of *wilderness* (iSimangaliso Wetland Park- History, 2020).

'*Increasingly, the wilderness became a metaphor for the unexplored qualities and untapped spiritual capacities of every individual.*'-(iSimangaliso Wetland Park- History, 2020).

6.4 The Conclusion to Desktop Study

The research into the area of iSimangaliso provided valuable insight into the economic, environmental, and social struggles of the seemingly picturesque context. Similarly, it had highlighted the strengths and opportunities within the region. The local cultures and architecture were examined to inform a critical regionalist design approach that aids in embodying the spirit of place.

The insight into the varieties and numbers of flora and fauna create parameters for the proposed facility. It allows a clear understanding of what needs to be measured when designing. Additionally, the analysis of the site's existing physical conditions will be instrumental in developing a contextually appropriate design response. To continue in line with their already established concept of *wilderness*, the planned facility should have a direct integration with the natural environment to preserve the land's cultural and biological diversity.

Additionally, findings had determined that the district is high in poverty. It is essential that the social, economic, and environmental aspects of sustainable development be recognized to achieve a holistic, sustainable model. Therefore, the findings encourage local job opportunities and educational empowerment for biological preservation.

Overall, it is evident that the area is rich in local flora, fauna, and cultural identity. It is essential that these factors are respected and enhanced through built form. This motivates the implementation of the proposed facility, which will align with the sustainable development of the iSimanagliso. Moving forward, this sets a framework of thinking for relevant factors to consider in the design process.

CHAPTER 7: FIELDWORK AND ANALYSIS

7.1 Introduction

From the interviews conducted, it was possible to obtain data relating to an ecological conservation centre's design. All interviewees are to remain anonymous. The interviews were conducted with key personnel in the environmental and architectural fields. Specifically, an architect that deals with sustainable design and relevant ecological conservationists.

These primary data sources were relevant towards constructing appropriate design considerations for the proposed facility in St Lucia. The following information attained from these interviews were analysed through thematic data analysis techniques to formulate patterns between the primary and secondary data. Following this, gaps in the research will be identified and expanded upon further.

7.2 Analysis of findings

7.2.1 Sustainable Architect (Architect X)

All information was gathered from a professional architect that practices sustainable design. To protect the interviewees' anonymity, they will be referred to as architect X. The interview had provided methods of achieving sustainable design and inform the researcher how architecture can reduce negative environmental impact. All the information was correlated through the literary sources and theoretical framework. The following questions proved to be the most instrumental and will be analysed accordingly:

How does architecture impact the natural environment?

The research has extracted that the impact of built form has dire consequences on natural ecosystems. Through the primary data, it has been determined that human-made human intervention often leads to:

- Natural resource depletion
- Destruction of natural ecosystems/ deforestation
- Pollution from construction and fossil fuels
- Extinction of species

Similar findings discussed in the literature review and precedents studies have, therefore, been confirmed through the architect's deduction. Accordingly, from the interview, Architect X enlightened that it is fundamental that the ecology on site is preserved during building construction phases to minimize human intervention's detrimental biological impact. The findings from architect X's interview align with Van Der Ryn and Allen (2013), who state that it is crucial to analyse the site's natural metabolism before development can commence.

From the theoretical framework, it was agreed that the *spirit of place* should be understood to provide responsive, sustainable structures. Similarly, primary data had determined that it is essential to *understand the environment* before conceptual stages. Architect X had also specified that any buildings' impact on the environment could be significantly low as long as the structure is planned sustainably.

Throughout the research, it is stated that one of the significant impacts of architecture is its overconsumption of resources. The architect had advised that it is only through practical resource usage and careful materiality selection that resource consumption is alleviated. According to Architect X, it is advocated that designers advise clients of sustainable and renewable solutions to reduce negative environmental impacts.

The theoretical framework encourages the use of local, renewable, and sustainable materials for structures to become an integral part of their context. Materials that are renewable and biodegradable are necessary for built structures to be considered sustainable for future generations.

It was concluded from the interview that energy consumption is potentially the most extensive negative environmental impact of built form. Information from primary data has encouraged the use of alternative energy sources to reduce reliance on fossil fuels. Therefore, ensuring that structures are resource-conscious, environmentally aware, and energy efficient are fundamental to creating sustainable developments. El Humadel is an excellent example of a form that utilizes multiple sustainable techniques. In the precedent studies, El Humedal was critically evaluated for its use of locally sourced, renewable materials and low energy usage practices through alternative energy.

How can sustainable architecture reduce environmental impact?

According to Architect X, "*the goal of sustainable architecture is envisioned to diminish the adverse environmental impact of a building during its life cycle. This may be accomplished through energy, efficiency, passive designing, waste management, as well as the use of innovative materials.*"

Sassi (2006) states that sustainability should strive for a balance between meeting needs for the present and future, which aligns with the definition of sustainable development in the Brundtland report (1984). In the literature on Sustainability, it was specified that sustainable development allows for buildings to be less reliant on non-renewable resources and thus more environmentally approachable. The primary data had correspondingly settled that energy consumption is potentially the most extensive negative environmental impact. Therefore, sustainable constructions should emphasize energy efficiency.

Architect X had determined that the green design initiative has significantly risen in the past few decades. This relates to the literature in chapter two, which mentions that we currently live in a new era of technology and life (Kurokawa, 1994).

From the interview, it was apparent that to create built forms that are responsive and sustainable; it is essential to consider passive design strategies such as ventilation, lighting, heating, and cooling to minimize energy consumption and promote healthier internal environments. Several of the interview recommendations align with the literature investigated in Sustainability theory (Chapter 4).

The findings had also specified the implementation of reclaimed materials such as wood, stone, and copper to help combat natural resource consumption. Concurrently, sustainable materials such as bamboo and cork were suggested as renewable material alternatives that could stand as flooring alternatives.

According to Architect X, some of the most commonly used sustainable design methods are:

- Improved insulation of a building to prevent heat dissipation.
- Increasing ventilation to remove polluted indoor air.
- Using the best conductors for electrical connections, reducing energy consumption.
- Incorporating passive solar building designs such as natural ventilation and lighting.

- Installation of renewable energy sources such as solar PV panels and Jojo tanks.
- Use of materials with low-E coatings.
- Reducing wasted internal space.

What are some of the main issues facing sustainable development, especially in South Africa?

Primary data from key personnel had revealed that a significant issue relating to sustainable development is a general lack of awareness of the matter. It has been discovered that clients often choose more standardized design methods since sustainability is a relatively new concept to people. Therefore, the demonstration of sustainable practice must become commonly practiced to raise awareness of negative construction habits and improve environmental health.

Sustainable and technologically innovative solutions are often seen as more costly and not the primary choice of design. This statement has been confirmed through primary data, as it is stated by Architect X that "*many clients often need developments completed with minimal cost and maximum efficiency*."

Considering a building could be achieved sustainably by employing local, inexpensive materials and well-thought-out passive design strategies, it is fair to state that sustainable designing is possible at reasonable budgets. However, it is central to advise clients of these matters in initial consultations.

How can the design of buildings be both inclusive and responsive to the natural environment?

It is essential to employ local laborers in construction and implement passive and innovative design techniques that ensure structures are contextually responsive and inclusive. This contextual receptiveness can be displayed in the buildings such as Siyabonga Centre and El Humedal, which were discussed in the precedent studies. Employing local workers and materials allows for built form to become an integral part of its context. Correspondingly, data from fieldwork had stated that an environment's character is reflected through architecture and its inclusion of local materials. This aligns with a critical regionalist approach, which encourages local materials and vernacular adaptations of architecture.

According to the architect interviewed, it is imperative that the building also be a direct response to its context through orientation and location. Similarly, visual connections to nature become vital in working environments. It was confirmed through the precedent studies that structures that have a visual link to the outdoors help in user productivity and general health. The research on visual connection to nature is supported by the interview, which determined that people often respond well to nature in built structures, regarding them as *comforting* and *aesthetically pleasing*.

- **What sort of architectural principles do you think might aid in an ecological conservation facility?**

According to the interview conducted, some techniques for the design of a conducive ecological conservation facility include:

- Integration with nature and environmental optimization
- Energy efficiency to minimize energy consumption
- Water harvesting for secondary uses.
- Waste reduction and recycling of waste to generate compost
- Protection of natural ecosystems in the construction phase of development.

One of the major design concerns of designing in sensitive settings was structural stability and low environmental impact. As discussed in the desktop study of iSimangaliso, the town of St Lucia is located on a floodplain and the site on a river's edge. Therefore, consideration of flooding in rainy seasons is critical. This concern may be adequately addressed through the use of stilt foundations. According to Architect X, stilt foundations can be piled and are among the least environmentally damaging construction methods. Concurrently, it is noted that the materials should durable for wet environments and unstable soil conditions. The technical requirements of stilted foundations will be elaborated further in the following chapter.

A notable design consideration obtained from the interview is the possibility of insects and animals (local fauna) entering properties. In many circumstances, this could be considered hazardous to occupants. As a safety protocol, it is best to employ insect screens on operable windows where necessary or limit natural greenery in certain areas.

7.2.2 Environmental Specialists

Key personnel in environmental research were interviewed to investigate their opinion on the relationship between man, nature, and architecture. Critical questions regarding the issues of sustainability and conservation were asked to formulate essential design decisions. The role of ecosystems holds great importance to humankind; therefore, interviews with an ecological researcher and personnel in Environmental Management were critical to understanding the needs and requirements of both human and nonhuman nature. Participants were not affiliated with any company and have answered all questions honestly and anonymously. Both participants will be listed as Participant A and Participant B to ensure anonymity. Some of the essential questions asked will be analysed against the literature and theoretical framework researched to formulate patterns and design drivers.

What are some of the most prevalent ecological issues in your field?

It was apparent from the interviews conducted that environmental pollution and natural resource depletion were the most common concerns, while secondary problems included climate change and oceanic health. Both participants had agreed that due to overpopulation and the rise in need for infrastructure, clearance of land would be needed for development. This results in deforestation and a loss of habitat for countless species. These findings have substantiated the research in chapter two, which discusses population growth and anthropocentric dominance. Participant A further states that there are innovative ways in which both man and nature can exist, but it was rarely noticed in South African facilities.

What types of architectural built spaces are most useful to your field?

The findings have identified important design requirements for the facility to perform efficiently. According to Participant A, it is crucial that facilities have proper equipment and spaces to achieve accurate results in research. Similarly, Participant B had stated that for effective productivity, workspaces must provide ample ventilation and light intensity. These findings substantiate the analysis in chapter three, which explains that conducive environments positively affect occupants. Some of the spatial requirements suggested by both participants were:

- Laboratory spaces
- Conference spaces
- Protected areas
- Office facilities
- Spaces for fume hoods
- Dissection/surgical spaces for large animals
- spaces for instruments such as microscopes

Notably, When the participants were asked what some of the issues experienced in their respective facilities were, the answers illuded to inadequate architectural design responses. Participant A stated that some of the issues were proximity to field sites, lack of spaces for workshops or events, a lack of appropriate laboratories, and access to these facilities. It was mention by Participant A that laboratories usually have various chemicals and specimens continuously passing through, and this was a form of distraction in the work setting.

Correspondingly, Participant B had similar issues in regard to congested laboratory and research design. When asked how these research spaces could be improved, both participants had requested that spatial zoning within the laboratories are considered. It is thereby fundamental that lab designs allow for adaptable, multifunctional spaces.

In the same way, both participants had agreed that spaces designed for animal rehabilitation are to be space conscious. Participant A stated that it is essential to generate conducive and adaptable enclosures to a variety of animal species while still humanely designed. This was confirmed by Participant B, who states that it is significant to maximize the space available for habitation.

In your opinion, should public integration be encouraged in conservation centres?

Both key personal have agreed that the integration of the public in ecological conservation is encouraged to an extent. According to Participant A, public involvement is to proceed with caution as there is a fine line between ecological protection and public integration. The interviewee further states that facilities often use awareness as an excuse to generate financial gains through the exploitation of wildlife. This is similar to many strong sustainability models, which were discussed in chapter four.

According to Participant A, many institutes make money off these animals while never having intentions of re-releasing them back into the wild. Therefore, the proposed ecological centre must develop strict regulations that ensure the facility's primary objective is being addressed: to ensure that both man and nature can mutually benefit from architectural design.

Participant B goes forth to say that it is mandatory not to allow for green-washing. Green-washing is a term used to describe when something is offset in the process of trying to be sustainable. An example given was that of a state-of-the-art facility that allows for environmental work but results in the facility harming the environment in another way. In order to combat green-washing, all social, economic, and most importantly, environmental factors should be considered thoroughly.

Do you think technologically innovative strategies such as Virtual Reality or Augmented Reality could benefit public awareness of conservation?

Both environmental specialists had expressed that technology could be a beneficial awareness tool. Participant A had stated that platforms such as Instagram, Facebook, and Twitter have all been fundamental in the spread of ecological conservation and climate change. Likewise, virtual reality conferences have already been initiated to enable individuals to experience environmental phenomena first-hand. Agreeably, participant B had stated that audiences are constantly captivated through creativity, and technology could provide uncharted territories to engage users with the natural world. This aligns with research explored in chapter two, which encourages the use of virtual environments for ecological conservation.

7.3 Conclusion

Fieldwork and analysis have determined how existing developments operate. From this chapter, it was possible to understand the influence of human-built intervention on the natural environment and formulate architectural strategies to alleviate some of these issues.

The general requirements and the lack of provisions were vital in formulating design requirements that benefit biological preservation and occupant comfort. Some of the key difficulties identified were lack of equipment, inadequate research spaces, and insufficient enclosures for wildlife.

An influential factor that aligns with developing a strong-sustainability model is to avoid the concept of green-washing. Local wildlife's health and release should be a constant objective to prevent animals from being contained for economic or tourism purposes. Therefore, the proposed typology should employ strategies that primarily focus on the well-being of nature, the context, and local communities.

CHAPTER 8: DESIGN RECOMMENDATIONS, TECHNICAL REPORT, AND BUILDING REQUIREMENTS

8.1 Introduction: Typology description

The research analyses ecological conservation through three significant components: Conservation through research, rehabilitation, and education. The three sectors of conservation dealt with in the study have specific functions adapted to environmental needs. All aspects of conservation should be adequately addressed to deal with ecological health holistically. The construction and development of all facilities should encompass sustainable design strategies that minimize energy, cost, resource consumption, and natural land use.

Research: Research is a fundamental attribute of ecological protection. Therefore, endemic flora and fauna are studied to conserve natural ecosystems. The proposed facility should contain all relevant spaces and equipment required for research to take place.

Wildlife Rehabilitation: Often, wildlife rehabilitation is scarce or not considered an integral part of human life. Each living organism plays a significant role in the health and maintenance of all ecosystems. The focus on rehabilitation is to offer the medical assistance required for local wildlife to be released back into the wild - aiding in the conservation of a species.

Education: Conservation education will help to influence the attitudes of humans to understand ecological complexities. The educational component allows for developing critical thinking skills to promote environmental conservation (Conservation Education, 2020). Concurrently, environmental education will act as a generator of tourism and socio-economic development.

8.2 Design recommendations for conducive environments

Critical components of the typology's anatomy were explored to determine the design requirements of the conservation facility,

8.2.1 Research facilities

Environmental research will involve many primary and ancillary amenities to ensure a conducive environment. Spatial requirements should be thoroughly investigated as there are many intricacies when designing for these accommodations. Relevant design recommendations for research spaces were studied and documented. There are two types of laboratories that are

needed for the design of research spaces. These are wet labs and dry labs. Each holds its own requirements and demands attention during design development.

Wet Lab

According to Bellingan (2008), some of the requirements for a wet lab are as follows:

- Adequate natural ventilation
- Fume hoods to extract toxic fumes
- Water supplies for sinks
- tiled surfaces that may be hosed down
- A walk-in freezer
- Roller doors

Dry Lab

These are labs such as Microbiological Lab and the Genetics Lab. A few of the spatial requirements are:

- Flatwork surfaces
- Data wiring
- Expensive electronics
- Water supply to individual sinks
- Adequate ventilation

For the design of laboratories, insect screens at windows and doors should be carefully measured. This is especially important when designing a research space in a natural setting. According to Loring (1986), it is mandatory that there is a minimum of 15 to 25 air changes per hour to remove toxins and gases (Loring, 1986).

Lack of storage is a common design problem in research facilities (Bellingan, 2008). This issue can be alleviated by providing a central storage space that can be accessed and maintained easily from workspaces. Likewise, chemicals and gases are to be kept in a centralized location that allows for storage and access convenience. When designing laboratory spaces, there is a prerequisite for preparation rooms. According to Bellingan (2008), preparation rooms should

be adjoining to laboratory spaces for convenience (Bellingan, 2008). Consideration of a change in level and non-porous flooring is obligatory to contain any spills in storage spaces.

Research aquariums are fundamental for examining and breeding aquatic species in conservation studies. This space plays a significant role in studying marine life and has similar requirements to a laboratory. Research aquariums necessitate ample water, electrical supply, and substantial natural daylighting for many species to survive (Bellingan, 2008). This research laboratory also needs temperature-controlled rooms as experiments are tested in various climates to document ecological responses. According to Bellingan (2008), sunlight is required for tanks to simulate a species natural habitat.

In a research study titled *Towards an architecture that facilitates research and education in a World Heritage Site: An Environmental Research Facility for the iSimangaliso Wetland Park* (2008), it was concluded that research occurs on two levels: namely the informal and formal spaces (Bellingan, 2008). This means that while discovery may occur in formalized, planned settings, there is the opportunity for innovation to occur in more informal social spaces through the transfer of information between researchers. Social spaces are encouraged as it is identified that researchers often develop a sense of cabin fever when isolated for long periods of time. In *The Meaning of Cabin Fever* (1984), it is said extensive periods of isolation can lead to depression, boredom, irritability, and moodiness (Rosenblatt, 1984). Hence, there is a need for built environments that promote social interaction between users and their environment.

It is observed from fieldwork that even in environmental research, there is a vast amount of time spent in offices to document findings and coordinating teams or projects. In *Sustainable Laboratory Design* (2007), it is said that research office spaces should be designed to allow for flexibility so that users may create the environment in which they find most comfortable and interactive. This leans towards office areas being open planned. The use of open-plan spaces is not a traditional design among research facilities (Griffin 2000) but a practice that should be enforced for future gain.

As with most institutional facilities, there is a necessity for meeting and conference areas for staff. These should be areas that maintain visual and aural privacy (Putnam Gould 1986:62). The rooms' sizes and requirements will vary according to the number of people utilizing the space (Bellingan, 2008). Typically meeting spaces do not have many design specifications; therefore, these rooms need to apply appropriate passive design strategies to minimize cost and increase the occupant's comfort (Sassi, 2006).

Due to the intensive amount of analysis conducted, research centres require designated spaces for stored documentation. Journals, books, and findings will benefit from being kept at a central point for ease of usage. iSimangaliso is a well-researched area that contains extensive environmental findings (Bellingan, 2008). Therefore, a library could provide resources and social spaces that inspire biological awareness.

8.2.2 Wildlife Rehabilitation Design strategies

Wildlife services are a critical component of the proposed typology. Therefore, the design of amenities catering to animals has been explored. By implementing principles from the theoretical framework, a place-responsive and empathic design model may be established to form a connection between man, nature, and architecture.

As with most medical facilities, architecture primarily accommodates for safety and efficiency. This is no different among veterinary clinics. While contemporary aesthetics are applied, structures do little to connect themselves with nature. There is an urgency for responsive design to create environments that meet specifications while creating calming, favorable settings for both human and non-human occupants. Some design principles of achieving an ecological structure involve large windows, ample green spaces, vegetation, and the use of natural materials, textures, and colors.

The fieldwork identified that the most common problem with South African animal rehabilitation and conservation is funding. This has resulted in inadequate, underfunded architectural responses. Many facilities like the Pietermaritzburg Lion Park, Mitchell Park zoo, and the uShaka Marine world display spatial conditions for wildlife that are below standard. The design of enclosures should be sufficient to deal with weather conditions as well as be humanely create for wildlife comfort.

The entire conservation facility is envisioned to demonstrate correct ecological and sustainable design practices to respond to the natural environment appropriately. The building itself should be an integral part of the landscape. This architectural extension of the environment should house not only humans but the ecosystems that surround it. Environmental inclusivity can be achieved through brown roofs, living walls, and habitat provisions.

- Brown roofs

Brown roofs are motivated to help attract local wildlife and treat the built form as an extension of its environment. These structures use the soil from the site containing its natural seeds to allow existing vegetation to grow on roofs (Sassi, 2006). This ecological strategy will aid in rainwater collection, attract local species such as birds and pollinators, and connect the built structure to the context.

- Living walls

It is important to note that all green wall systems can be irrigated by recycled water and photovoltaic panels, making them energy-efficient and environmentally friendly. There are three systems for living walls. These are:

Panels: Plants are pre-grown, and the panels are installed. The panels are made using plywood as a base, layered with a drainage mat and modular tiles to distribute nutrients and oxygen evenly. Water is irrigated through drip systems, which can be used from municipal sources or private water supply. The set up is minimal. (An Architect's Guide To Green Walls -, n.d.)

Tray system: This involves a metal profile that pre-grown plants are planted into. Each pocket contains its own water source. There are issues of insects that result in this method being used strictly outdoors for health purposes in research facilities. However, plants may need to be changed monthly, which can be time and cost consuming (An Architect's Guide To: Green Walls -, n.d.).

Freestanding trays: These are freestanding walls that come with their own portable irrigation system. For a large facility, this method will not be feasible.

In order to create a symbiotic structure, both man and nature must be able to coexist. It is essential to cater to the ecosystems that existed there before an architectural built intervention had developed. To cater for prevailing biodiversity, external green walls are promoted to attract local nature. Additionally, generating bird pockets among green walls increase habitat development. Thus, enabling the structure to embody an actual *living wall*.

8.2.3 Public education and ecological awareness recommendations

"*In order to repair man's indifference about deteriorating environmental conditions, it is crucial to create visual, didactic and educational connections with the world which man is so disconnected from*" (Bellingan, 2008:100).

The ecological centre will not only facilitate research and rehabilitation but offer educational opportunities for visitors. Education and awareness play a critical role in conservation as it is up to future generations to move forward sustainably. Therefore, the facility should offer public knowledge of the environment to encourage a shift in perception towards the natural ecosystems.

From the literature and fieldwork, it is evident that virtual environments are effective educational tools to promote ecological conservation. Virtual reality and augmented reality spaces pose as recreational, innovative, and alternative approaches to learning. Auditorium spaces will be required to facilitate digital education and should be designed to accommodate flexible use, adequate lighting, sufficient acoustics, electronic and sound control.

St Lucia is located near many schools and tourist locations; therefore, the promotion of biological awareness amongst the youth and socio-economic growth is enabled through the built intervention. Experiential laboratories are relatively new concepts targeted towards a younger demographic to perform recreational experiments aiming to influence interest in ecological conservation and research. The design of these rooms is similar to that of the research laboratories but scaled down. They are open-plan rooms that resemble classrooms (Bellingan, 2008). Adequate natural lighting and ease of access are compulsory for these spaces.

To promote environmental awareness, the research endorses a phenomenological connection to the natural environment. The use of boardwalks along local mangroves, rivers, and rehabilitation pens will directly connect man and nature. A similar tactic has been implemented at the Siyabonga tourist centre, enabling users to experience sensory walks with informational signs along existing mangroves. This is a didactic approach used to inform the public about the importance of the natural ecosystem.

8.2.4 Services

Service design recommendations

Research facilities, specifically laboratories, put a high demand on services required for the building to operate. This reason causes the distribution of services to be problematic. In *Design for Research, Principles for a Laboratory Architecture* (1986), Lore states that there are four core strategies for service distribution (Loring, 1986:69-70). These are:

- Interstitial floors

This model inserts a new service floor between laboratory floors (Bellingan, 2008). By housing utility services and equipment, this method allows for flexibility and ease of maintenance. However, it increases cost, construction time and adds 20 percent to the buildings' volume (Loring, 1986:9, 69). This method proves unfeasible for this research as it requires the building to infringe upon the natural skyline and is cost and resource extensive.

- Continuous end-wall service corridors

This method proposes service spaces across each laboratory. Continuous end-wall service corridors prove to be highly flexible and easy to maintain but often poses as a physical and daylighting obstruction. This is not a viable option, as natural light is critical for designing the proposed ecological centre.

- Vertical distribution

This method of servicing has a lower cost and minimal floor height. However, it is inflexible and costly to modify and maintain. In order to create flexible research environments, this method will not be utilized.

- Horizontal distribution

Horizontal distribution works by grouping major services into an overhead carrier fixed to the structure above. By casing utility services between floors that are in use, there is better flexibility, ease of maintenance, and modification. This method proves the most useful strategy for service distribution.

However, keeping these service distribution techniques in mind, it can be further noted that a laboratory generally can be serviced by a regular 220 V system along with distribution boards places every 55 m² (Loring 1986). This should be kept separate from the entirety of the building (Bellingan, 2008). Therefore, design consideration needs to be given to spaces for backup generators as well as an uninterrupted power supply location. Due to large amounts of energy needed, a backup energy source will be prioritized to conserve natural resources and certify the systems within the facility are maintained (Bellingan, 2008).

Gas supply

The laboratories will require the usage of gas to carry out research. In environmental facilities, the amounts of gas are not heavily utilized. Concurrently, a central gas storage facility where

gas may be transported from should be considered. This space is to be sun protected, situated located off ground level, and away from combustible sources.

Water supply

The facility's water supply should minimize the usage of municipal water sources. Additional sources of water are to collected via rainwater harvesting and river water recirculation for environmental purposes. All taps are to be fitted with flow control, which assists in water conservation (Bellingan, 2008). Water will be recycled through various systems to address water scarcity and pollution. The water treatment methods will be discussed further in this chapter.

Solar energy, ventilation, daylighting

To generate a structure that is low energy, the use of alternate energy is fundamental. Secondary sources of energy will be harnessed through solar energy. This is possible through photovoltaic (PV) panels. The use of PV systems allows for energy to be collected in an environmentally friendly manner. The system consists of PV panels, batteries, power converters, and a generator where converted energy may be stored (Singh et al., 2011). This strategy, along with LED lightings, adequate daylighting, light dimmers, and motion sensors, will ensure that the structure consumes as little energy as possible.

In the case of research spaces, lighting should run perpendicular to workbenches to avoid shadows being cast. It is of best interest that lights be motion censored to save energy and cost. Natural lighting is considered central to the design of the facility. According to Bellingan, natural daylighting is proven to provide the most comfortable and productive environments. Concurrently, it is advised that direct sunlight be avoided at workstations. This reinforces the concept of open-plan spaces that facilitate place-making.

Natural lighting further strengthens a passive and sustainable approach as well as creating visual dialects between the user and the natural environment. Natural ventilation will omit reliability on Airconditioning systems and thereby reduce cost-efficiency.

According to Africa Environmental Management Consultants (ACER), the area of iSimangaliso is a migratory pattern of various fish and crustaceans (ACER 2001:8). Bellingan highlights that artificial night lights from the built form in a natural area could negatively affect the migrating species (Bellingan, 2008). In order to combat this, it can be suggested that outdoor lights be shaded or situated away from the water's edge (Bellingan, 2008).

Waste

Waste generated by laboratories and services will be adequately dealt with to ensure environmental sustainability. Waste will be categorized into solids, liquids, and gases. All laboratories' wastewater lines should be separated from the main domestic sewage to avoid contamination. Sampling points are required at convenient locations situated outside and away from the building.

- Solid waste management

There is often a significant amount of solid waste generated from environmental facilities. In *Laboratory Design Guide* (2000), it is stated that the most efficient way of solid waste management is to dispose of it in containers within the facilities and then have it collected by the local waste management (Griffin 2000:67). Plant waste can be used to generate compost, which can be used on site.

- Liquid waste management

There are several ways to discard liquid waste from laboratories. The most common method being waste being channeled into a dilution pit containing limestones to raise pH levels and then drained into the municipal water supply (Loring 1986:85). However, more sustainable ways include draining the water into a holding tank, where it is then collected by local waste management. (Griffin 2000:47,67)

- Gas waste management

Considering the minimal amount of gaseous waste produced by environmental centres, harmful gases may be appropriately dealt with by means of fume hoods or fume cupboards in laboratories (Bellingan, 2008)

Fire and safety

In order to effectively plan for safety, access points are to be kept to a minimum to ensure no uninformed visitors wander into hazardous areas. Signage should be mandatory within research areas to avoid injury.

For fire safety, it is best to ensure all areas be equipped with a sprinkler system, fire hoses, reels, and fire extinguishers (Loring 1986:91). Fire equipment is not to be more than 30 meters apart from each other. All rooms are to be equipped for emergencies with a clear safety path highlighted.

Finishes

- Local, sustainable & materials

As discussed in Chapters 3 and 4, the building's materials, equipment, and services should be locally soured whenever conceivable. Local materials include reed, stone locks, clay bricks, thatched roofs, and bamboo. These raw materials will be utilized on the exterior of the building as well as spaces that do not require specifications, such as laboratories. Labs will differ from these material choices to meet design requirements.

- Laboratory finishes

The laboratory finishes will differ from the rest of the facility according to the design requirements. The laboratory spaces should be finished with floor surfaces that are layered with a prefinished material that can be joint-welded to the floor. Griffin (2000) states that floor finishes be extended 150mm up walls to avoid contamination of other surfaces (Griffin 2000:34). Sustainable materials such as vinyl and linoleum are to be considered for flooring. These materials are manufactured with a wooden swatch and will be utilized to match the rest of the building's natural aesthetics.

Similarly, wall finishes should also be non-porous for ease of maintenance and hygiene. Porous wall surfaces will require treatment or a coat of acrylic paint (Bellingan, 2008). Wood finished walls are not appropriate in the laboratory environment. Wooden textures allow for the absorption of hazardous materials and are stated to be impossible to decontaminate (Laboratory Standard & Design Guidelines – Stanford Environmental Health & Safety, 2020).

According to research conducted by Stanford University (2018), Some non-suitable materials for furniture are laminate, wood, and fiberglass. (Laboratory Standard & Design Guidelines – Stanford Environmental Health & Safety, 2018) Furniture materials should be smooth and non-porous to resist the absorption of chemicals. Advisable materials for workbenches and furniture are moulded epoxy resin, stainless steel, and epoxy coated metal (Pillay, 2019).

8.3 Design recommendations for Sustainable Development

Through the desktop study, the social, economic, and environmental issues of iSimangaliso have been distinguished. It is only through a responsive design that these problems be addressed.

- Economic sustainability

From the desktop study of iSimangaliso, it has been evident that the site is surrounded by poverty-stricken communities. The proposed facility should aim to address this issue by offering ample job opportunities to combat unemployment. Jobs will be offered to both unskilled and skilled local community members to reduce the drastic unemployment rate. These workers should be upskilled so that they may be appropriately equipped to deal with environmental conservation. Some job opportunities are:

- Security
- Cleaners
- Administration
- Maintenance
- Service management
- Rehabilitation and wildlife conservation
- Gardeners and site management
- Educational positions
- Cafeteria management

- Social sustainability

The facility should prioritize the health and safety of all occupants. It is important to consider human safety from wildlife and vice versa. The site of St Lucia is home to expansive amounts of crocodile and hippopotamus species. These animals are considered dangerous to humans, and preventative measures to ensure occupant safety. According to Bellingan (2008), the hippo populations grazing in residential areas within the town are a common safety concern. To combat this hazard, there needs to be a creation of awareness through signs as well as staff members discouraging users from getting close to the water's edge. Another precautionary measure could be secure walkways and nets that prevent visitors from getting near possibly dangerous areas. Similarly, to ensure social safety, minimal access, security guards and cameras need to be considered.

- Environmental sustainability

In previous chapters, a great emphasis is placed upon an innovative sustainable design that is responsive to the environment. By observing the surrounding natural environment, many clear design principles had become apparent.

o Flooding

The area of St Lucia lies on a floodplain, which is located approximately 4.0 meters above sea level (ACER 2001:7). The site itself is located along the water edge of the main river of lake St Lucia. According to the Africa Environmental Management Consultants (ACER), 'the lake has a mean level of +0.17 MSL, with fluctuations from +0.85 MSL to -0.6 MSL' (ACER 2001:7). Since the estuary is prone to unpredictable flooding (ACER 2001:7), the facility needs to be appropriately designed.

Flooding can be avoided by ensuring the facility is designed above the ground (Bellingan, 2008). According to ACER (2001), "floor levels are kept at a minimum of +5.0 MSL (thus designed for a 1: 50-year flood)" (ACER 2001:7). This can be achieved by using structural systems such as stilted foundations. Stilted foundations will also encourage empathetic designing so that the structure touches the earth lightly and preserve existing ecosystems. By allowing the building to be elevated off the ground, the space underneath the stilted platforms become habitation spaces for local wildlife.

o Alien vegetation

It is common for the wetland area to contain various alien plant species. These plants jeopardize the health of existing natural species and thereby the health of the ecosystem. Therefore, it is crucial to remove any invasive alien plant species that are found in or around after the earthworks have concluded, to ensure a healthy natural ecosystem (ACER 2001:8).

o Earthworks and construction

The site of the proposed facility lies on a bank along the water's edge. It is naturally stabilized by the wetland systems and swamp forests. However, if necessary, the bank may be stabilized through the use of an armor flex mat and geotextile fabric (Bellingan, 2008). According to ACER (2001). if "any banks are affected by construction, earthworks are to be stabilized with suitable vegetation to match the existing wetland and forest ecosystems" (ACER 2001:9).

Rigid enforcement of sustainable construction practices is to be carried out in the construction phase of design. It is well known that the construction industry is one of the major contributors to natural habitat destruction and resource depletion. The process is also affiliated with pollution from materials, sewer, and machinery (Bellingan, 2008). Thus, there is a need for strict regulations and the education of building techniques that adequately deal with pollutants and hazardous materials occurring throughout the construction phase (ACER 2001:9).

8.4 Understanding wetlands: Sustainable development through wastewater recycling

Wetlands were once considered wastelands that were valueless to humans, and governments would encourage farmers to convert existing wetlands into suitable land for farming (DEA, 2017). It has been documented that between 35 to 60 percent of South Africa's wetlands have been destroyed. According to Ramsar, freshwater pollution is a rising issue, with an estimated 80 percent of untreated waste produced being dumped into the water (Wetlands; a sustainable solution for water purification and security | Ramsar, 2017). Therefore, it is important to find more efficient ways of controlling freshwater and coastal destruction.

Wetlands are considered one of the most significant natural water purification methods. Wetlands have been used for water purification since ancient Egyptian and Chinese cavillations (Brix, 1994). Today, these same methods are considered state of the art, green, and sustainable water treatment systems (Carvalho, Arias, and Brix, 2017). This purification process occurs through the removal of natural contaminants through microbes, soils, and wetland plants called macrophytes. As nutrients chemicals and sediments flow off the ground, it is filtered by the wetlands before reaching open water. The plants then absorb the nutrients while sediment settles at the bottom and filtered water rises (Constructed wetlands for water treatment | CTCN, 2018).

The two main types of constructed wetlands are subsurface flow and surface flow systems. Both these methods will require to be constructed above a waterproof basin in the ground. Similarly, both systems are cost-effective, easily maintained, and reliable sources of water recycling.

Subsurface flow purifies water below the soil's surface. The basin is filled with porous soils or sands, and water is cleansed following a gravitational pull to the bottom. At the bottom of the basin, clean water is collected and piped into storage (Constructed wetlands for water treatment

| CTCN, 2018). The research will utilize a subsurface system to purify rainwater since there is a higher chance of bacterial removal this way.

Surface flow systems are made up of non-porous, silty soil that allows water to flow above. As the water flows through a horizontal pattern, it is naturally filtered. The purified water will then be harvested through pipes at the edge of the wetlands. (Constructed wetlands for water treatment | CTCN, 2018)

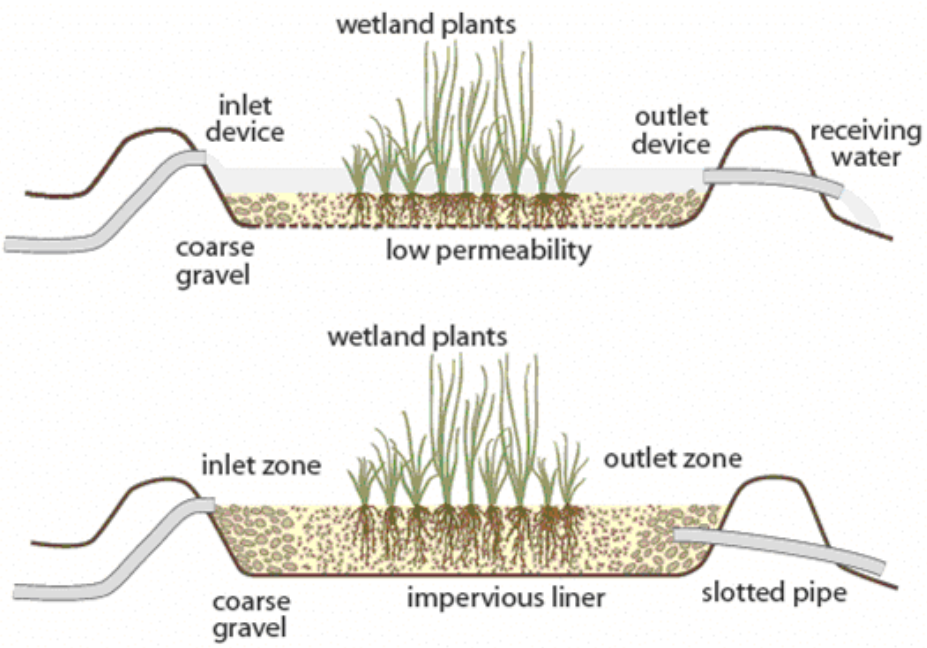

Figure 56: Image displaying subsurface and surface constructed wetland systems. Source: (Md Saat, 2006).

Both greywater and blackwater are collected and recycled on-site to follow a sustainable methodology. Blackwater will be treated through septic tank systems, reed beds, and constructed wetland systems. However, there have been issues of reed bed systems being climatic reliant and a possible sanitation hazard. Considering the well-adapted climate of iSimangaliso, these issues can be addressed by regular maintenance, the wetland treatment system located away from the site, and the use of indigenous plant species.

In order to successfully achieve on-site water purification, wastewater will be sent by a gravitational pull to a general tank located underground. The water is to be filtered through a degreaser, followed by a septic tank and a sump pump. This process is used for Aeration, Sludge settling, and chamber irrigation purposes (Green Living Tips, 2009). The semi-treated water will be sent to a constructed wetland containing a reed bed system where the water is

further purified. The water will then be transported to a drainage pipe where it is further filtered and stored in a reservoir. The purified water may then be used for irrigation and to feed the river if needed.

Some of the additional benefits of wetlands include:

- Absorbs large amounts of water, which prevents flooding.
- They are natural barriers that protect the coastal shoreline.
- Wetlands recharge and purify groundwater supply.
- They generate habitat spaces and attract local wildlife.

8.5 Conclusion

The design report and technical consideration have provided an in-depth design guide to the approach of sustainable architectural design. This chapter, therefore, becomes more of an outline for the construction of the planned typology in St Lucia. Through this chapter, the theoretical framework may be correctly adapted to inform an innovative and environmentally responsive built form.

CHAPTER 9: CONCLUSIONS, RECOMMENDATIONS, AND FINDINGS

9.1 Introduction: Limitations, concerns, and gaps

Identifying the limitations of the study is critical to pinpoint gaps in the research. One of the restrictions was not physically visiting the site due to the Covid-19 pandemic (which limited travel and interactive opportunities). It would have been beneficial to have a first-hand experience of the site prior to the development of an appropriate architectural response of the planned ecological facility.

Due to St Lucia being an undeveloped area, it proved challenging to acquire maps and online information regarding the site. However, the lack of primary data has been compensated for with extensive literature, digital media, and other secondary sources to fill information gaps.

A notable issue was not being able to visit many facilities discussed in the precedent and case studies. The research would have benefited from the visitations of facilities and more interviews with key persons. However, from online interviews and literature, areas of improvement and noteworthy architectural responses were identified. The pandemic restricted travel and interaction with others. Thus, many of the facilities were unable to be accessed. The key personnel could not be directly engaged with; however, this was overcome through online communications.

An additional challenge faced was the typology encompassing various components from different disciplines. This required more detailed research to adhere to precise safety protocols and standards. Many regulations that are specific to the work of research, wildlife rehabilitation, and biological education were examined and will be employed in the design of the conservation centre.

9.2 Conclusions

- Chapter 2

By investigating the relationship between man, nature, and architecture, it was possible to understand nature's impact on the built form. This fundamental relation has been analysed from the age of the Anthropocene into current times. The shift from a nature-oriented world to a human-centered one displayed how human-made built interventions have dominated the natural environment. From this chapter, the dissection of human, nature, and built form helped reveal the past's strengths and weaknesses to rectify design issues for the future.

- Chapter 3

As a paradigm, phenomenology has determined that human perception and perspective greatly influence the experience of place and architecture. It was, therefore, central to consider the experienced human phenomena that occur when designing. Phenomenological thinking has highlighted the importance of creating multisensory spaces that engage occupants with the constructed and natural environments. As an overarching paradigm, phenomenology has allowed for the human-environment relationship to be prioritized when designing an architectural built form.

Similarly, a phenomenological approach to place demonstrated how a place is perceived differently in relation to how individuals perceive their environment. However, it was proven that this approach alone was insufficient. According to the study conducted by Nogué I Font (1993), place holds its unique attributes that contribute to its character and is simultaneously perceived differently by individuals: attributing their sense of place. Therefore, for a holistic architectural response, both the character and the human-related identity of place were considered.

- Chapter 4

The theory of sustainability provided crucial information relating to the design of responsive architecture in a sensitive setting. The principles from Stefanovic has guided the study into perceiving sustainability through a philosophical lens. This adaption of sustainability has proposed a reorder of thinking whereby human development is conscious of the needs of the future. A philosophical approach to sustainability has also shed light on how to design empathically and responsively for the ecological processes that occur on every site. Sustainable strategies were investigated to gain a critical understanding of systems, principles, and innovative design techniques. Thereafter, examples were reviewed to enquire how innovative approaches were applied to architectural schemes.

- Chapter 5

The precedent studies examined local, national, and international models through the theoretical framework. Each precedent was analysed for its phenomenological approach to design, its response to place, and its use of sustainable principles. Through this evaluation, it was clear to find both advances and setbacks within the schemes. Many design principles were noted and will be employed in the proposed ecological centre in St Lucia. Correspondingly,

the precedent studies have highlighted many of the gaps missing between theoretical framework and architectural built form.

- Chapter 6

A desktop study of iSimangaliso provided essential data that was required to understand the area. Since no two sites are the same, information about the area has guided the research with facts relating to terrain, people, place, and cultures to respond to place adequately. Local constructions and materials provided relevant critical regional principles and sustainable responses that help preserve the local identity or *spirit of place*. The desktop study, combined with the theoretical framework, will ensure that the proposed facility directly responds to both man and the natural ecosystem's needs.

- Chapter 7

The analysis and fieldwork made it possible to gauge how sustainable architectural developments and ecological conservation facilities operate. By receiving input from a practicing architect, accurate information on sustainable and appropriate design approaches were achieved.

Likewise, receiving input from participants who understand environmental needs allowed for relevant design reflections. It was specified in findings from fieldwork that conducive environments should be prioritized for accurate natural conservation results. Interviews were central to integrate factors from various disciplines to create a hybrid facility. The fieldwork had made it apparent that green-washing is a common phenomenon in sustainable developments. Thus, the deliberation of sustainable intentions becomes crucial to avoid green-washing. Both fields were analysed through thematic and discourse analysis to form design principles that achieve mutually symbiotic environments.

- Chapter 8

Informed by the findings from fieldwork, the technical resolutions and design recommendations were investigated further to establish a distinct set of architectural principles that may appropriately counter the negative impact of built form on natural ecosystems. By having a strong understanding of the requirements needed for a sustainable ecological facility, the proposed typology becomes a conscious response to its context. The information obtained from this chapter will serve as a design guide for the environmental facility in St Lucia.

Materials, services, and relevant design recommendations were extensively researched to ensure that the facility reaches optimal sustainable goals.

9.3 Achieving the aims and objectives

Aim of research

- To investigate how natural ecosystems influence the responsive built form

The natural ecosystems that surround us are integral to the survival of man. By learning the importance of the natural setting, we can begin developing structures that are less environmentally invasive and damaging. Through the research on the relationship between man and nature, it is evident that, historically, man did acknowledge the importance of the natural world and its' resources. Although evident, this relationship has since degraded. Therefore, it crucial to generate a built form that does not negatively impact its natural context but co-exists within it and forms an extension of the natural landscape. It has been determined that one of the most harmful effects of architecture is its overconsumption of resources and non-renewable energy. Therefore, to ensure future needs, radical sustainable thinking is critical. Through the theoretical framework, precedent studies, fieldwork, and design recommendations, establishing methods to construct a responsive, sustainable built form was possible.

Research objectives:

- **To analyse the impact of built form on natural ecosystems.**

Industrialization, along with advances in technology, had forged a separation between man, architecture, and the environment. The literature research and primary findings affirm that natural resource depletion leads to deforestation and destruction of habitats. Similarly, the construction of built form has resulted in pollution, destruction, and degradation of the natural environment. The state of ecological decay is imminent, and many refer to the present times as an environmental crisis. Therefore, in an age of life (Kurokawa, 1996), it is essential to mend the relationship between man and nature through innovation and sustainable development.

- **To explore how technological development can aid ecological conservation and socio-economic advancement.**

The consideration of natural ecosystems and acknowledgment of the *spirit of place* are consistent themes throughout the research. It was concluded that through sustainable design and innovative construction techniques, negative environmental impact is minimized.

Findings from literature and fieldwork have determined that innovative and conducive research facilities allow for maximum results in productivity, ecological conservation, and environmental awareness. Similarly, the implementation of digital technology in the ecological field has proven to provide safer and more efficient methods of conservation. Examples of digital environments such as museums, augmented reality, and virtual reality spaces can be viewed as emerging learning tools that have the potential to become alternatives options to zoos and such facilities where wildlife is held captive.

While the proposed facility strives to be a strong sustainability model for ecological benefit, sustainability is considered holistic only when all social, economic, and biological needs are met. Therefore, the proposed building aims to assist in socio-economic development by providing job opportunities and upskilling local workers. Correspondingly, digital museums, tours of wildlife sanctuaries, seminars, and educational spaces will also allow for opportunities to boost eco-tourism and raise biological awareness.

- **To critically assess how responsive architecture can enhance ecological conservation facilities in the 21st century.**

The theoretical framework both discuss place and sustainability under a phenomenological paradigm. These theories directly fall in line with the criteria for acknowledging the human-environment relationship. Place theory has demonstrated that it is the experiences of people who occupy the environment that create a place's identity. Simultaneously, it is also the physical attributes of a place that provide its character. Taking notes from this dual approach to place theory, the proposed design should consider each factor of the site holistically to make sure all inhabitants are comfortable and immersed in a healthy, biologically-integrated environment. The principle of building structures that are place-responsive should be a consistent deliberation to preserve natural ecosystems and cultures in the region.

This provides a point of departure to design more empathetically, which is to construct built environments that are conscious of all beings on site. With these principles applied to ecological conservation, it is fundamental that all occupants, from human to non-human beings

occupying the site, are considered and designed accordingly. In the precedent studies and fieldwork, the provision for ecological facilities were generally deemed inadequate. With this consideration, it is vital to create receptive environments that allow maximum efficiency in multidimensional aspects.

- **To define a set of sustainable architectural design principles for an ecologically responsive built form in the 21st century.**

Theoretical framework, primary data received from fieldwork, and relevant design recommendations have made it possible to gather appropriate design strategies that aid in sustainable development. All principles discussed will be applied to the proposed research facility but may also be universally applied for the development of sustainable structures.

Both passive designing and innovative advances help reduce the environmental impact by using less energy and thereby having less ecological impact. From the information accumulated throughout the research, design for a sustainable ecological model has been attainable. The building will stand as a demonstrative structure that acts as a metaphor for a symbiotic designed, built form. Therefore, the use of ecological principles and innovative design inform an architecture that physically and symbolically represents environmental awareness.

9.4 Conclusion to research

Findings from the study have led to the conclusion that there is a general lack of investment in new research and ecologically focused facilities in South Africa. As affirmed through interviews in primary data, current ecological facilities have proven unresponsive or disengaging as they lack an authentic connection to the natural environment and cater less to innovative sustainable design techniques.

While the findings had determined that many South African ecological facilities lacked sustainable innovation, it is fair to state that there is a growing increase in sustainable built development. This can be supported by the fact that, in South Africa, sustainability principles are currently an essential constituent of the national building regulations. It is stated in the literature that for the future success of sustainable progress, it is crucial to have a shift in mindset. According to Sassi(2006), the first step towards achieving sustainable development is

determining the desired type of relationship with the environment. Only afterward would it be possible to establish strategies that achieve this relationship.

Similarly, in the literature, it has been stressed that it is crucial to understand the systems that occur on-site when designing with/for nature. From the desktop case study, principles such as touching the earth lightly, embracing the natural environment, and generating minimal waste were determined. These principles provide drivers for designing built form in sensitive settings and will be applied to the proposed design in St Lucia.

The role of literature, precedent studies, desktop studies, fieldwork, and technical design recommendations all played a significant role in investigating the research problem. It has been made evident that historically, man has dominated natural ecosystems. The findings demonstrate that the most efficient way of overcoming the adverse effects of built form on the natural environment is to raise awareness of the issue. Therefore, the proposed architecture should serve as a narrative of ecological awareness. The implementation of biological consciousness in architectural design will serve to physically benefit the environment while metaphorically representing a change in stance towards the relationship between man, nature, and architecture.

It can be settled that architecture needs to be more adaptive and responsive to its environment to achieve a more holistic relationship between people and place, which in turn caters to both the user's and natural ecosystems' health. Therefore, aligning with the hypothesis, it has been established that a sustainable architectural design approach will foster a symbiotic relationship between man and nature to create the optimal setting for research, rehabilitation, and public awareness of environmental conservation.

APPENDICES

KEY INFORMANT: _____ PROFESSIONAL ARCHITECT _____

PARTICIPANT 1

The following interview schedule is to help better understand how built form impacts the natural environment.

How long has this firm been operating?

.....

.....

In your opinion, how does architecture impact the natural environment?

.....

.....

How can sustainable architecture reduce environmental impact?

.....

.....

What are some of the main issues facing sustainable development, especially in South Africa?

.....

.....

What is the price variation between standard architectural construction and sustainable design?

.....

.....

How can the design of buildings be both inclusive and responsive to the natural environment?

.....

.....

What are some of the negatives of building structures integrated with nature?

.....

.....

What are some of the essential sustainable design principles that you utilize when designing?

.....

.....

What sort of architectural principles do you think might aid in an ecological conservation facility?

.....

.....

What are some of the essential design principles when designing on sensitive natural settings such as wetlands?

.....

.....

Is there any further information you could provide that will help benefit this research?

.....

.....

INTERVIEW SCHEDULE: ENVIRONMENTAL SPECIALIST

The following interview aims to gather data required to formulate architectural design principles for the development of a proposed ecological conservation centre in St Lucia. Conservation in the context of this research is broken down into three categories: Research, Rehabilitation, and Education/Awareness. All information will be analysed to answer the primary research question: "*how can natural ecosystems influence responsive built form*?"

CURRENT FIELD/QUALIFICATION: .....

1. How do you describe your field of work? What work does your job entail?

.....

.....

2. What ecological issues are most prevalent in your field?

.....

.....

3. What types of architectural built spaces are most useful to your field?

.....

.....

4. How do you perceive the spaces in which you work? Do they affect your mood or productivity?

.....

.....

5. What are problems that current environmental facilities face?

.....

.....

6. Were any of the facilities environmentally/contextually responsive? (Did they integrate nature or open spaces into architecture, use local materials, etc.)

.....

.....

7. How can the design of wildlife rehabilitation spaces be improved? (vets, enclosures, etc.)

.....

.....

8. How can the design of research spaces be improved? (Laboratories, etc.)

.....

.....

9. In your opinion, should public integration be encouraged in conservation centres?

.....

.....

10. Are there any environmental awareness strategies that you feel could be beneficial for ecological conservation?

.....

.....

11. Do you think technologically innovative strategies such as Virtual Reality or Augmented Reality could benefit public awareness of conservation?

.....

.....

12. Do you think architecture and human developments have negatively impacted natural ecosystems? If so, please explain.

.....

.....

13. Is there any further information you could provide that will benefit this research?

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PART B

(DESIGN REPORT)

CLIENT BRIEF: ISIMANGALISO WETLAND PARK

SPACIAL PLANNING
Accommodation Schedule

- Proposed Development
  - Services
    - Bin Area
    - Generator
    - Water purification
    - Maintenance and cleaning
  - Ancillary
    - Screen Room
    - Accommodation
    - Veg Garden
  - Research
    - Endemic species
    - Breeding & propagation
    - GIS Room
    - Laboratory
    - dissection Room
    - library
  - Rehabilitation
    - Veterinary
    - Exam room
    - Operation room
    - Habitat spaces
    - Quarantine
    - Recovery space
  - Education & Tourism
    - Tours
    - Live Encounter
    - Virtual Reality
    - Digital Museum
    - Classrooms

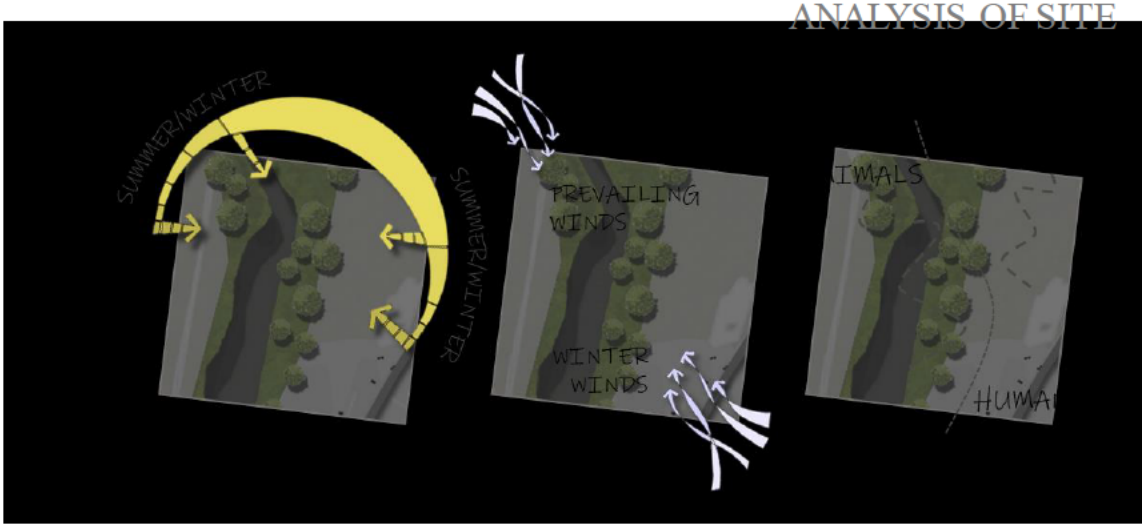
LOCAL VEGETATION

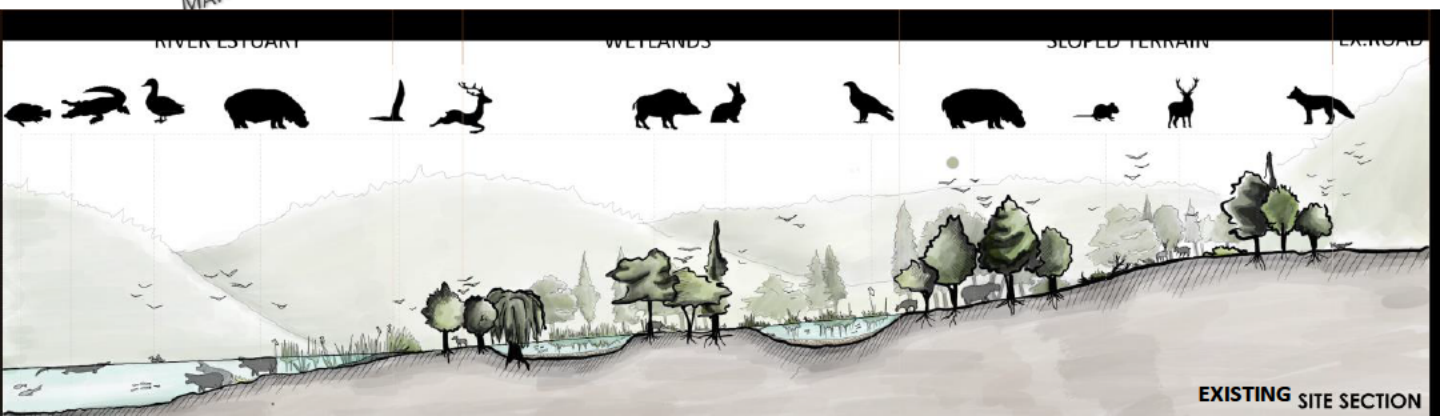
DUNE MYRTLE

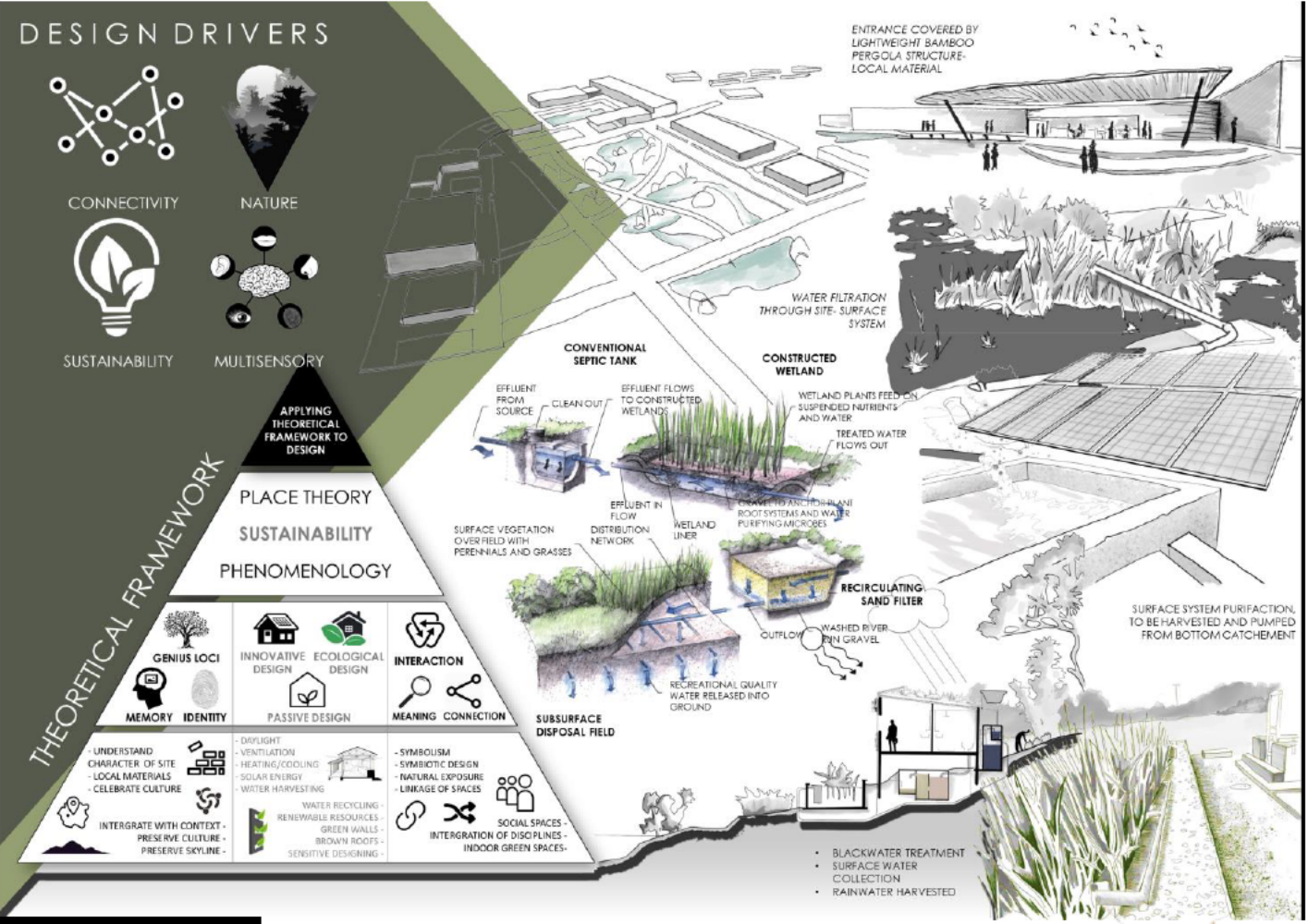
ILALA PALM

MARULA TREE

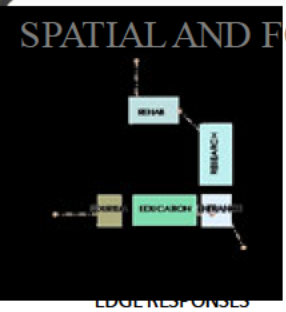
ANALYSIS OF SITE





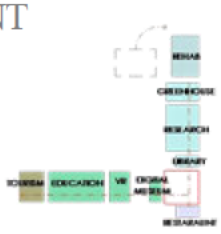


SPATIAL AND FORM DEVELOPMENT

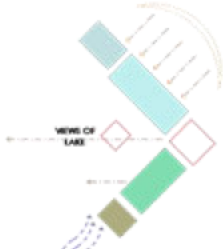


EDGE RESPONSES

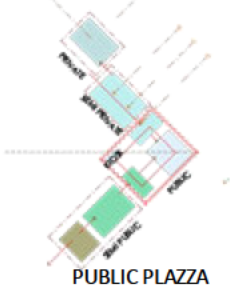
ZONING



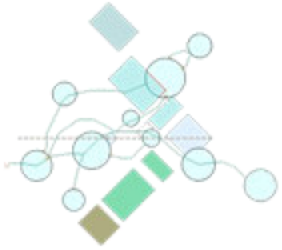
FUNCTIONS



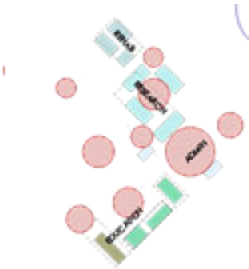
SOLAR AND VIEWS



PUBLIC PLAZZA

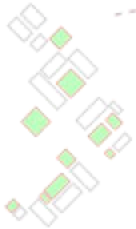


WATER BODIES

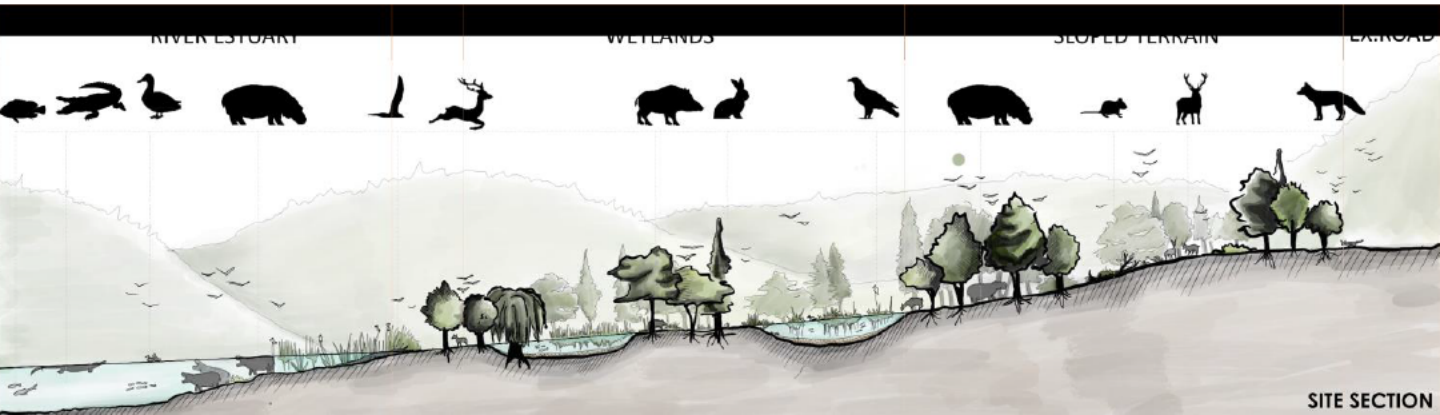


NODES OF INTEREST

ACCESS AND MOVEMENT



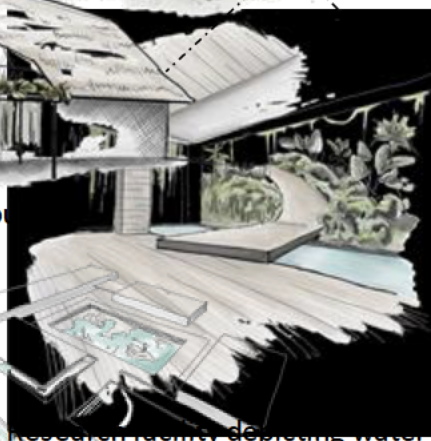
GREEN SPACES



CONCEPTUAL DEVELOPMENT

wildlife walkways

Greenhouse and research aquarium

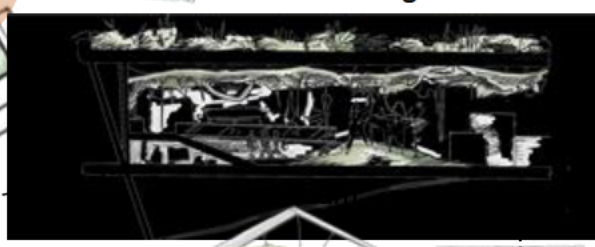


Greenhou

REHAB

RESEARCH

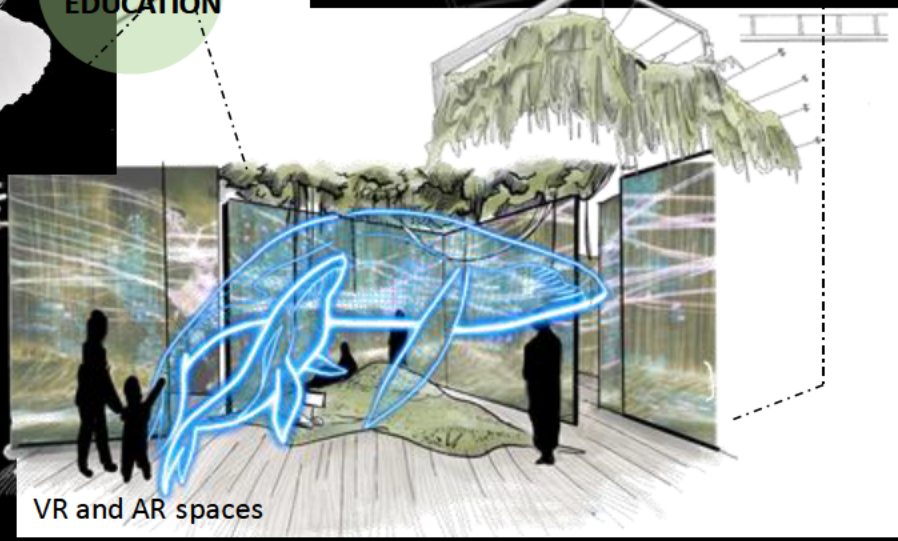
movement through built form



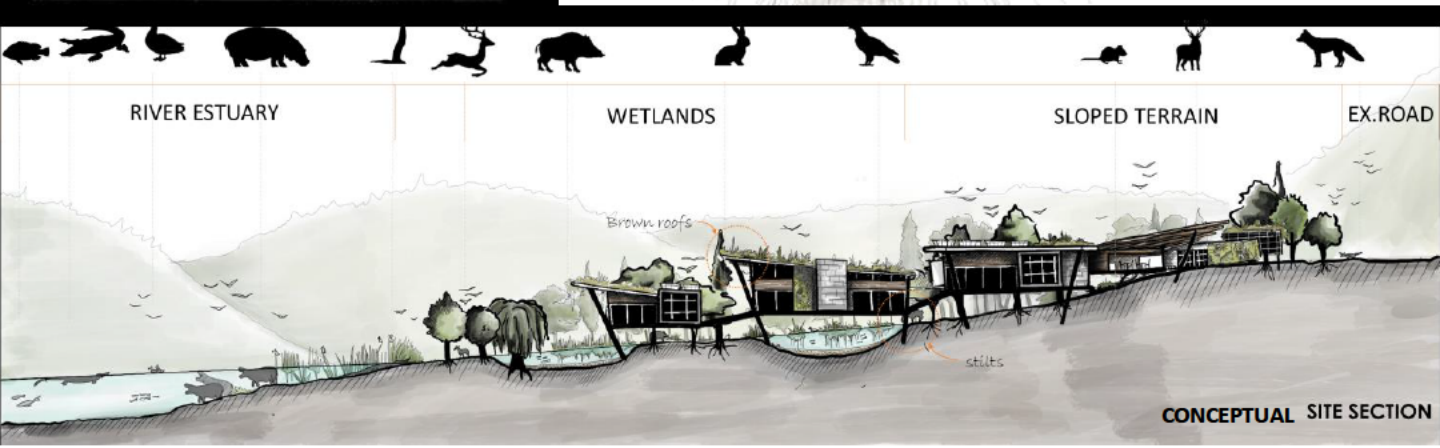
EDUCATION

mmodation and wildlife

gital mu m and classrooms



VR and AR spaces



CONCEPTUAL SITE SECTION

SITE PLAN

ARIAL RENDER

SECTIONAL ELEVATION

RENDERS