Architectural response to environmental conflicts caused by pollution:

Towards a waste incineration and eco-educational facility in the South Durban Basin

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ABSTRACT

This research considers the South Durban Basin area in KwaZulu-Natal as an industrial city. It highlights the framework that moulds the city's infrastructure, including changes that could be implemented from an ecological perspective. By responding effectively to challenges that the city faces, and essentially changing how it functions in relation to the pollution and environmental issues encountered, it can become a more sustainable city. Government, business and society alike need to gravitate towards an approach of creating environments which are adaptive to change. The concept of sustainability, Theory of Perception and the New Urban Agenda will be investigated in this research, which will help to inform the foundation for a sustainable framework for this nature of urban infrastructure. The study will also exclusively explore the South Durban Basin as a whole, and the effects of apartheid that has led to the city's appalling environmental capacity being where it is today. Through a holistic approach, it will lead the research to accomplish a great environmental initiative through architectural design development, as well as economic and social impact.

DECLARATION

The Registrar Academic
University of KwaZulu-Natal

Dear Sir/ Madam

I, Kiyara Sewraj, Registration Number ********, hereby declare that unless otherwise indicated, this thesis is my work under the supervision of Juan Solis-Arias. It is being submitted for the degree Master in Architecture for the University of KwaZulu-Natal and has not been submitted in part or full for any other degree purposes at any other university.

30 November 2018

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Kiyara Sewraj
Master's Candidate **Date**

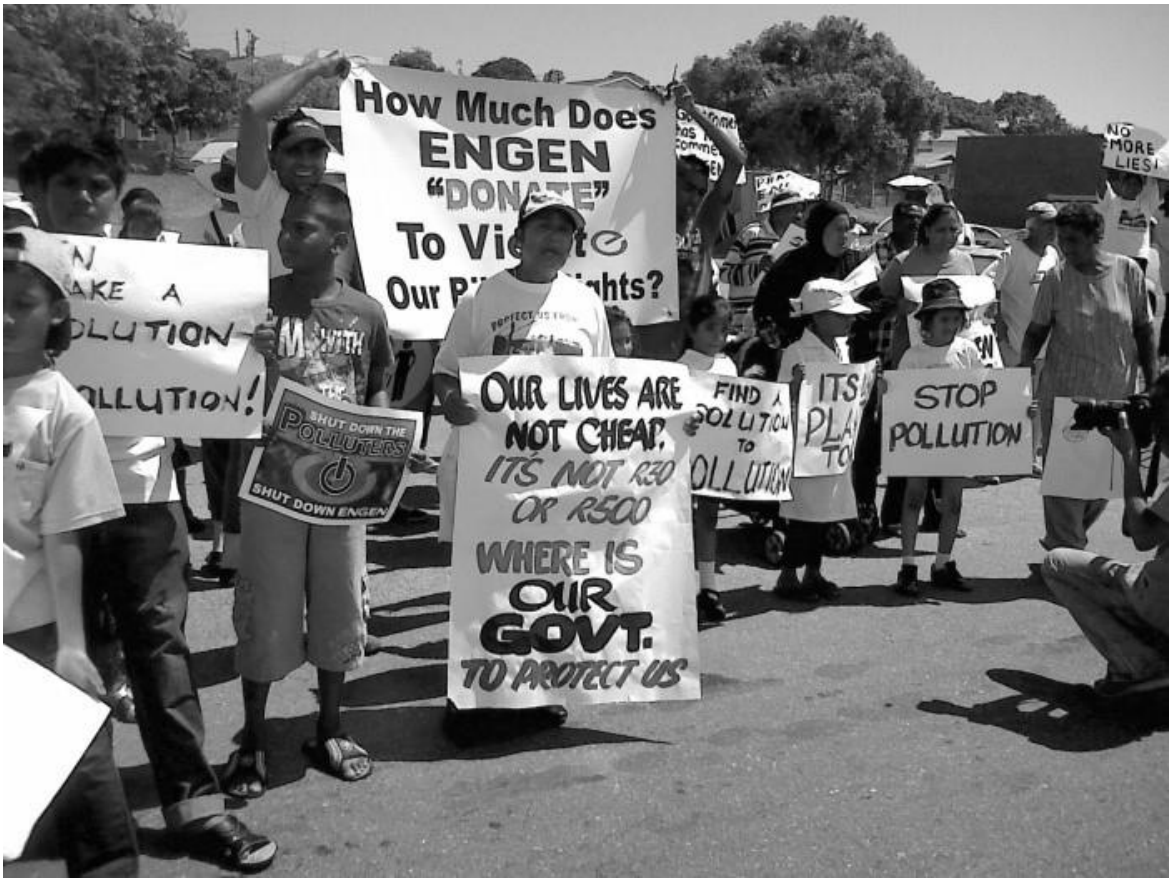

Figure 1.1: *SDB community protesting for pollution to come to an end. Source: Naidoo, P. (2011)*

Figure 1.2: *SDB youth protesting for end of pollution. Source: Naidoo, P. (2011)*

DEDICATION

Dedicated to the South Durban Basin Community Members

1950s to present

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To my Supervisor Juan Solis-Arias, thank you for the continuous guidance and motivation to reach my full potential, and for the endless encouragement throughout the research and design process. Your dedication and commitment to your students is inspiring and this thesis would not have been possible without you.

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ABBREVIATIONS AND ACRONYMS

LIST OF ABBREVIATIONS

ABMDP	Area Based Management and Development Programme
ABWEP	Amager Bakke Waste-to-Energy Plant
BCR	Brundtland Commission Report
CBD	Central Business District
CFLs	Compact Fluorescent Light
DSW	Department of cleansing and Solid Waste
EMA	Ethekwini Municipal Authority
GEA	Global Environmental Agenda
HGW	Horizontal gas extraction wells
ICC	International Convention Centre
ICT	Information and Communication Technologies
MLC	Mariannhill Land Conservancy
NACSA	National Association of Conservancies of South Africa
NEMA	National Environmental Management Act
NGO	Non-governmental Organisations
OCF	Our Common Future
SCR	Selective Catalytic Reduction
SDGs	Sustainable Development Goals
SDB	South Durban Basin
SDCEA	South Durban Community Environmental Alliance
UNDP	United Nations Development Programme

CHAPTER 1: OUTLINE

1.1 INTRODUCTION

1.1.1 Background

Durban, KwaZulu-Natal, is the second largest city in South Africa. For this reason, migrant labour from all parts of the country, as well as other countries, are captivated by the growing city (Vartak, M., 2016). Consequently, an influx of migrants and lack of adequate housing strategies remains the primary cause and creation of a large amount of informal residential sprawl across the metropolis. The majority of the migrants look for economic opportunities for the perceived improvement of living standards and essential services; however, with the overcrowding and lack of services, it has led to poor, inadequate and unaffordable housing. The result is that there are substandard scattered residential areas within the city, many of which are in close proximity to the industrial zones.

Figure 1.3: *Aerial view of Durban City and Harbour Port Source: Bhika, P. (Kierran Allen Photography) 2014*

South Africa's apartheid past has had a deep and enduring impact on housing, more acutely in the case of poorer communities. Colonial and later apartheid-era laws, including the Group Areas Act of 1950, ensured that housing was segregated along racial lines and attempted to confine communities to race-based zones. Jaggernath (2010) states that due to large-scale industries and major transport systems being a multifaceted mix in the city, the South Durban Basin (SDB) residential area in particular has been exposed to the environmental impacts and conflicts of the region. Environmental conflicts consist of a variety of issues and resources, which has in turn led to further cumulative issues. These matters include: quarrels over public and private land use, preservation of property, air quality, water usage, health, and many other conflicts caused within the environment (Dukes, 2004). This study will investigate the environmental encounters faced in the SDB, specifically, air pollution, water and energy consumption and excess waste within the area, as well as a brief overview of other influencing forms of pollution.

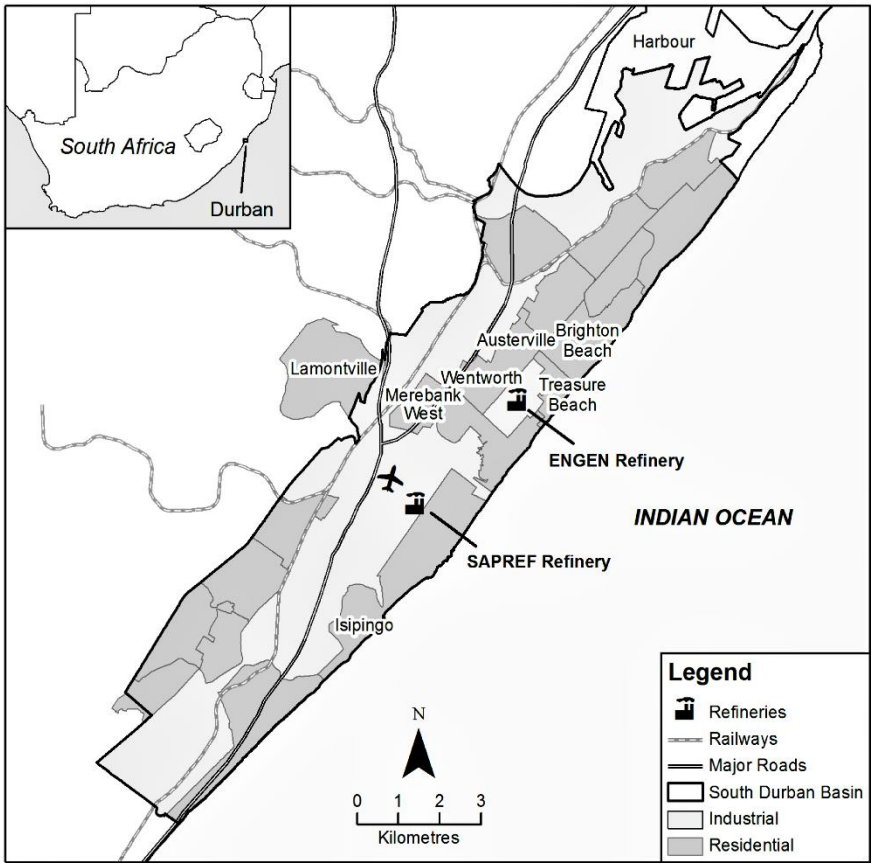


Figure 1.4: *Map of the South Durban Basin illustrating industrial and residential zones Source: Brooks, S.; Sutherland, C.; Scott, D.; Guy, H. (2010)*

1.1.2. Motivation/Justification of the Study

The motivation for the research is inspired by the effects on human health in the SDB caused by various toxic waste in the area. Exploring the key issues that contribute to the factors which negatively impact the community is motivated by the desire to strive for an ecological difference and regeneration of living standards for the people of the SDB. These factors include the government, current legislation, employment, race and health. Exploring these keys issues will provide knowledge of all contributing influences towards a design development that would efficiently respond to the forthcoming issues. In addition, there is motivation to encourage the community and the entire city of Durban to become involved in the process of being educated in recycling and redistribution of unwanted biodegradable materials. This is due to the reality that in society today, communities are too focused on generating income and living a high-income lifestyle, ignorant of the truth that there are attainable means to

assist in improving the quality of life for others (Frampton, 1983). There is an absence of a socially-inclined venue that allows the community to partake in recycling as an enjoyable activity whilst contributing to a more sustainable city and improved air quality. Justification for the research is therefore towards the understanding that, according to Oliver *et al* (2003), local forms of construction have the capability to capitalise on the users' knowledge of how developments can be efficiently designed to promote traditional perception and cultural conservation.

1.2 DEFINITION OF THE PROBLEM, AIMS AND OBJECTIVES

1.2.1 Definition of the Problem

There are intolerable levels of pollutants caused by industrial zones that contain emissions, a large content of Sulphur dioxide and chemical waste, which intensely compromises the SDB's ecology (Jaggernath, 2010). The affected environment has led to major concerns regarding the health of the community, including reluctance to tolerate such conditions any longer by a handful of the community members. There is also an absence of knowledge regarding the impact that the pollution has on them among a large number of the community. Studies carried out by Van der Merwe (2004) suggest that the growth of the industry has resulted in additional struggles between the industry and residents regarding the unendurable distribution of subsequent costs, including water and electricity costs, and health expenses by community members (Ozawa, 1996).

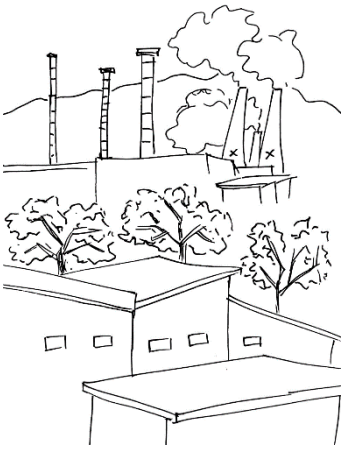


Figure 1.5: *Sketch illustrating the residential area being in close proximity to the industrial zone in the SDB*
Source: Author (2018)

1.2.2 Aims

The aim of this research is to create more awareness among the households located in close proximity to the industrial areas and the environmental implications on the health and well-being of the community, as well as to the rest of the city. Through extensive research of the SDB, the study will provide a deeper understanding of the environmental issues faced. The inadequate response to legal pollution legislations is an aspect to be further investigated, as well as the relationship between industry and the community and the involvement of the community in the decision-making

progressions of the area. Through investigation of these aspects, along with orientation, climatic responses, governmental laws, water supplies to the area, locally resourced materials and additional environmental conflicts, it will allow a profound understanding of what the next step may be, thereby permitting ecology and architecture to hopefully make a promising transformation to the SDB.

1.2.3 Objectives

In order to achieve the aims of the study, the following objectives contributed to the research problem:

1. The key objective of this research is to provide an environmental catalyst to revitalise the city that will dynamically avoid the consequences caused by the industrial developments in the South Durban Basin.

2. To showcase social, economic and environmental sustainability within the South Durban Basin, providing an informative experience for the local people and visitors to the city whilst at the same time providing recycling facilities for the area.

3. To create a waste incineration and eco-educational facility in order to encourage recycling and to raise public cognisance of the consequences of pollution on human health and the environment.

4. To identify the community's interpretations and opinions on racial discrepancies caused by the Group Areas Act, leading to an understanding of socio-economic groups within the area (low, middle- and upper-income areas).

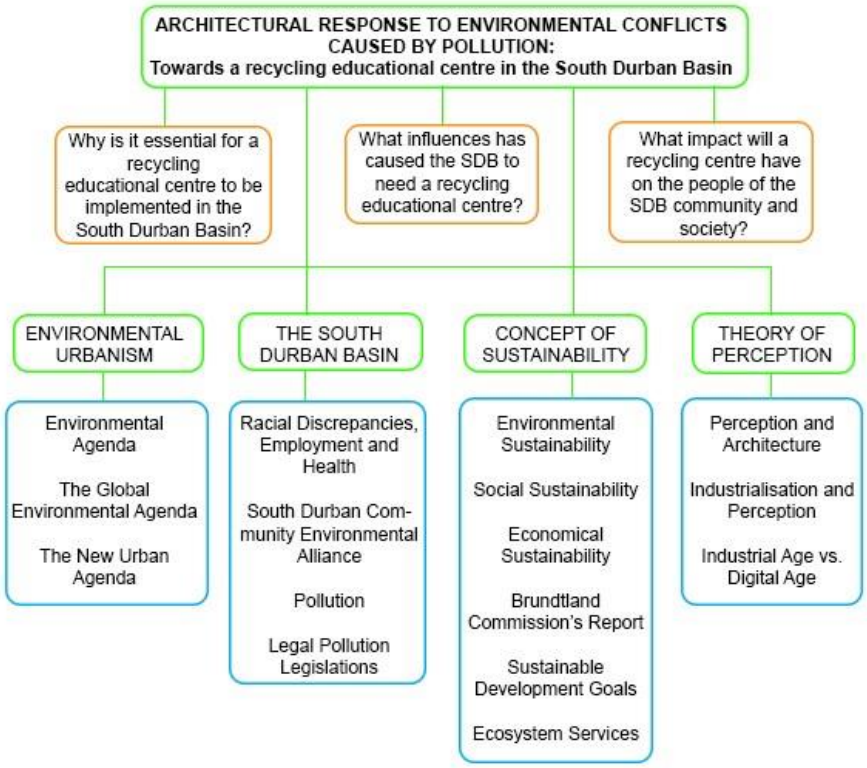


Figure 1.6: *Mind map illustration of thesis context*
Source: Author (2018)

1.3 SETTING OUT THE SCOPE

1.3.1 Delimitation of the Research Problem

This research will explore the South Durban Basin exclusively, which is located in the industrial hub of Durban, KwaZulu-Natal. According to the Area Based Management and Development Programme (ABMD), a programme founded by the eThekwini Municipality in 2003, the industrial hub consists of approximately 5,000 businesses, 22,000 households and 200,000 residents, as well as motor manufacturers, two large petrochemical refineries and a large paper mill. The industrial areas include parts of Jacobs and Prospecton, while the residential areas include parts of the Bluff, Clairwood, Isipingo, Lamontville, Merebank and Wentworth. Research will be carried out within these areas for investigation of the environment. This study aims to identify the different influencing factors of environmental deterioration within the South Durban Basin, specifically Isipingo, Mobeni, Merebank, and the surrounding areas.

1.3.2 Definition of Terms

a) Awareness
In relation to the research topic, awareness is viewed as bringing about recognition, acknowledgement and understanding of an issue

b) Cognisance
Knowledge or awareness of an entity

c) Ecological design
Design forms that minimise environmentally destructive impacts by integrating with living processes

d) Effluence
Contamination, toxic waste or greenhouse gases

e) Environmental conflicts
Traditional conflicts induced by environmental degradation, manifesting as conflicts over resources, as well as social, economic, political, ethnic, religious or territorial conflicts

f) Land degradation
A disturbance or change to the land that is perceived to be detrimental, in which the magnitude of the biophysical ecosystem is affected by human-induced interference acting upon the terrestrial

g) Pollution
The existence in or introduction into the environment of a substance that has harmful or poisonous properties

1.3.3 Stating the Assumptions

Studies carried out by Vissers (2010) suggest that matters such as drug abuse, high unemployment levels, lack of recreational facilities for the youth, pollution and lack of quality housing are the main issues that affect the acceptable standard of living of the SDB residents. Neglect of

maintenance and poor living conditions have contributed to these issues and change is therefore required to improve the community through development of affordable and sustainable communities.

1.3.4 Hypothesis

The hypothesis is that creating an "urban sponge" in the form of a building or venue will act as a self-sufficient entity which will respond to environmental conflicts through absorbing air and water pollutants. This premise could be achieved through the implementation of multiple energy efficient systems, and in doing so, will contribute towards a positive change to the environment (Liao, 2015). If a facility, as such, is combined as a socially-inclined recycling and educational public facility, it will also result in new found knowledge to the community. By achieving this in an industrial area, it would lead to an improvement to the SDB society, allowing them to live and work in a healthier environment.

1.3.5 Key Questions

Primary Question:

What architectural solutions can be used in the design of a waste incineration and eco-educational facility to improve quality of life to the SDB?

Secondary Questions:

1. Why is it essential for a waste incineration and eco-educational facility to be implemented in the SDB?
    - What drives this need?
2. What influences have caused the SDB to require a waste incineration and eco-educational facility?
    - What has contributed to the decrease in environmental well-being?
3. What impact will a waste incineration and eco-educational facility have on the people of the SDB community and society?
    - Will there be an improvement in the health and lifestyle of the community?

1.4 CONCEPTS AND THEORIES

1.4.1 Outline of Environmental Agendas

In the late 1980s, the Global Environmental Agenda of fundamental large-scale environmental concerns of the international community was defined by the United Nations. In response to this programme there was an upsurge of international congresses, negotiations, action plans, treaties and other initiatives where new fields of global environmental law and diplomacy had been born (Speth, 1989). Environmental agendas, both dated and current, influence the direction of environmentally responsive strategies in all states around the world today. The Global Environmental Agenda and New Urban Agenda will be investigated in section 2.1, exploring urban change, industrial and neighbourhood environments, environmental issues and amendments, the urbanising world and environmental well-being.

1.4.2 Overview of the South Durban Basin

Being a pollution-based zone containing both industrial and residential areas, the SDB is beset with many environmental, social and economic issues. Factors such as pollution, the South Durban Community Environmental Alliance (SDCEA), legal legislations and the Engen Refinery will be investigated in section 2.3, highlighting key issues and influences in this regard. Human geographer and publisher, Dianne Scott is a senior researcher at the Africa Centre for Cities and Environmental and Geographical Sciences Department. She explored the SDB through two articles in 2002 and 2003, *"Double Trouble; Environmental injustice in the South Durban Basin"* and "*Creative destruction; Early modernist planning in the South Durban Basin"* respectively. Scott's approach will provide insight into existing literature regarding the trials and tribulations faced in the SDB concerning the ecological issues experienced over several decades.

1.4.3 Concept of Sustainability

Sustainability is a concept that has led to environmental conservation and ecological responsibility. In the built environment, sustainable development can be categorised into three components: Environmental Sustainability, Social Sustainability and Economical Sustainability (Mensah and Castro, 2004). Environmental conflicts, contributions and solutions contribute to this approach, including the different forms of environmental hazards such as air pollution, toxic/hazardous waste and noise pollution, which will be explored in Chapter Two.

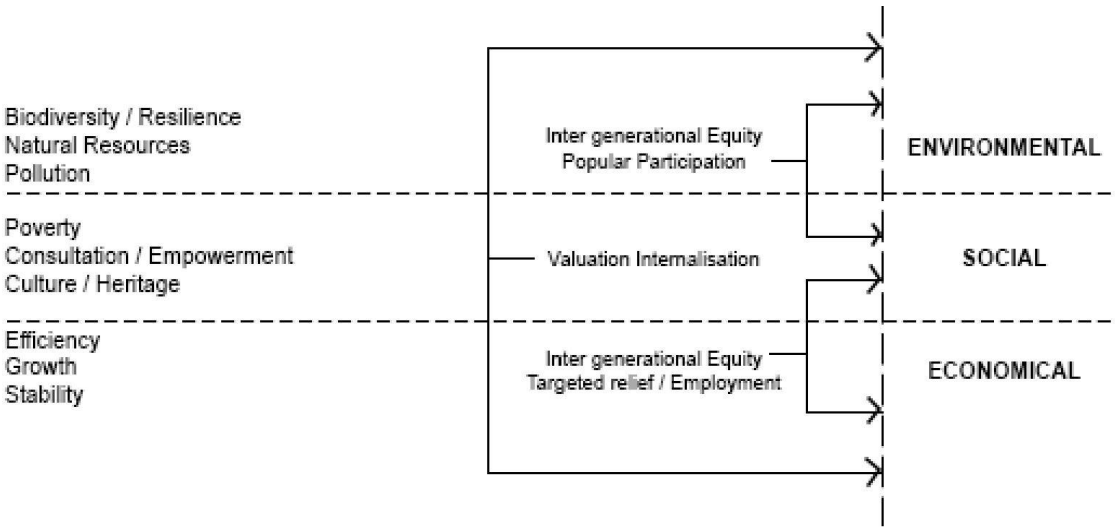


Figure 1.7: *Sustainable Development Approach*
Source: Author (2018)

The Brundtland Commission's report will also be examined. This report was drawn up in 1983 by the United Nations – a body that encourages countries to work together in order to pursue sustainable development – and focuses on meeting the needs of present generations without compromising the future of forthcoming generations, an effective approach that has positively impacted countries since its commencement. Following this will be research on the Sustainable Development Goals (SDGs) Act, along with ecosystem methodologies.

1.4.4 Overview of Theory of Perception

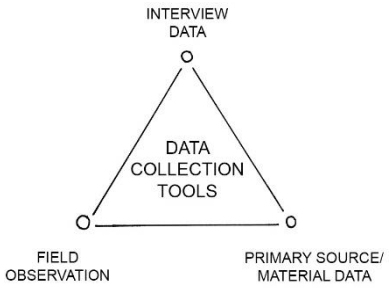
Justification for exploring the Theory of Perception in relation to architecture is due to a driving force in the creation of spaces by means of the users' reactions and responses to articulate the characteristics of a location (Gibson and Carmichael, 1950). Scale, size, position and climatic responses are all fundamental features that contribute towards facilitating a space into its desired outcome.

Author and psychologist, James Gibson published the book *The Perception of the Visual World* in the year 1950. His interpretation of the Theory of Perception will be the basis of this research through all five human senses: touch, sight, hearing, smell and taste. However, Gibson did not believe that human responses were independently scientific and believed that a user's perception was created in addition to their emotional contributions, consequently augmenting their experiences. Through the mentioned work and literature, comprehending and linking the work to the research problem will assist in articulating the research matter through investigating multiple aspects of the area. This will contribute in formulating an in-depth acknowledgment of the research problem and what may perhaps be accomplished through a waste incineration and eco-educational facility.

1.5 RESEARCH METHODS

1.5.1 Qualitative Method

The research method approach that the study will use to gather data, based on the research topic, will be qualitative research. This method is conducted to discover a phenomenon and determine the feelings/perceptions of the respondents (Patton, 2002). The study will be appropriate in relation to the research proposal due to the interaction with the residents and industrial workers, and the experiences and knowledge of those who are negatively affected by the area's environmental issues. Consent and confidentiality will be undertaken to provide discretion of each individual's experience, affirming the dignity, safety, well-being and rights of the potential research participants.



1.5.2 Data Collection

With this approach, data collection was gathered through understanding the users' points of view whilst viewing and interpreting their experiences within the environment. Primary data was collected, which entails data produced and collected by the researcher. This way, a "what", "how" and "why" approach to the phenomena will be investigated and understood, as an alternative to "how many" or "how much" in a numerical method (Patton, 2002). Each key question was investigated searching for "what" the issue is, "how" we would be able to make a change to assist with the problem, "how" we would go about retrieving the data and conducting research, and "why" this needs to be done. To achieve this through a qualitative approach for data collection, individual interviews and group interviews were conducted with people who are in immediate proximity to the site. Secondary data/sources/research was also conducted, which is data collected by other researchers/writers for alternative purposes but utilised by the researcher for her own motivation.

Figure 1.8: *Diagram showing the interactive cycle of data collection/analysis*
Source: Author (2018)

1.5.3 Data Collection Instruments

1. Questionnaires were distributed to companies and neighbours in the surrounding areas to gather data regarding their views of the environmental conflicts in the area and what they deal with on a daily basis, with a total of 88 participants enrolled.
2. Observation: photos and video recordings were executed to gather physical evidence, assisting in the design approach.
3. Case studies were conducted, where management and the head architects of the companies or buildings were approached for individual interviews, followed by an investigation of the buildings in question. Refer to section 1.6.5 for more information on the selected case studies.
4. Precedent studies were examined as an investigation of existing projects by various architects. Refer to section 1.5.6 for information about the selected precedent studies.

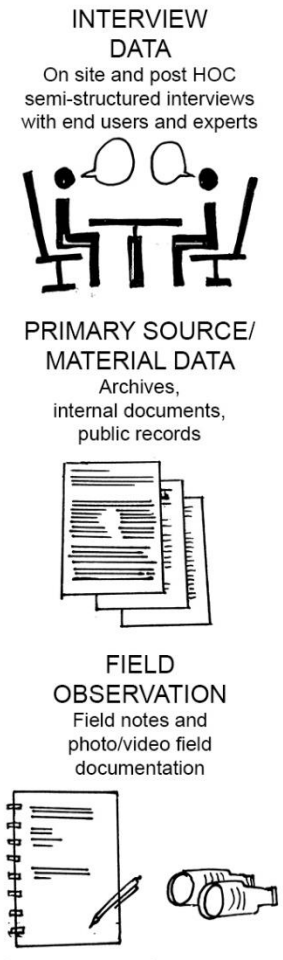


Figure 1.9: *Illustrations of data collection instruments*
Source: Author (2018)

1.5.4 Sampling

Non-random/judgemental sampling will be conducted. The discretion of a person who is familiar with the relevant characteristics of the population is how a judgement sample is obtained. The data collected will be aimed at residents and workers in the SDB, chosen at random to verify that there are no biased opinions, and collecting data that will be authentic and reliable.

1.5.5 Case Studies

The primary data research conducted will entail the case studies investigated. The study enrolled 88 participants in total, including residential and industrial participants from the studied area, which included persons of all ages, races and gender.

The Mariannhill Landfill Conservancy is the first case study. This organisation hosts educational tours to communicate the importance of recycling and our environment to the public, whilst converting waste to energy through modern technologies.

In addition to this, the Durban International Convention Centre was studied, displaying sustainability that successfully responds to Durban's ecological concerns and locale. Through collection of data from these organisations and the approached participants, the study will conduct dependable and reliable research to proceed with the design proposal appropriately, which will be explored in Chapter Four.

1.5.6 Precedent Studies

Bjarke Ingels' Power Plant Ski Slope building, which is currently under construction in Copenhagen and close to completion will be examined as a source of secondary data. The selected precedent will be investigated in Chapter Three, linking the theoretical background of each precedent to the SDB's proposed initiative.

1.6 DISSERTATION STRUCTURE

Chapter One explored the scope of the research examined. It introduced the key issues, aims, objectives, theoretical approaches and the justification for the study in the South Durban Basin. This overview provides a synopsis of the subsequent chapters and an indication of how the key issues and theoretical framework will correlate to generate a solution to the problem explored. Chapter Two provides an in-depth investigation of the conceptual and theoretical framework, offering a variety of authors' works through foregoing literature. Precedent studies that share corresponding strategies through concurrent developments are investigated in Chapter Three. Chapter Four offers insight into case studies inspected in Durban, providing knowledge of existing developments through the author's tangible research and analysis. The data collected and an analysis of the findings will be specified in Chapter Five, with a summary of the entire analysis and recommendations derived from the study explored in Chapter Six. To conclude, Chapter Seven will investigate the research design and methodology, exploring the selected area location and characteristics, the methodological approach, the linkage to the theoretical framework, and an evaluation of the intended design outcome.

The following chapter aims to provide a study of diverse literature which will be supported through the theoretical framework examined. The hypothesised sources aim at environmental sustainability, perception through different dimensions of the human psyche, global agendas which formulate the regulations which the architectural field abides by in the new age of structural design, and an examination of the South Durban Basin on the basis of varying issues faced in the area.

CHAPTER 2: ENVIRONMENTAL URBANISM

INTRODUCTION

This chapter explores the Global Environmental Agenda, the New Urban Agenda, modern-day agenda strategies and environmental and urban change, followed by an investigation of the South Durban Basin (SDB) which will include the Group Areas Act, the South Durban Community Environmental Alliance (SDCEA), the Engen Refinery, pollution and the Brundtland Commission Report. Key authors of the theoretical framework will later be explored through sustainability and the Theory of Perception, including Hardoy, Filos, and Gibson.

2.1 ENVIRONMENTAL AGENDA

2.1.1 Introduction

Environmental urbanism may be described as a way of combining the relationship between people and their material surroundings, as human behaviour influences the design of a city. According to Hardoy (2001), the developing urban influence at present has resulted in the need to incorporate and expand ecological establishments for a greener environment. This is as a result of the disruption and decrease of environmental zones in cities. Consequently, an increase in environmental organisations will be beneficial to the area and will have a positive influence on the economy, social equity and health of the general public. According to Satterthwaite (2002), urban development has become increasingly concentrated since the 1950s, which has led to the increase of both social and economic progress, understood as hubs of commerce, transportation, communication and government. Satterthwaite affirms that due to the rapid growth of an urban environment, it is important to embrace sustainable development so that urbanisation is regarded as a positive transformation for future generations. Disregarding environmental needs in cities will lead to further economic, environmental, social and health issues. As specified by Adams *et al* (1985), the

Environmental Agenda for the Future is structured across eleven major subject areas, as illustrated in **Figure 2.1**.

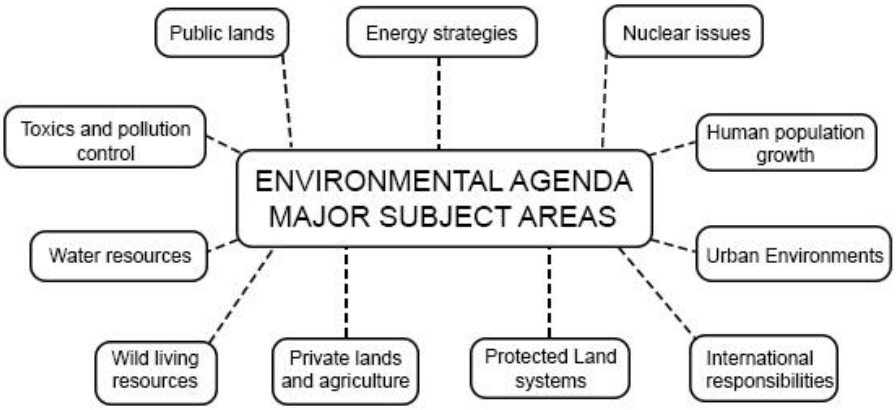


Figure 2.1: *Illustrations of the Environmental Agenda Major Subject Areas*
Source: Author (2018)

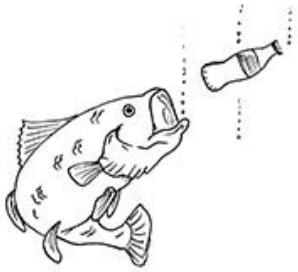
2.1.2 The Global Environmental Agenda

Global environmental consciousness arose in the early 1970s, this being the result of environmental issues that began to arise during the last few decades of the 20th century. Consequently, global environmental policies began to develop at a rapid rate to respond to issues which had entered the international agenda. The commencement of the 21st century marked the inauguration of the Global Environmental Agenda (GEA), which embodied principal large-scale environmental concerns of the international community (Speth, 2004). Studies by Speth (2004) suggest that the reaction to the newfound agenda was remarkable, triggering an increase in action plans, international conferences, negotiations and treaties, among many other initiatives. Significant scientific research had also emerged due to the GEA, with ongoing action by the global community which extended from local to the global society (Speth, 2004). The Agenda stated that a worldwide ratio of challenges was compellingly brought to the government's attention through systematic efforts which underlined ten fundamental concerns, shown in **Figure 2.2**.

Loss of Crop

Loss of crop and grazing land due to desertification, erosion, conversion of land to non-farm uses, and other factors

Marine Pollution



Overfishing, habitat destruction, and pollution in the marine environment

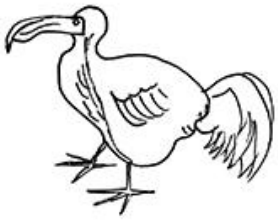
Loss of Forestry

Depletion of the world's tropical forests, leading to loss of forest resources, serious watershed damage (erosion, flooding, and siltation), and other adverse consequences

Threats to Human Health

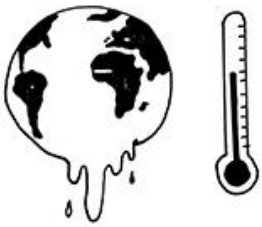
Threats to human health from mismanagement of pesticides and persistent organic pollutants

Extinction of Species



Mass extinction of species, principally from the global loss of wildlife habitat, and the associated loss of genetic resources

Climate Change



Climate change due to the increase in greenhouse gases in the atmosphere

Population Growth

Rapid population growth, burgeoning Third World cities, and ecological refugees

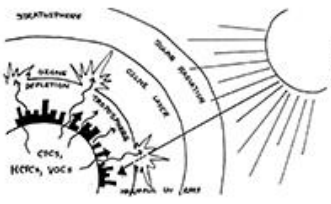
Acid Rain

Acid rain and, more generally, the effects of a complex mix of air pollutants on fisheries, forests, and crop

Shortage of Freshwater

Mismanagement and shortages of freshwater resources

Depletion



Depletion of the ozone layer

Figure 2.2: *Illustrations showing environmental concerns. Source: Author (2018)*

As stated by Speth (2004), there were also many international establishments that were in disagreement with the new agenda; however, those who embraced the new programme became vastly innovative in incorporating the Agenda into their organisations, often taking action before their governments. Global environmental affairs became a major topic of intellectual inquiry and teaching in the academic world. Due to this, a great body of scholarly analysis now exists, including the 2002 World Summit for Sustainable Development in Johannesburg, which followed the 1972 Stockholm Conference on the Human Environment and the 1992 Rio Earth Summit (Speth, 2004). As a result, worldwide environmental organisations encouraged governmental consideration, Non-governmental Organisations (NGOs), bilateral agencies and the business community towards a more responsive approach for the future of the environment.

2.1.3 The New Urban Agenda

Origin of the New Urban Agenda

The New Urban Agenda programme was the outcome of an approved agreement at the Habitat III cities conference, which was held in Quito, Ecuador, in October 2016. It has set a new universal standard for sustainable urban development and aims to help cities to reconsider how we plan, manage and live in city environments. In accordance with Habitat III, the New Urban Agenda embodies what sustainable development advocates by protecting the environment and well-being of the citizens, which then allows for positive changes both economically and socially, leading to an improved cultural well-being within the community. The United Nations Development Programme (UNDP) (2016) reveals that the Agenda also aims to interpret the Sustainable Development Goals (SDGs) and offers guidance in achieving SDGs successfully, especially in matters relating to climate change. This is done while implementing the New Urban Agenda programme as they go hand-in-hand to achieve similar goals. It is solely up to the government and municipalities of each city to perform the Agenda and provide for methodological and financial assistance. Refer to section 2.3.2 for more information about the SDGs.

Aims and Development of the New Urban Agenda

Local authorities and the government of each city aim to provide the following nationally agreed deliverables based on the New Urban Agenda. To achieve this, new urban rules and regulations are required, including improved municipal planning and design, along with finance, among many other aspects (United Nations Development Programme, 2016). As stated by the UNDP, included in the developed programme are the following acts:

Address climate change and promote cleaner cities

A fundamental environmental issue that needs to be taken into consideration is climate change. To do this, action needs to be taken to reduce greenhouse gas emissions. The Agenda is dedicated to increasing the use of renewable energy and decreasing air pollution. According to the UNDP (2016), solutions that could assist in decreasing air pollution in such environments include the conservation of energy used, the process of reducing, reusing and recycling, green energy sources, energy-efficient devices, and the use of public transportation, thereby reducing the number of cars used to transport individuals to work each day. This will consequently improve human and environmental health by sustainably managing natural resources provided in each city, thereby contributing to a greener atmosphere. Reducing these emissions and creating a more resilient city that can address climate change will play a lead role in a healthier environment.

Basic services

Human rights call for the ability to receive basic needs and services from any metropolitan. The government is responsible for providing these facilities and amenities. These services include shelter in the form of appropriate/liveable housing, education for people of all ages, healthcare and family planning, nutritious food, sanitation, safe water, cultural amenities and access to technology for communication purposes.

Equal opportunities for all citizens

The New Urban Agenda ensures that the government considers basic human needs, making sure that every person in the city is treated equally, regardless of their race, gender or disability. The needs of the youth and children, women, the elderly, indigenous people and relegated groups are all included, considering every category and developing the city accordingly.

Promote accessible, green and safe public spaces

To ensure that a city provides for social and liveable entities, public areas that are convenient and secure play a key role. To achieve this, the Agenda promotes human interaction by incorporating these needs in the programme, developing public cycling lanes, gardens, parks, sidewalks and squares. As a result, the city does not only become more sustainable in a social aspect but environmentally as well, encouraging human participation and social health.

Respect the rights of all citizens

There are multiple groups of people living in large cities and migration can often cause challenges in these urban areas, while simultaneously bringing substantial contributions to the economy and the urban environment as a whole. The Agenda therefore encourages cities to fully respect the rights of all migrants, internally displaced persons and refugees irrespective of their migration status, and is dedicated to creating measures that will further assist them to make positive contributions to the city.

Strengthen resilience

In many cities, the ability to reduce the risk and impact of natural disasters showcases how sustainable a city is, as well as how complicated interdependencies that exist between the people and ecosystems work. The Agenda aims to make the city more resilient and to transition and transform the society in order to become a more durable metropolitan. Due to the impact of natural disasters experienced in so many cities around the world, it is vital to establish measures to minimise these effects in the case of future events. These procedures embrace improved urban planning, improved resident responses, and quality infrastructure.

Support innovative and green initiatives

To establish a successful green enterprise within a networking city, an improvement of connectivity needs to be undertaken by implementing sustainable solutions to enhance and make positive contributions to urban challenges faced. This can be established by founding partnerships with businesses in the city, as well as the civil society of each locality.

The neighbourhood environment

A typical residential neighbourhood generally consists of fewer pollutants than an industrialised zone. However, this is not always the circumstance, as poorer communities often face issues such as waste disposal, pollution and shortage of electricity, among many others. As stated by Ikiara-Zamberia (2016), it is the government's responsibility to provide a door-to-door waste collection from neighbourhoods to ensure cleaner streets and organised waste removal; however, not every neighbourhood is granted that benefit, which leads to waste disposal developing into a huge problem in the community. In these cases, communal skips are provided for each household to transport their waste to the site. In some instances, these communal skips cause overflowing of waste that creates a waste dump site in the neighbourhood, leading to unwanted odour in the air and triggering an unbearable living environment (Ikiara-Zamberia, 2016). The South Durban Basin has had to deal with a handful of these issues, including waste accumulation, air pollution, noise pollution and industrial odour, which have caused the neighbourhood to develop into an environmentally unfriendly zone.

Environmental influences can cause positive or negative impacts on the people thereby associated. Through research over the years, it has been found that ill health, disablement or premature death have been caused in lower-income groups due to environmental causes and insubstantial living environments. Accidental poisonings, cuts and diseases are among the few affects that have influenced ill health in communities, in addition to poor roadworks and lack of pedestrianised areas, which contribute to premature deaths and accidents (Jaggernath, 2013). It is fundamental for environments to promote healthy living, particularly for children growing up in these

neighbourhoods, in order that they are endowed with good physical health, stability and emotional support.

As stated by Jaggernath (2010: 143-145), research gathered reveals that there is a very negative approach towards the industrial areas in the SDB due to the environmental conflicts. However, regardless of the compelling perception that health is negatively affected by pollution in all forms, a rather high neighbourhood satisfaction exists in the SDB.

2.1.4 Environmental Change

Environmental change can be caused by human land uses and activities as well as biophysical processes, which are interrelated sequences of cause-and-effect relations. Agriculture, fishing, forestry, industry, mining, recreation, tourism and urbanisation are all effects of human land use activities (Izakovicˇová, Špulerová and Petrovic, 2018). Studies by Izakovicˇová *et al* (2018) suggest that these causes can influence the change of the earth's ecological system and include actions such as non-physical functions, application of fertilisers, building on dunes, channelling of watercourses, covering terrestrial areas with solid surfaces, draining of marshlands, extraction of ground liquid, irrigation, ploughing, use of off-road vehicles, and vegetation clearance (Izakovicˇová, Špulerová and Petrovic, 2018). Consequently, the environment responds to these human land use activities regarding biophysical processes. These types of developments include accelerated earth corrosion, acidification of soils, beach erosion, climate change, a decline in biodiversity, enhanced conservatory effect, and weed incursion. All the mentioned methods have a profound impact on the environment, and sustainable development plans and ecological systems are inclined to modify these activities to create healthier and improved environments.

Many issues experienced in residential areas are ripple effects of nearby industrial zones, with the exception of poor communities who suffer their own environmental encounters. Although action is required to amend environmental concerns in these zones by the government, there are many solutions that the residents can execute to reduce environmental issues, as illustrated in **Figure 2.3** below.

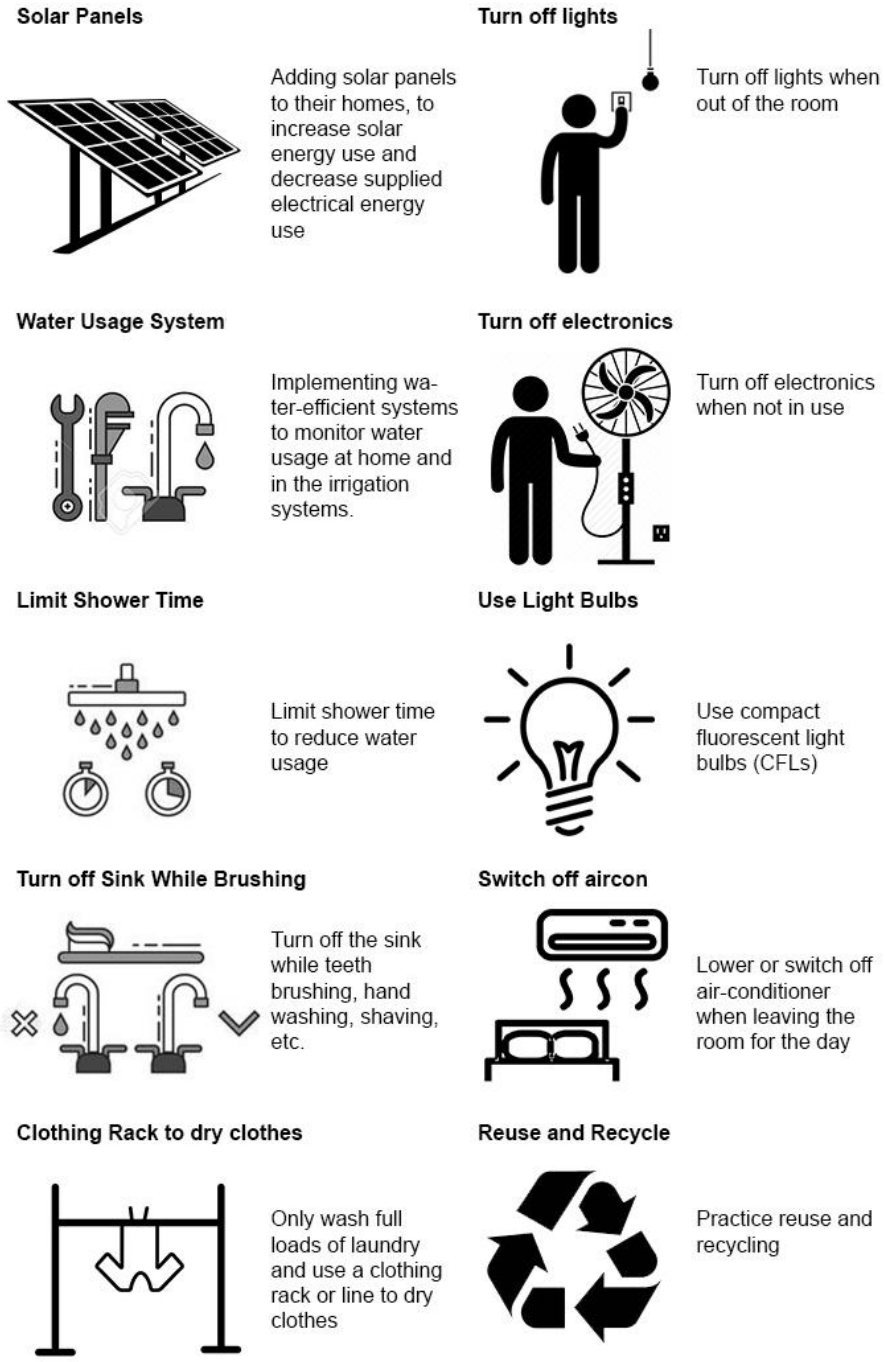


Figure 2.3: *Illustrations showing environmental solutions. Source: Author (2018)*

Environmental problems within urban settings are predominantly due to high air pollution levels, as well as hazardous waste (Speth, J.G., 1989). In South African cities, this is exacerbated due to the high rate of city commuters who work in urban areas and reside in peri-urban surroundings. However, in the case of the SDB, the residential neighbourhood is contiguous to the industrial zone, causing higher risk factors to the area. The cause of this prodigy is due to the prevailing change in approach to the urban environment, having a home in close proximity to work, as well as the Group Areas Act of 1950 which influenced the placement of settlements.

2.2 THE SOUTH DURBAN BASIN

2.2.1 About the SDB

The South Durban Basin has been considered one of the most industrialised areas in Durban, which negatively impacts the community's health and well-being. Industrial environments often operate as inhospitable working situations in comparison to a conventional office due to the exposure to numerous precarious elements. As stated by Joshi (2008), typical industrial environments consist of manufacturing facilities, factories, warehouses and plants, and often lack cooling and heating systems alongside a general lack of natural ventilation, which leads to the cause of air contamination. Noxious waste and noise pollution contribute to the undesirable surroundings, producing more effluence in the area. The environmental challenges faced in the SDB originated during the implementation of the Group Areas Act due to apartheid laws. In the year 1950, the Group Areas Act was initiated, forcing South Africa to divide into non-racial residential areas (Tolsi, 2008). This resulted in most of these residential areas coexisting adjacent to the SDB industrial zones which arose in the 1930s. According to studies by Peek (2002), up until 1938 the SDB was considered a flourishing market garden area, which then developed into an industrial zone due to the Durban City Council, which aimed to provide the labour force from the Black residential area that was in proximity to the SDB. The SDB was then viewed as an industrial hub, which contained more than 150 businesses that depend on unrefined oil, two petrochemical refineries, fibre

plants, dangerous compound storage facilities, numerous hazardous waste landfills, the Mondi paper mill, and the then main airport in Durban (Peek, S., 2002). While the airport is no longer situated in the SDB, the area's industries have since developed further, creating additional industrial pollution to the area. Studies by Durning (1990) state that even though apartheid displayed political inequality, it was also responsible for environmental injustice. Environmental struggles in South Africa also arose due to the spatial planning strategies of apartheid politics (Durning, 1990). As illustrated by Jaggernath (2010), the key community challenges in the SDB include: racial discrepancies, environmental pollution, health problems and medical bills, crime/drug abuse/violence, poverty and unemployment, devaluation of property, concentration of industries close to residential areas and lack of proper infrastructure and government funding. These aspects influence the community and contribute to the segregation that is currently still experienced. Since the SDB's existence and ongoing environmental conflicts, there have been several protests by the community due to many accidents emitting even more pollution. This has been caused by the industrial zones including the Engen refinery, which has contributed significantly to the uncontrollable and increasing pollution issue. As a result, the South Durban Community Environmental Alliance (SDCEA) was initiated to protect community members and to strive for a cleaner future.

> *"Tracing the area's beginnings, the tour is as historical as it is sociological. It reflects apartheid's harshness as well as its absurdities, presented with the colloquial humour typical of its inhabitants" (Tolsi, N., 2008)*

Racial Discrepancies, Employment and Health

Studies carried out by Vissers (2010) examined the influence of variables on community perceptions and the mindset towards possible responses with which to tackle air pollution. The investigation discovered that variables such as race and level of education had minimal impact on the outcomes. Studies by Brooks *et al* (2010) reveal that in the SDB, the African townships has been located in Lamontville, adjacent to the industrial zones,

the Bluff was established for White occupation, Merebank was demarcated for Indian people, and people of mixed race were situated in the Wentworth/Austerville area. Consequently, due to the differentiation of poverty status, it is evident that in South Africa, and profoundly in the SDB, communities of colour are unequally subjected to socio-economic dispossession and industrial effluence (Kalan, 2002). As stated by the South African Constitution (Section 24) by the Department of Environmental Affairs and Tourism (2005), regardless of colour, race or ethnic differences, all members of society have the right to a clean environment that is not detrimental to their health or well-being. This statement makes it evident that there is significant discrimination directed at communities of colour, and that the constitution does not abide by its own policies due to the lack of consistency to provide equal rights to all South African citizens.

The inability to provide equal rights is apparent in regard to employment in South Africa. Studies by Bush *et al* (2001) state that stigmatism has an effect on place identity and therefore influences social stigma that is connected to crime, deprivation, high levels of poverty and unemployment. Through a study conducted in the 1980s, it revealed that the number of people dying due to ill health caused by pollution was overemphasised by those who were low-income earners, divorced or unemployed (Bickerstaff, 2004). The study by Bickerstaff (2004) suggests that this is due to distrust of constitutional organisations by participants who are unemployed as a result of being economically and socially disadvantaged, leading to overestimating risks as well as estranging themselves from contributing to community decision-making in any regard. Awareness of air quality is not comprehended worldwide and is generally associated with “People’s sense of power over their space; psychological satisfaction of their living environment; and geographical distance to a specific pollution source” (Bickerstaff, 2004). This suggests that those who put forth their concerns about being in an environment that is polluted are generally people who have had no control over their physical circumstances, which proves to be evident and relevant to those in the SDB due to their geographical placement of residency by the Group Areas Act, displaying different social classes, racial discrepancies and employment in the area as a result of the Act. Due to the intensity of air pollution and health concerns in the SDB in

KwaZulu-Natal, it is the most investigated region in South Africa, with the result that within the SDB neighbourhoods there have been many studies explored regarding these issues (Brooks, Kistanasamy and Vissers, 2010). In addition to Vissers' (2010) study on air pollution was the negative impact that it had on health, with a focus on particular illnesses that contributed to the general lack of well-being by many of those affected in the area. According to Kukreja (2009), health issues associated with the effects of air pollution include respiratory and heart problems as well as cancer, among other conditions. As shown in **Figure 2.4**, there have even been newspaper articles regarding the health of the SDB community, leading to a City Cancer watch. Studies by Scott *et al* (2002) indicate that after interviews had been conducted with women living in South Durban, it was understood that Black women had higher levels of awareness of health concerns due to their geographical placement within the industrial zones, as well as those who resided in Merebank and Wentworth.


City cancer watch

A surveillance unit is to be launched to investigate links between environmental pollution across Durban and cancer cases among its people

City unit to lead cancer fight

Figure 2.4: *Newspaper Article regarding the health of the SDB community*
Source: Vissers, A. (2010)

2.2.2 South Durban Community Environmental Alliance (SDCEA)

The South Durban Community Environmental Alliance is an environmental justice establishment that has been operating since 1996 and comprises an association of fourteen civic and residents' assemblages in alliance. The organisation applies acts of environmental engagement which represent involvement of social protests in conjunction with anti-apartheid unions in order to mobilise the South Durban communities regarding race and class (Brooks, Sutherland, Scott and Guy, 2010). The SDCEA's aim is to implement their strategies to strive towards preventing further issues from arising. The policies construed by the SDCEA are in collaboration with the Area Based Management and Development Programme (ABMDP), an influential instrument that is used within the city. The ABMDP was introduced by the Ethekwini Municipal Authority (EMA), which pursued development action to improve service delivery, the democratic state and spatial and social discriminations, after forty years of supremacy through Area-based Initiatives (Pillay, 2015).

Research by Pillay (2015) demonstrates that the ABMDP was initially intended to be a five-year programme, however, after successful initiatives which gathered positive results that benefited the EMA, the programme was then established as an official agenda. The EMA considers the SDB as the industrial core of the initiative due to the decline of production in the SDB industrial region (Pillay, 2015). **Figures 2.5** and **2.6** demonstrate how the SDB community have rallied together on multiple occasions to petition for a cleaner future and city. The youth of the community have also been involved in these appeals, coming together and striving to make a difference for their fellow residents, as shown in **Figure 2.7**.Although there is a large number of pollution incidents that have transpired through the existence of the South Durban industrial areas, the major pollution incidents have been recorded by the SDCEA from the years 2000–2016, including the following: smoke covering South Durban in 2005; fire at Engen Refinery in 2006; overwhelming smoke from the Engen Refinery in 2006; fire at SAPREF Refinery in 2006; fire at Island View Storage in 2007; fire at Engen Refinery in 2007; fire erupting at Engen Refinery in 2011; fire at KZN Oil in 2015; and fire and explosions at SAPREF Refinery in 2015. These incidents have been recorded through local newspaper articles, revealed below in **Figure 2.8**. It is evident that most of the major pollution accidents that occurred were caused by fires, many of which were on account of the Engen Refinery. The Engen Refinery can be considered an influencing factor regarding waste and major pollution in the SDB, having been scrutinised for the gas omissions it produced in the area. In 2008, a memorandum of signatures through a petition regarding apprehension about the environment included signatures by concerned Durban residents, the SDCEA, political ecology students and GroundWork (Oosthuizen, 2008). After Engen had performed an evaluation, they perceptively responded to the commotion by stating their compliance with the legislation which encompasses the environmental standards, a response that reassured the neighbourhood. However, through the numerous accidents that continued to occur over the years and as a result of evidence conducted by Brooks *et al* (2010) via interviewing community members of the SDB, there has been minimal response to residents who have contacted the Engen Refinery for feedback on the implications that the refinery poses, and due to this, there is little faith that ENGEN will be controlled in the future.

Figure 2.5.: *Durban South residents petition for a cleaner future.*
Source: Beukes, L. (2015)

Figures 2.6.: *Durban South residents petition for a cleaner future.*
Source: Beukes, L. (2015)

Figure 2.7: *Durban South residents' children petition for a cleaner future.*
Source: SDCEA (2017)

Figure 2.8: *Compilation of newspaper articles illustrating multiple fire exposures experienced in the SDB, the public's concern with the Engen Refinery and their response to the SDCEA and increase in air pollution.*

Article 1: Fuel clouds billow as fire rages – November, 2007.

Article 2 & 4: Explosion at Island View Depot – September 2007.

Article 3: Fire heightens fears of residents – November 2008.

Article 5: Community resistance – September 2007.

Article 6: Uproar due to absence of refinery members to address 300 protesting community members – November 2007.

Article 7: Engen Refinery responds to the SDCEA – April 2009.

Article 9: Increase of Air Pollution in the Bluff – July 2009.

Source: Vissers, (2010)

2.2.3 Pollution

Pollution can be categorised into multiple types including air pollution, soil pollution, water pollution, noise pollution, toxic/hazardous waste and land degradation, among others. Industrial areas are a huge cause of producing pollution, with the South Durban industrial area being a prime example. **Figure 2.9** reveals the type of environmental pollution issues associated in the SDB through investigations by Jaggernath (2010). The percentages demonstrate the intensity of each pollutant within the SDB area. Air pollution is the infectivity of air caused by harmful gases, smoke and/or dust in the form of pungent odour, black smoke, white vapours and black ash particles, among other detrimental chemicals which are released by industrial environments. These chemicals include "*various Sulphur and carbon oxides, activated carbon with unknown quantities of dioxins and other pollutants, complex hydrocarbons, lead still emitted from vehicles, and other products of incomplete combustion"* (Wiley, Root, Peek and Ramurath, 2002). The contaminated air causes a decrease in plant growth and human health, interrupting the natural process of life. Due to the rapid growth of development in the world, there has been a major increase of air pollution that has altered the Ozone layer's magnitude, resulting in one of the most threating challenges that our generation faces. Regarding toxic/hazardous waste, research has revealed that Hexavalent chromium, or chromium-6, a toxic chemical produced by several industrial processes and known to be carcinogenic, had been discovered in the groundwater in Merebank (Brooks, *et al*, 2010). If waste is not appropriately disposed of it can leak into the water and surrounding terrain, which is extremely harmful to plants, humans and animals. In terms of noise pollution, this can be defined as noise which activates a damaging effect on human and animal life. Noise pollution is a disturbance and is caused by transportation systems, heavy operated machines and other sources of noisy industrial equipment (Kukreja, 2009). This disturbance can also be classified as environmental noise. In the SDB, this is an effluence issue that has contributed to the urbanisation of the neighbourhood area. Solutions that could contribute to reducing air pollution include the conservation of energy used, the process of reducing, reusing and recycling, green energy sources, and energy-efficient devices (Kukreja, 2009). The use of public

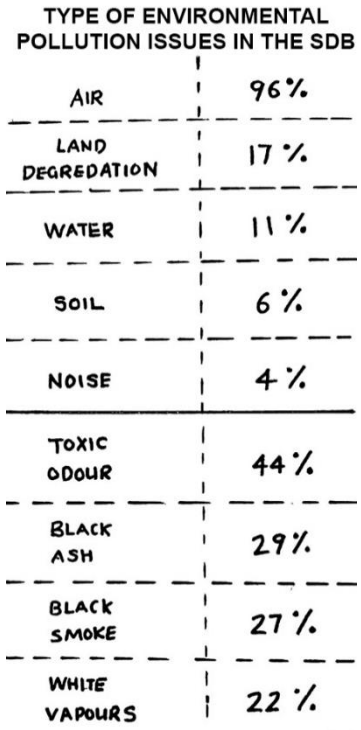


Figure 2.9: *Environmental issues associated with the SDB industries through investigations by Jaggernath (2010)*
Source: Author (2018)

transportation will furthermore decrease the number of cars used to transport those who work every day, which will also diminish air pollution.

2.2.4 Legal Pollution Legislations

Governmental laws and legislations are formulated to control the immoderation of an issue and to monitor unwanted issues from escalating. Legal pollution legislations in particular require these laws in order to supervise pollution from developing out of control. The SDB is a zone that obligates legal pollution legislations to manage various pollutants produced within the area, yet the issue of effluences remains out of control. The National Environmental Management Act (NEMA), Act No. 107 of 1998, is the framework with which to enforce Section 24 of the Constitution of South Africa and provides a fundamental framework for environmental law. The laws specified according to NEMA are as shown in **Figure 2.10**.

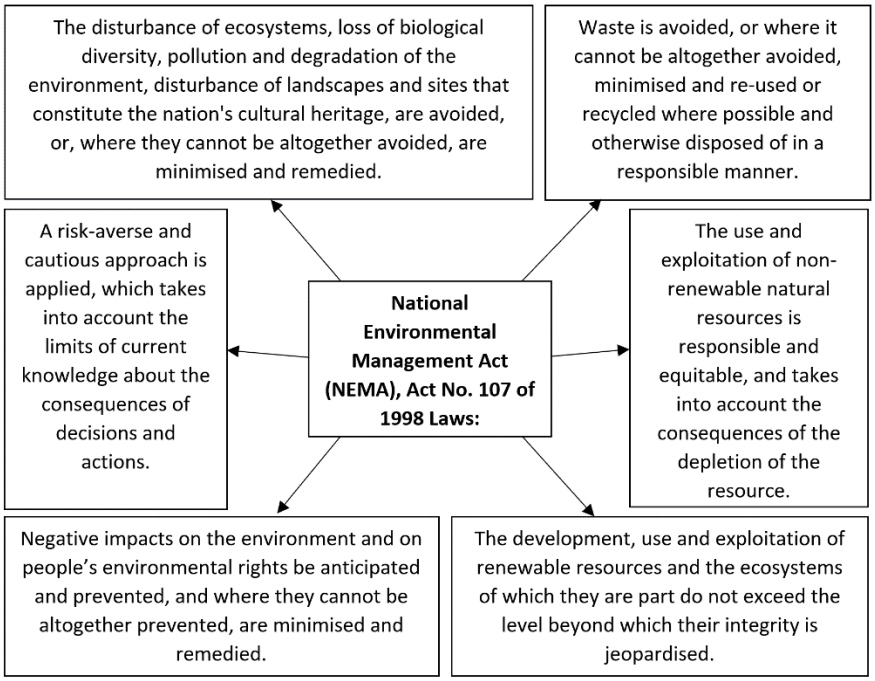


Figure 2.10: *The National Environmental Management Act Laws*
Source: Author (2018)

2.3 SUSTAINABILITY

2.3.1 Analysis of Sustainability

As mentioned in section 1.4.2, sustainability in the built environment from a global perspective is categorised into three components: Environmental Sustainability, Social Sustainability and Economical Sustainability, as shown in **Figure 2.11**. The basic objectives of environmental sustainability are to reduce consumption of non-renewable resources, minimise waste, and create healthy, productive environments whist conserving a viable natural environment (Akadiri, P.O.; Chinyio, E.A.; Olomolaiye, P.O., 2012). From an architectural point of view, sustainability is maintaining a congruent, long-lasting relationship between inhabitants and their surroundings and aims to maintain the earth's ecosystem and improve physical life on earth, which in essence are environmental elements, vegetation and animals. In order to achieve this, ecosystem services can be put into practice in urban settings to reduce and improve pollutants experienced by rapid growth and destruction of the environment. Socially, sustainability plays a role in the community, relating to the community's contribution in keeping a clean and healthy environment and maintaining an alliance of participation from all community members. Economical sustainability is one of the most important components in maintaining a sustainable environment. The aim of an economical approach is to preserve and improve the living standards and working environment of a city, and to avoid a decline in the economic system in a region. This chapter will further investigate sustainable building issues regarding economic, environmental and social sustainability according to Akadiri *et al* (2012), as well as research by author Jorge. E. Hardoy, researcher Dianne Scott, author William McDonough and the United Nations Brundtland Report.

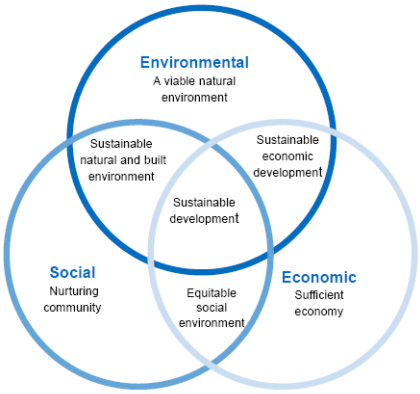


***Figure 2.11**: Sustainability illustration*
Source: Turner, P (2007)

Justification for applying the sustainable building issues is due to the SDB enduring most of the environmental, social and economic issues mentioned above. According to Hardoy (2001), there are imperative problems that go beyond the prevention of health issues, including the growth of populations in urban cities which causes excessive levels of greenhouse gases, resource

use and waste production, among many other key issues experienced through the different categories of sustainability.

Environmental Sustainability

The principle issues that environmental sustainability needs to respond to are: *minimising pollution emissions; counteracting irritation from noise and dust by site and depot management; waste minimisation and elimination; preventing pollution incidents and breaches of environmental improvement; protection of sensitive ecosystems through good construction practices and supervision; and green transportation plans for site and commerce activities* (Akadiri, Chinyio and Olomolaiye, 2012). Solutions to these issues are through effective protection of the environment by avoiding pollution, protecting and enhancing biodiversity, and transport planning.

Social Sustainability

Akadiri *et al* (2012) illustrate that the key issues regarding social sustainability are: *Establishment of effective training and appraisals; reasonable terms and conditions; equal opportunities; health, safety and conducive working environment; upholding employee satisfaction; involvement in decision-making; minimising local nuisance and disruption; minimising traffic interruptions and delays; building operative channels of communication; making a contribution to the local economy through local employment and procurement; delivering services that improve the local environment; developing long-term relationships with clients and local suppliers; communal citizenship; and delivering services that provide best value to clients and focus on developing client business.* In order to respond to these aspects efficiently, social progress that recognises the needs of everyone can improve action of these issues through respect for staff, working with local communities and road users and partnership formation.

Economical Sustainability

Sustainability in an economic context faces principle issues of: *Improved productivity; consistent profit growth; employee satisfaction; supplier satisfaction; client satisfaction; minimising defects; shorter and more predictable completion time; lower-cost projects with increased cost probability; delivering services that provide best value to clients; and*

focusing on developing client business (Akadiri, Chinyio and Olomolaiye, 2012). Responding to these key issues through maintenance of high and stable levels of local economic growth and employment will effectively improve project delivery as well as increased profitability and productivity.

Brundtland Commission's Report

Due to the growth of the population, along with economic and technological development in the 20th century, around the 1980s many new challenges and benefits were encountered by society (Bowory, 2014). For many privileged communities around the world, the change was beneficial in multiple ways. Life had become more convenient, healthier, longer and richer, and there was a rapid increase in first world countries with the middle class entering a high-income lifestyle. However, for low-income households and poorer communities, there was a major decrease in lifestyle. Although jobs had become more attainable due to the increase in job opportunities, there was a diminishment of the natural environment which had a ripple effect, from toxins contaminating agriculture, to lack of resources and ill health. The transformation anticipated for a change to be made, which is why the *Brundtland Commission Report* (BCR) originated. Norway Prime Minister, Gro Harlem Brundtland had a strong background in public health, and due to her association and experience with environmental health through the human environment and ecology, in 1983 the United Nations appointed Brundtland as the chairperson of the Commission (Bowory, 2014). The BCR was initiated to unite countries around the world to engage in sustainable development cooperatively. The Commission acknowledged that in order to articulate fundamental methods for the conservation of the environment, gender equity, poverty reduction and wealth redistribution were imperative elements to respond to (Pyla, 2012). The BCR was active until 1987, until *Our Common Future* (OCF) officially replaced it in 1988, also referred to as the *Brundtland Report*. The OCF embedded the BCR's qualities and aims whilst aspiring to treat the environment and development as one matter, which it subsequently achieved by embracing the concept of sustainability into the action plan. Investigation by Bowory (2014) describes sustainability as the competence of any conveyed system to subsist and reproduce on a long-term basis. This

statement, particularly, represents what the SDB requires in order to sustain a durable and resilient locale, maintaining and – more importantly – improving the current state of the area. By means of implementing these methods, the *Sustainable Development Goals* Act was then initiated.

2.3.2 Sustainable Development Goals (SDGs)

Origin and aims of the Sustainable Development Goals

The Sustainable Development Goals Act originated in the year 2012 at the United Nations Conference in Rio de Janeiro, which was held regarding sustainable development. The primary objective of the SDGs Act was to meet the crucial economic, environmental and political challenges faced in recent years by producing an established set of universal goals. Previously, there was the Millennium Development Goals Act, which was created to challenge poverty in the 2000s and contributed to the start of a stellar effort. The SDGs have now replaced the MDGs, currently also known as the Global Goals, which form part of a worldwide call to protect the earth, ensure harmony and prosperity, and sequentially end poverty (United Nations Development Programme, 2017).

In reference to the UNDP, it states that there are 17 goals associated with the SDGs, as seen in Figure 2.12. Each of these goals is interconnected in one way or the other and responding to one may subsequently improve another. The SDGs provides for common strategies for all countries to apply and practice the implementation of sustainable improvements, which will allow for positive changes in response to the environmental challenges faced. The United Nations Act of Sustainable Development Goals implies that there are numerous positive outcomes from which environmental and human life is impacted. These include food support, vaccine provisions, safety from escaping war, tackling poverty, defending human rights, health facilities, and many more humanitarian needs faced by millions of people around the world.

Development of Sustainable Development Goals

In 2016, New York implemented the Sustainable Development Goals programme to improve economic development in the city and ensure that all fundamental human rights are met, having seventeen varying goals, as demonstrated in **Figure 2.12**. Many aspects of the goals have been deliberated, with the seventh goal being the ability to provide for inexpensive, consistent, sustainable and modern energy for all. According to the Africa Progress Panel (2017), it also raises the concern that with energy usage, we have to remember that climate change could immediately affect how effective energy-based development is implemented. In Africa, there are endless possibilities when it comes to renewable energy. With assistance from countries around the world, the opportunity for expansion of low-carbon power would be promising. There are many opportunities for countries in Africa and numerous other nations to adopt the latest technologies and the practice of the SDGs. We need to rethink the existing relationship between growth and power, and consequently, plan for a better future.

***Figure 2.12**: Sustainable Development Goals*
Source: The United Nations (2016)

2.3.3 Ecosystem Services

Through the practice of sustainable development, compelling change to the environment could be generated by regenerating the existing environment through modernised systematic methods. There are several developing systems that are tested and produced in order to decrease our carbon footprint on earth. These systems are introduced as products or goods and services, either performed through manual exertion or technological systems. Studies by Le Maitre *et al* (2007) state that the outcome of these ecosystem services can be broken into four categories, namely: stabilising and regulatory processes, regenerating processes, production of goods, and life-fulfilling functions. Through stabilising and regulatory processes, the services provide regulation of the hydrological cycle, partial stabilisation of climate, moderation of weather extremes, compensation of a species, coastal and river channel stability, decontamination and maintenance of the gas composition in the air, and control of the majority of potential pest species (Le Maitre, O'Farrell and Reyers, 2007).

The regenerating processes provide generation and renewal of soil fertility, purification of water, detoxification and decomposition of wastes, pollination and the dispersal of seeds/spores necessary for revegetation. Examples of systems that can be used in relation to energy production and air control, are waste incinerations and hydropower systems. Waste incinerations use waste as a resource to reduce waste and create energy through excess gases formed from burning the waste, and a hydropower system uses the movement of water flow to create energy through generated turbines. Food, durable materials, energy, industrial products, genetic resources and pharmaceuticals are provided through the production of goods, whilst life-filling functions provide aesthetic beauty, serenity, cultural, intellectual and spiritual inspiration, scientific discovery and preservation of options for the future (Le Maitre, O'Farrell and Reyers, 2007). However, there are fundamental attributes that need to be considered in order to create a sustainable structure, including: passive solar design; energy-efficient building services; water conservation; materials specification; and landscape design and external works.

The SDB is an area desperately in need of the above-mentioned regenerating processes. Using these approaches and services in the SDB will allow for an improvement of the natural bionetwork, which will have a positive impact on the industrialised atmosphere. Although a drastic change will not occur or completely diminish all pollution overnight, it will slowly reduce the emissions in the air and gradually improve environmental facets and air quality.

Following the study of sustainability and the influencing factors of the Acts which contribute to environmental design and planning, is the Theory of Perception. From an environmental and regulative approach, to human observation and sensitivity. The subsequent chapter will outline and examine the relationship between perception and architecture, perception and industrialisation, and the industrial age versus the digital age.

2.4 THEORY OF PERCEPTION

2.4.1 Perception and Architecture

The Theory of Perception can be viewed as a human genetic response, considering that there are scientific and systematic responses to an environment based on the physical adaption of the human body. However, some believe that the human responses are interpreted through an emotional experience, along with scientifically proven attributes, and that there are amplified experiential attributes which contribute to a user's perception. As stated previously, each person's perception of touch, sight, hearing, odour and taste varies (refer to **Figure 2.13**), permitting every individual to have an inimitable experience. James Gibson is a psychologist and author whose approach entails these attributes. Culturally-shaped perception models change our understanding of space, our relationship to space and our use of space. According to Crary (1990), human perception is based on a considerably cultural range of expertise that is revolutionising over time and has become contained since the invention of optical devices in the 19th century.

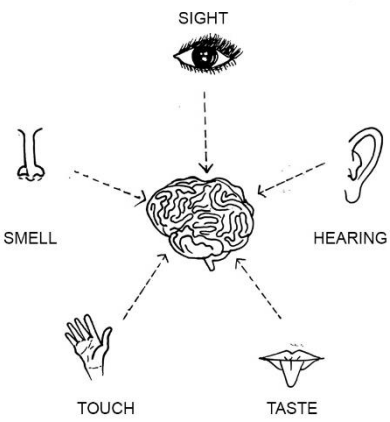


***Figure 2.13**: Human Sensory Responses: Sight, Hearing, Taste, Touch and Smell*
Source: Author (2018)

Sensation was a topic that was largely examined in the past, due to hesitation that sense and visual perspective were rational characteristics of sight. This made it difficult for many to gather the visual conception of three-dimensional spaces (Gibson and Carmichael, 1950). Through this phenomenon and the search to find answers, many possibilities arose which suggested that there was no correct resolution to be found. Studies by Gibson *et al* (1950) suggest that solidity and distance cannot be sensed by vision, which raised concern about how they are fundamentally perceived. Alternatively, perception is regarded as the conception that a material stimulus is not observed as a physical entity alone. It goes beyond the stimuli and bases its focal point of receptivity on sensations. Nativism and empiricism focus on the varying opinions of the three-dimensional perspective and the localisation of a space through the axis points which create two-dimensional location visuals (Gibson and Carmichael, 1950). Therefore, nativism and empiricism explore geometrical space perception. This marks significance architecturally due to the relationship between the

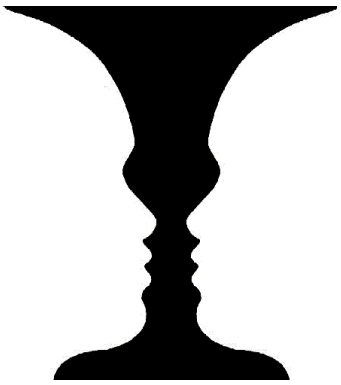


***Figure 2.14**: Gestalt Principle illustrating "Figure Ground", a visual principle in which an individual organises an image by separating a figure from the ground*
Source: Principles of visual perception (2017)

built environment and users' perceptions of a space. In architecture it is a fundamental concern to provide for the dwellers of the space created, which brings us to the justification as to why perception is so important to grasp in a built environment. The SDB is an example that displays what a perceived environment entails, being an industrial hub of overproducing noxious chemicals. It is perceived through the visual sight of a displayed concrete jungle which causes harm to the environment. So, how do we as a society alter the vision of such a categorised area to be seen as a positive space? Research by Gibson *et al* (1950) links Extensity and Location to Nativism and Empiricism, stating that the observation of a space constructs a localised characteristic of each point of reference as viewed by the retina of the eye. Due of this, each point materialises into a distinct category in our mind and translates into our derived perception thereof.

> *"Direct perception is the activity of getting information from the ambient array of light. I call this a process of information pickup that involves the exploratory activity of looking around, getting around, and looking at things. This is quite different from the supposed activity of getting information from the inputs of the optic nerves, whatever they may prove to be" (Gibson 1986, p. 147)*

Similarly, when designing a space that aims to encourage a positive outlook, there needs to be special attention given to detail in order to be perceived as an appealing location. This can be achieved through the choice of materials, colour, scale, size, form, shape, depth, distance and position, using each element to attract a perceived reaction from the users. Depth, distance, shape and form are fundamental contributors to the visual line of sight. However, the truth that our vision is in fact a line of sight and rays which focus two-dimensionally is what brings about the unsettlement as to why three-dimensional objects are viewed as is (Gibson and Carmichael, 1950). A contributing factor that assists in the formation of an object through the retinal vision is light. Light shines onto objects from multiple angles, whether it is the sun, the moon, or artificial lighting. No matter the source of light, it reflects off objects at a strength depending on the objects' material and, due to surrounding objects, shadow reflections add to the effect of light. The unification of light and shadow and the line of vision

and angle, together, allows any form to become three-dimensional to the naked eye. In **Figure 2.15**, a virtual interior is shown that illustrates how a space can be defined and demonstrated in multiple ways, which displays many alternatives for interpretation.

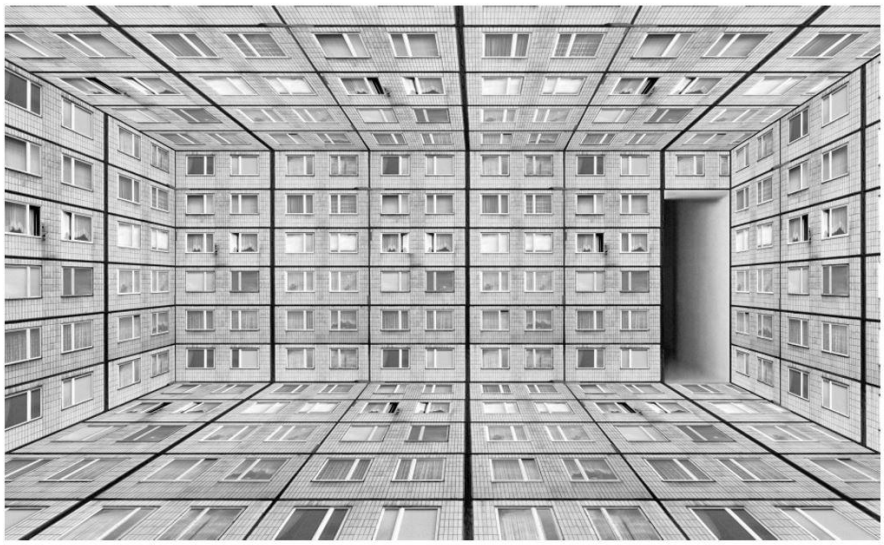


Figure 2.15: *Virtual interior illustration of a room space*
Source: Zinsmeister, A. (2007)

2.4.2 Industrialisation and Perception

Research by Kao *et al* (2017) demonstrates that an industrial urban zone traditionally features manufacturing enterprises. These zones are often located in the main urban areas of cities, thereby becoming a fundamental aspect of such cities. The perception of industrialisation represents growth and progress (Tan, 2016). Studies by Tan (2016) reveal that apart from being zones of evolution, they are also archetypes of a revolution of progression which reduces system environments. Old urban industrial environments are perceived as they are expressed. They express an authentic and unprocessed atmosphere of industrial texture, material and production. Industrialised areas have rather intense spatial integrity, with high buildings with many floor levels and large spaces within the buildings, the result being that the buildings become massive structures (Kao and Sung, 2017). However, with an increase in environmental growth, the decrease of industrial requirements and the waste of resources due to industrial areas, it is necessary to transform industrial zones to conform to

the growth of the world, improving and enhancing buildings in urbanised cities whilst protecting the structures and their cultural heritage. As stated by Kao *et al* (2017), there are many steps to be taken in order to accomplish these changes and enhancements, which include: the demand for land use zoning to be amended; development of urban ecological functions within an industrial environment; improvement and transformation of urban functional spaces; modification of existing structures; and the protection of the culture and history of a city.

Industrial Age vs. Digital Age

> *"Organizations today strive to become agile and to operate profitably in an increasingly competitive environment of continuously and unpredictably changing markets. The digital age is different from the industrial age in various ways"*
> *- (Filos, E. 2006)*

With an ever-changing world and eras that change rapidly as a consequence, there is constant and drastic transformation which occurs every few years. Each decade holds a time that elevates and encompasses certain attributes and fundamental characteristics, and an example of this would be the revolution from an industrial age to a digital one. The manner in which organisations and economic environments are perceived vary between these two ages, as shown in **Figure 2.16**. Society is required to change with the times and conform to the attributes that each age acquires. The SDB industrial zone is emblematic of what the industrial age symbolises. In order to design a recycling and educational centre in the SDB, modern fundamental qualities need to be taken into consideration in an attempt to create a balance between efficiency and social networking (Filos, 2006). In so doing, the proposed scheme will be perceived as intended, i.e. as an industrial revolution to combat air pollution and recycling issues whilst providing a socially-inclined active programme for the community. Health is not only a matter that is location specific to the SDB community, because health, fitness and striving towards having a healthy lifestyle has become a cultural aspect which has progressed through social media in our generation today. As demonstrated by Filos (2006), the

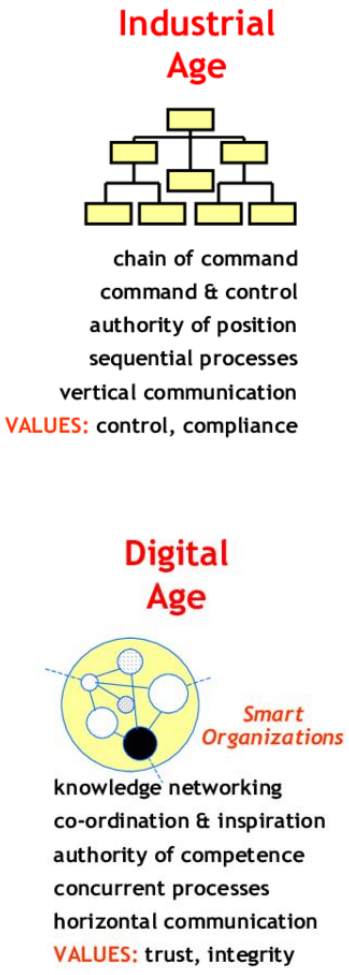


Figure 2.16: *Organisational culture of the industrial vs. the digital age*
Source: Filos, E. (2006)

industrial age organisations are efficient, hierarchal and tangible, whereas the digital age organisations embrace learning, are internetworked and are both tangible and intangible. In an economic environment, the industrial age displays certainty, little change, simple jobs, traditional skills, mass production, simple products and processes, and value is based on the "law of scarcity". The digital age, on the other hand, exhibits uncertainty, highly dynamic, complex jobs, e-skills, mass customisation, value-added products and processes, and value is based on the "law of abundance".

In addition, Filos (2006) suggests that over the last few decades Information and Communication Technologies (ICT) have influenced industrial value franchises by being the sustaining factor of executive change and modernisation. Studies by Ticoll *et al* (1998) suggest that the networking economy demonstrates that its fundamental attributes are through having the right connections, primarily between organisations and people. This is in response to the increase of networking in the global economy, which has revolutionised the economy as a result of the Internet and ICT. The Internet has enabled hyperlinking of all document types and also organisations and people over recent decades (Levine *et al*, 2000).

> *"In relationships that are fostered via networks, roles become blurred: the seller becomes the 'buyer' of valuable feedback on his product. Smart business organizations today see customers, suppliers, regulators, and even competitors as stakeholders who can make valuable contributions to their success"*
> *- (Filos, E. 2006)*

2.4.3 Conclusion

Justification in using this approach is due to including the varying parties in contributing to the SDB design proposal, as well as including the general public as an additional party to participate in the network of recycling and being educated about it through a modern industrialised approach. The culture of social media and the influence that it currently has on the community is also a major contributing factor which can influence the facilities provided in the design approach.

Through social media, the impact is not limited to one online platform. Instead, the influence comes from the content shared on each network and the ability to share eye-catching and intriguing photographs and videos of the subject matter intended. In order to do this, the use of corrected lighting, contrast, shadows, colour and clarity are used to create captivating content. Similarly, it is not limited to the device used, but rather, the content that is stored on the device. In comparison to architecture and the built environment, perception is viewed in a similar approach, due to the observation of a space being dependent on the substance of the space, not the location or placement of it. The colours, textures, light, size, and shape, are all contributing factors to the viewer, which is the attraction created. Consequently, in response to sight, the other primary senses of touch, sound, and smell articulates a response to create the viewer's perception of the space.

In the next two chapters, perception is highlighted through selected existing architectures. These chapters include examinations of sustainability and urban agenda within the precedent and case studies, and aims to identify key factors which relate to environmentalism in urban settings, as well as strategies used to implement ecological responses whilst correlating human scale connections through modernistic approaches.

CHAPTER 3: PRECEDENT STUDY

Amager Bakke, Bjarke Ingels' Waste-To-Energy Plant

3.1 Introduction

In this chapter, Bjarke Ingels' Amager Bakke Waste-to-Energy Plant (ABWEP) in Copenhagen will be investigated. Bjarke Ingels' unique approach to sustainability through a climatic-inclined design method fundamentally contributes to sustainability. Linking his tactics to the design approach will contribute to identifying methods of eliminating air pollution in the Durban environment, which provides considerable strategies from which to derive inspiration. The project's urban context, objectives, programme and planning, theoretical and conceptual analysis, analysis in relation to the studies' research questions, and design rationale will be examined. Through analysing the selected precedent and linking the design to the research problem, a developed understanding of the design approach will be attained.

Figure 3.1: *Elevation of the Amager Bakke*
Source: Bjarke Ingels Group (BIG) Architects (2018)

3.2 Urban Context

The location of the ABWEP embodies the Oresund Region coastlines of Denmark and Sweden within a marine west coast climate zone, with annual winter snowfall and moderately pleasant summer days (Schröpfer, 2016). Research by Schröpfer illustrates that the ABWEP is located on the island of Amager, linking the cities of Amager and Copenhagen. It is situated alongside the Amagerforbraending energy plant in Copenhagen, currently in existence for 47 years (Refer to **Figures 3.1** and **3.2**). The two areas of Copenhagen and Amager that the ABWEP encompasses are divergent zones, which include an industrial zone and residential area. This marks significant comparison to the South Durban Basin (SDB), having distinctive differing areas adjacent to one another. The environmental aspects of both the Amager/Copenhagen and SDB zones are similar, therefore implementing a similar strategic method will be beneficial to the design approach of this study. The design of the ABWEP was through a partnership between the Bjarke Ingels Group (BIG) and Danish landscape

Figure 3.2: *Urban context of the Amager Bakke*
Source: Bjarke Ingels Group (BIG) Architects (2018)

architects SLA and constructed by Danish municipality-owned company Amager Resource Centre (Nelson, 2018). The ABWEP will be the tallest structure in Copenhagen, alongside the city's largest yacht harbour (Schröpfer, 2016) as shown in **Figure 3.3**. The urban setting is predominantly flat, hence creating a tall and angled structure would bring dominance to the building, marking it as an attraction to the city.

Bakke from the yacht harbour
Source: Bjarke Ingels Group (BIG) Architects (2018)

3.3 Project Objectives

According to Gore (2017), the objective of the Amager Bakke was to create a waste-to-energy plant by introducing the scheme as a public building, thereby changing the public's perception of a power plant as a utility building and encouraging people to embrace the objectives of the scheme. Ingels' argument illustrates that while there are many people who believe that the world is taking a direr turn, there are still those who are optimistic about growth and improvement of environmental matters through technology. Ingels' (2011) approach towards sustainability is what he refers to as "hedonistic sustainability", which can be defined as a method that embraces urbanised change towards self-satisfaction and an improvement of quality of life, a methodology the ABWEP innovatively incorporates (Ingels, B., 2011). In **Figure 3.4**, a corner elevation of the building is shown, revealing how the powerplant has been transformed into an element which not only stands out in its location, but also blends into the surrounding ecology through the use of the slope integration. Having the two elements of "snow" on the slope and the land greenery congregate effortlessly, allows the structure to effectively incorporate a contrasting relationship between machine and nature. The ability to create a ski-slope which incorporates nature and human interaction on the power plant is a major factor which sets the Amager Bakke apart from other archetypal power plants world-wide. **Figures 3.5** and **3.6** reveal what the outcome of the ski-slope will entail once launched, allowing public interaction on a recreational scale. If these images were viewed without knowledge of the ABWEP, it would cause for misconception of the milieu of the arena. This correlates with the theory of perception, and reveals how successfully the operation of integrating a public space on an industrial facility has been delivered.

Figure 3.4: *Elevation of the Amager Bakke*
Source: Bjarke Ingels Group (BIG) Architects (2018)

Figure 3.5: *Amager Bakke ski-slope daytime illustration*
Source: Bjarke Ingels Group (BIG) Architects (2018)
Figure 3.6: *Amager Bakke ski-slope night illustration*
Source: Bjarke Ingels Group

Research on the ABWEP by Nelson (2018) states that the design intends to incorporate a 52,000-square-foot park, which will be developed on the steep sloped roof. This will allow the roof to have a functional purpose, accommodating multiple open-air activities. Due to the climatic traits of snowfall during the winters, the roof will act as a ski slope, being the primary feature among other activities (Nelson, 2018). However, in creating such a bionetwork there are many obstacles to be faced. These include the climatic conditions at a height of 100m, which will stagnate trees and plant growth in comparison to if they were to be planted on the ground, as well as the temperature experienced from within the building due to the energy boilers inside, which create heat up to 60º C (Nelson, 2018). In response to this, SLA established suitable vegetation and material compounds through a range of examinations that would be suitable for these conditions, the result being a green space which generated an ideal environment for open-air activities that can be conducted throughout the year. According to studies by Coffey (2016) and Nelson (2018), the ABWEP includes a 440-metre slope which splits into three varying skiing lines; climbing walls (Refer to **Figure 3.7**) due to the height of the building; a 180-metre black running path with a slope of 45 degrees which will be accessible through carpet ski lifts; an elevator inside the ABWEP to take snowboarders and skiers to the top; hiking trails; playgrounds and scenic views.

Figure 3.7: *Amager Bakke climbing wall illustration*
Source: Bjarke Ingels Group (BIG) Architects (2018)

> *"We've had to ensure that the rooftop's many activities are realised in an accessible, intuitive and inviting manner…. The goal is to ensure that Amager Bakke will become an eventful recreational public space with a strong aesthetic and sensuous city nature that gives value for all Copenhageners—all year round"* *- Rasmus Astrup, partner of SLA (Nelson, 2018)*

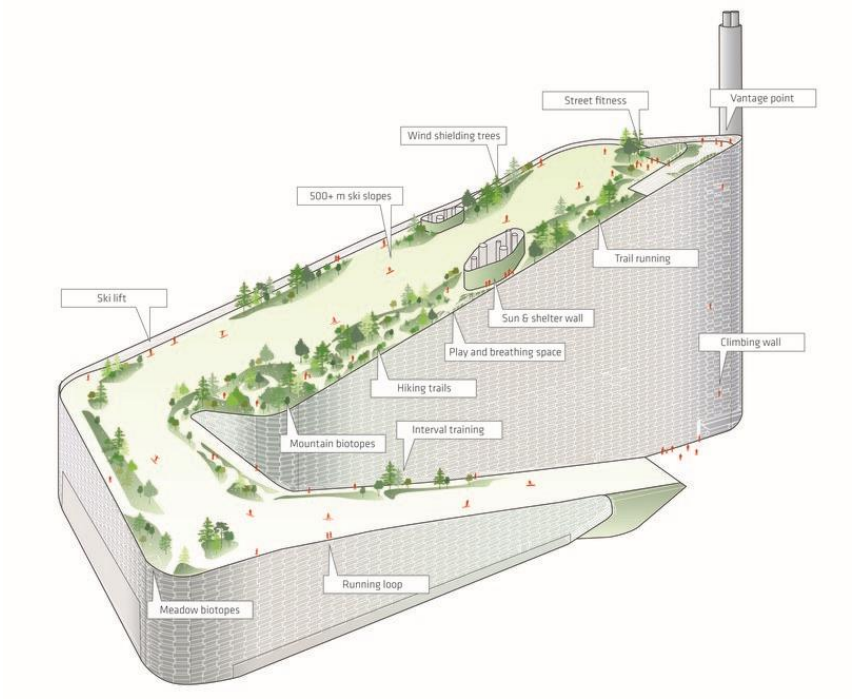


Figure 3.9: *Diagram showing the roof's layout of the ski slope power plant*
Source: Nelson, T. (2018)

3.4 Programme and Planning

Through Ingels' approach of hedonistic sustainability, the style of the building is required to respond to the surrounding context. In order to achieve this, and with the power plant's prerequisite of a smokestack, BIG made the innovative decision to raise the building on one end, thereby creating the ski slope (Schröpfer, 2016). Obtained through research by Babcock and Wilcox Volund (2013), the energy plant is set to accomplish the following goals: provide clean energy to 60,000 households with electricity annually; supply district heating to 120,000 households annually; consume steam data at 440º C and 70 bars (this doubles the electrical efficiency in comparison to the former plant Amagerforbraending; and burning around 400,000 tonnes of waste produced by 500,000 – 700,000 inhabitants and at least 46,000 companies annually. The result of burning 400,000 tons of waste a year will be: 99% energy efficiency; 100 million litres of spare water recuperated through flue gas compression; 90% reuse of metals from waste resulting in 10,000 tonnes of metal a year; and

Figure 3.8: *Amager Bakke hiking trail illustration*
Source: Bjarke Ingels Group (BIG) Architects (2018)

100,000 tonnes of bottom ash reused as road material, which will save large amounts of gravel (Babcock & Wilcox Volund, Undated).

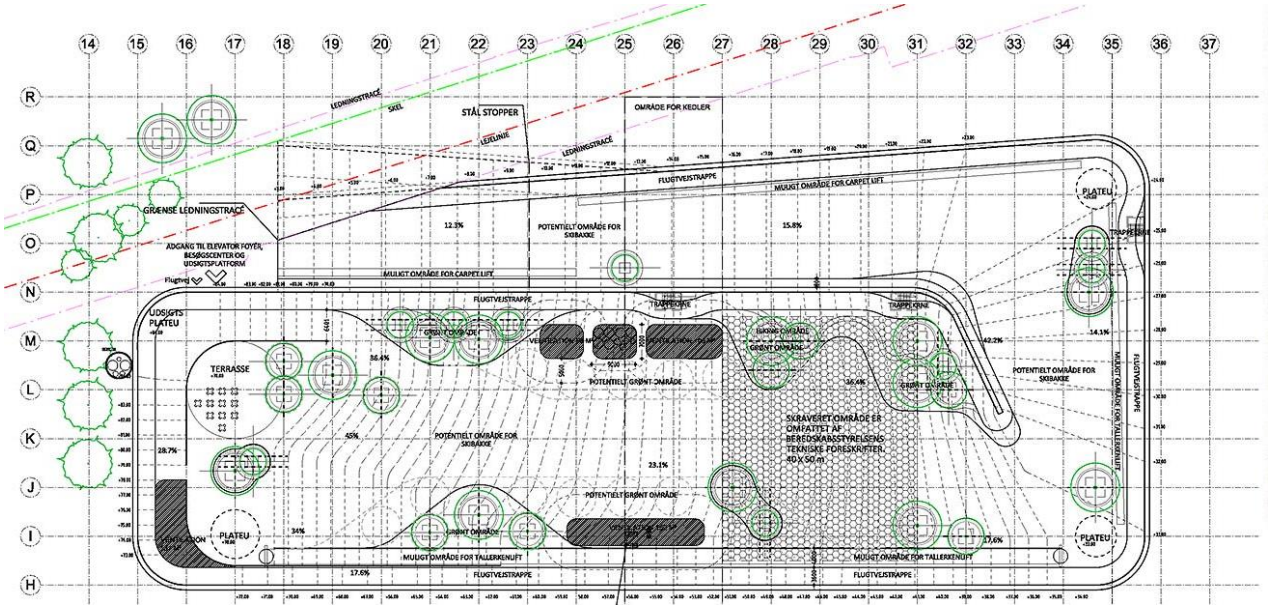


Figure 3.10: *Plan of the Amager Bakke*
Source: Bjarke Ingels Group (BIG) Architects (2018)

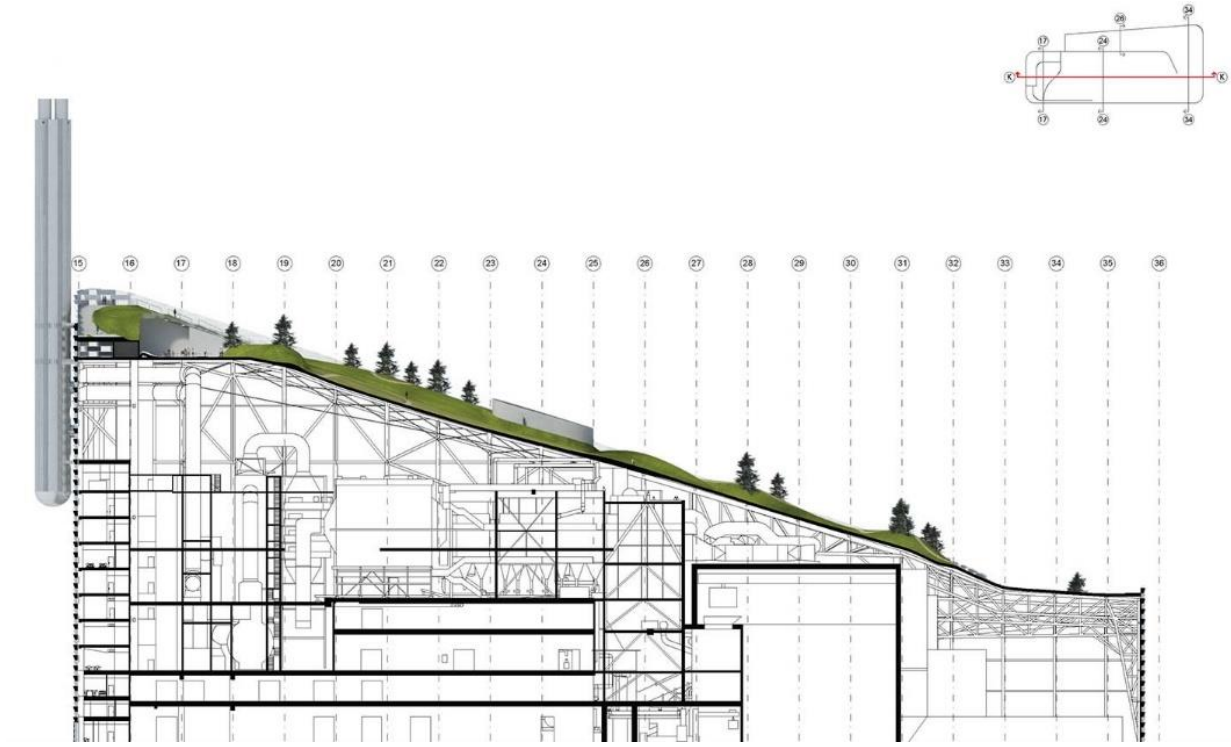


Figure 3.11: *Section of the Amager Bakke*
Source: Bjarke Ingels Group (BIG) Architects (2018)

3.5 Energy Efficiency

An aspect of the new technologies to be implemented into the ABWEP included a contribution from Babcock and Wilcox Volund. These contributions included a crane feeding system with a hopper, DynaGrate with a water-cooled wear zone, a boiler, ash system, electrical system, electrostatic precipitator for the diminution of particles in the flue gas, Selective Catalytic Reduction (SCR) for decrease of NOx emissions, economiser for cooling of flue gas and a combustion control system.

> *"State of the art technology at Amager Bakke has an incredibly high environmental performance. Not least because the plant makes full and efficient use of the energy contained in the waste. It is possible to process all types of waste as fuel and still obtain a high level of energy recovery. For instance, we are able to use the organic fraction contained in the waste very efficiently"* (Babcock and Wilcox Volund, 2013)

Process Parameters:	
(Guaranteed values)	
Waste capacity	35 t/h
Heat value, lower	11.5 MJ/kg
Steam output	141.1 t/h
Steam temperature	440 oC
Steam pressure	70 bar
Boiler outlet flue gas temp.	160 oC
Feed water temperature	130 oC
Flue gas out of boiler:	
(Guaranteed values)	
NOx**	15 mg/Nm³
CO***	50 mg/Nm³
NH3**	3 mg/Nm³
TOC	5mg/Nm³

Figure 3.12: *Guaranteed Values displaying the plant design data set to be accomplished by the ABWEP in compliance with the EU directives.*
Source: Author (2018)

According to Babcock and Wilcox Volund (2013), the ABWEP is a plant that consumes and utilises more than 100% of the fuel's energy substance, has a 28% electrical efficiency rate, reduces Sulphur emissions by 99.5% and minimises NOx emissions to a tenth, compared to the former plant. The NOx reduction is enabled due to a flue gas cleaning technology, and SCR will be installed in cooperation with the catalyst manufacturer Haldor Topsoe. The ABWEP is the first Danish waste-to-energy plant with an installation of SCR in it; therefore, this can alleviate ski enthusiasts about the air quality at the slope on the operating plant.

3.6 Theoretical and Conceptual Analysis

Sustainability

The Amager Bakke embodies many fundamental qualities of sustainable development and perception. Through sustainability, the ABWEP aims to deal with waste management through design, which is typically not a connected duo. Similarly, to the SDB, in the 1960s Denmark's waste caused many health concerns, and waste was viewed as an environmental issue.

Through sustainable approaches and international involvement over the decades, waste went from being a health problem to a resource, as seen in **Figure 3.13**. The approach of the ABWEP incorporates and responds to multiple aspects of the Sustainable Development Goals Act (refer to Figure 2.12), including: affordable and clean energy; industry, innovation and infrastructure; sustainable cities and communities; responsible consumption and production; climate action; and life on land.

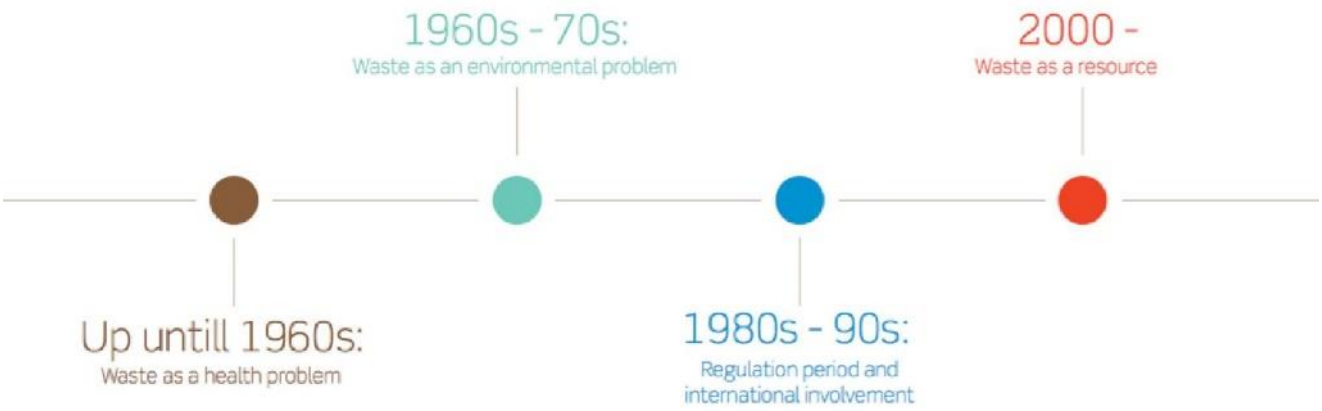


Figure 3.13: *The history of Danish waste management*
Source: Sattari,. (2017)

> According to the ARC, *"With the construction of Amager Bakke, we are creating a multifunctional, social and cultural waste-to-energy plant with an emphasis on sustainability. The residents of the capital area will get, aside from more green energy, access to first class architecture and a new modern recreational opportunity – and Copenhagen will have a new green landmark."*

Perception

In relation to perception, Ingels' vision has innovatively taken a building that originally served no public interest in terms of leisure and transformed it into a project which is usable by the community in a considerable way. It is evident that the industrial age vs. the digital age has been accounted for through the ability to function as a concurrent process rather than an authorisation of position. This has been accomplished through the fundamental aspects that target the users' sensory responses, which in this

paradigm influences *sight* through the view of the ski slope, *smell* of the simulated natural environment, *touch* through the ability to interact amidst the intended activities, and *sound* through the sounds produced from the ski slope activities and the power plant machinery. The power plant is considered as a public domain, which in itself indicates that perception of the development has been successfully achieved as intended, which conventionally is difficult to achieve with a building as such.

Environmental Agenda

The major subject areas (refer to **Figure 2.1**) of the Environmental Agenda display matters in relation to environmental urbanism and the relationship construed between an urban location and the people who experience the environment. The Amager Bakke has taken these subject matters into account and has dealt with energy strategies, toxics and pollution control, urban environments, international responsibilities, protected land systems, and water resources. This has been displayed through the relationship of land and water, public and private use of the building, and strategised methodologies which combat and reduce pollution issues. Systematic efforts have been incorporated using the Global Environmental Agenda (GEA) effectively, addressing climate change, promoting a cleaner city, providing basic services, promoting green public spaces, strengthening resilience, and supporting green initiatives.

Conceptual Analysis

Conceptually, the waste-to-energy plant uses a comprehensive strategy towards sustainability. The implemented methodologies extend from the level of the building systems to the urban and social incentives applied. The exterior façade of the building encapsulates an indoor / outdoor construction through the use of a contrasting panelling system of glass and concrete. This provides natural lighting and ventilation into the building to create a relationship between the power plant's operative accommodations to the natural world outside. As illustrated in **Figure 3.14**, skeleton-like shadowing is created on the building which allows the building to "breathe". This is achieved through its ability to formulate the exterior pattern, establishing a visually dense but aerated building.

Figure 3.14: *Amager Bakke interior illustration of lighting and wall construction.*
Source: Etherington,. (2011)

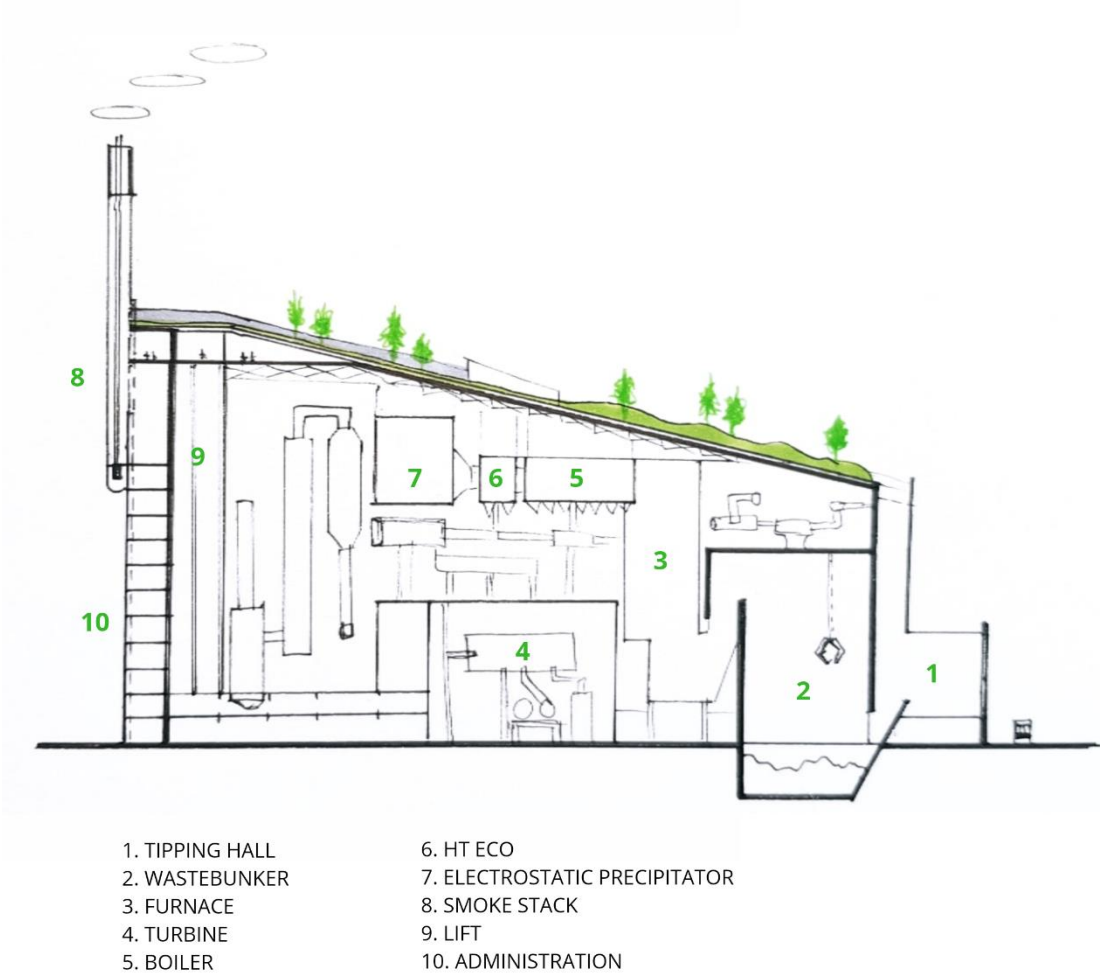


Figure 3.15: *Amager Bakke Sectional Illustration showing how the Waste-to-energy system works*
Source: Author (2019)

The Waste-to-energy system process documented in **Figure 3.15** illustrates the primary steps in which the waste incineration is used to burn waste to create energy, showing the first step in the process being the tipping hall where the waste is dropped off, working its way to the final step where the smoke stack releases steam smoke rings once the incineration process has completed.

Rooftop rainwater collection systems are included in the nature-to-machine correlation in the ABWEP, and are reused for stormwater management and irrigation purposes (Refer to **Figure 3.16**).

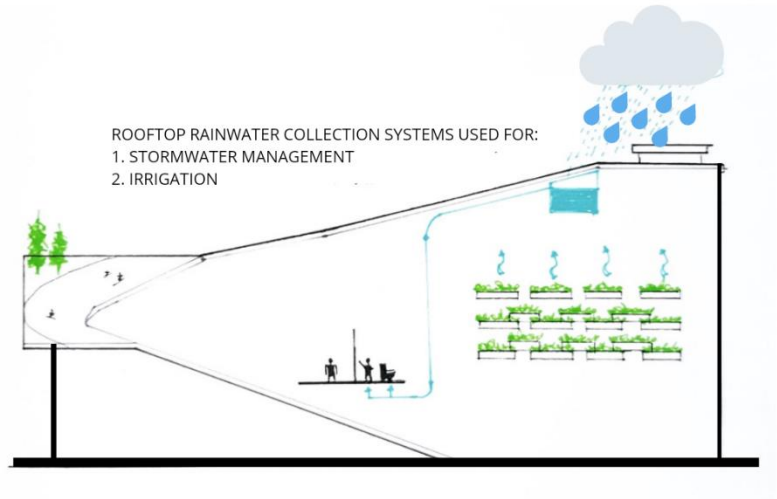


Figure 3.16: *Illustration of rainwater collection systems and waste sorting plants*
Source: Author (2019)

The fumes and smoke from the waste incineration are processed through a mechanism which transforms the smoke into smoke rings. These smoke rings will be created through flue gas machines which will clean and purify the smoke of toxic particles, releasing steam, which once processed, creates the rings (as seen in **Figure 3.17**).

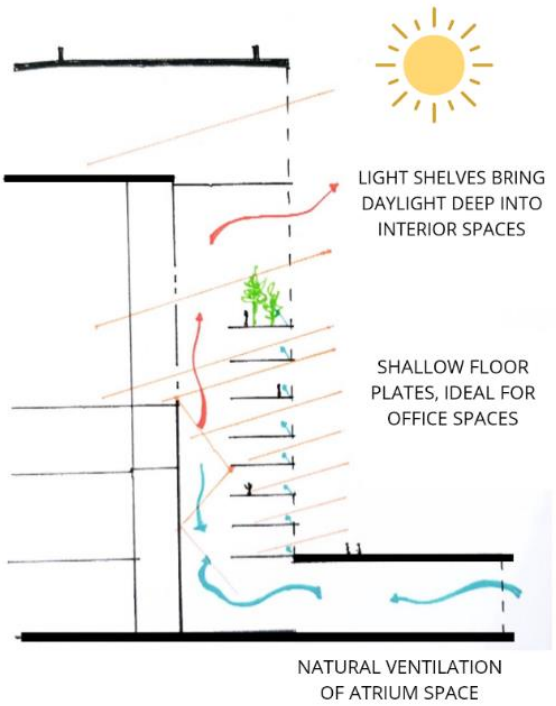


Figure 3.18: *Illustration showing natural ventilation and light into the building*
Source: Author (2019)

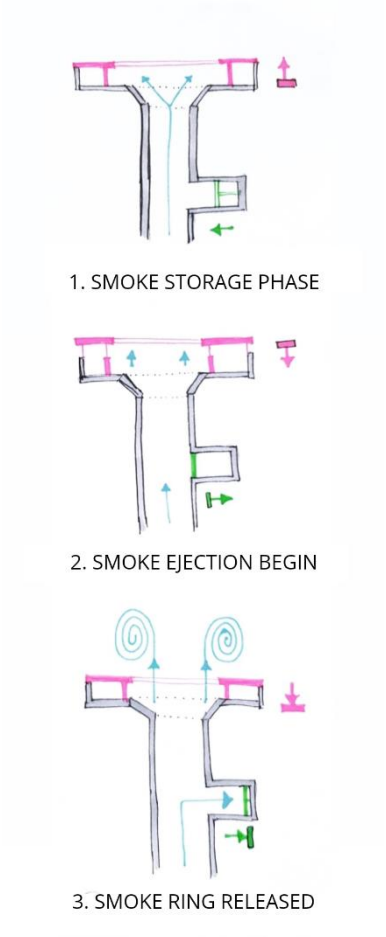


Figure 3.17: *Illustration showing smoke ring process*
Source: Author (2019)

3.7 Conclusion

Amager Bakke is a megaproject that has aimed to transmute a large amount of waste to benefit a substantial area in Amager and Copenhagen by providing energy to the community and reducing waste. It is a remarkable paradigm that utilises an existing industrial structural system and transforms it into an exhibit that incorporates multiple aspects of sustainability, advancing environmental, economic and social sustainability effectively. The ABWEP is a prime example of what can be achieved through considerable design and implementation, and if similar approaches and methodologies are integrated into the South Durban industrial precinct, in time, waste issues will also have the ability to transform from being an environmental issue to a resource for the city of Durban. This responds to the primary research question of what architectural solutions can be used in the design of a waste incineration and eco-educational facility to improve quality of life to the SDB, and how it will have a positive impact on the health and lifestyle of the community. This chapter aimed to understand the process of a waste incineration system and how waste can efficiently be transformed into energy without creating more air pollution. Gaining this understanding can now translate into the design response effectively if implemented correctly. The next chapter studies two existing architectures within the city of Durban, analysing and examining the different organisations, and studies how the design principles used could also be adopted and used as a response in the design proposal to the research problem.

CHAPTER 4: CASE STUDIES

4.1 MARIANNHILL LANDFILL CONSERVANCY

4.1.1 Background and Urban Context

Waste management is a major enterprise in every city around the world. Regulating excess waste proves to be difficult in many instances due to the uncontrollable odour and hazardous effects that are caused through landfills. Research by Nel (2007) states that in the year 2003 the National Association of Conservancies of South Africa (NACSA) was non-existent; however, by 2007, NACSA was operational in seven South African provinces, protecting thirty million hectares of property through seven hundred and fifty conservancies (Nel, 2007). The spokesperson from NACSA articulates that, *"If we are to strive for healthy communities within a healthy environment, we have to protect the spaces that sustain us… Citizens are empowered to oppose powerful and elitist developers. We manage the land at community level. That's our strength."* Through this network of conservation through resources, a huge impact has been made by NACSA, regardless of limited funds to sustain such organisations (Nel, 2007). The Mariannhill Landfill Conservancy (MLC) has been acknowledged as the only conservancy in Africa that is proclaimed as a nationalised conservancy. It has been operating since 1997 and is located in Mariannhill in Pinetown, KwaZulu-Natal. This South African conservancy reveals a range of environmental resources through engineered creativity. According to Black Balance Projects (2015) in conjunction with innovative sustainable solutions, the Pinetown South Local Area Plan review states that the area contains substantial natural assets which include grasslands, forests, nature reserves and wetlands. The eThekwini Municipality has been in union with the reserves in order to re-establish environmental infrastructure in the area, including the MLC, through acclimatisation involvement. The MLC has been integrated into a location that is considered as an environmental restoration zone and is legally enlisted as a National Conservancy Site, as stated by the Impumelelo Social Innovation Centre (2016).

Figure 4.1: *Urban Context and Location of the Mariannhill Landfill Conservancy*
Source: Landfill Conservancies (2016)

Figure 4.2: *Signage upon arrival of the Mariannhill Landfill Conservancy*
Source: Author (2018)

Figure 4.3: *A load of waste being delivered to the MLC, with a view of smoke from the landfill machinery*
Source: Author (2018)

4.1.2 Justification for the study

The MLC has conveyed an inventive technique and methodology of landfill waste administration and maintenance, which establishes the justification for the study in relation to the SDB. It embodies similar problematic factors in relation to excess waste and dealing with precarious pollutants. Although the conservancy accommodates no actual structure, it symbolises attributes of the key concepts and theories explored in Chapter Two, namely sustainability and perception. Being a communal-founded preservation organisation, the conservancy attempts to undergo maintenance and sustainable upkeep of the area's resources without negotiating the use of land unreasonably. Furthermore, coexisting in Durban, the MLC deals with comparable socio-economic and equivalent climatic concerns as the SDB.

Figure 4.4: *Refuse removal signage at the Mariannhill Landfill Conservancy*
Source: Author (2018)

4.1.3 Project Objectives and Planning

The primary objective of the MLC is to reduce emissions of greenhouse gases and waste consumption for protection against pollution in the environment. A realistic engineering approach has been taken in order to incorporate a "closed-loop" system, as stated by John Parkin, the Deputy Plant Manager and as illustrated in **Figure 4.5**. Mariannhill's approach to the conservancy is through merging conservational landfill procedures with modern energy-efficient and sustainable technology, as well as community participation, to promote recycling and educate the public of the importance of contributing to environmental concerns.

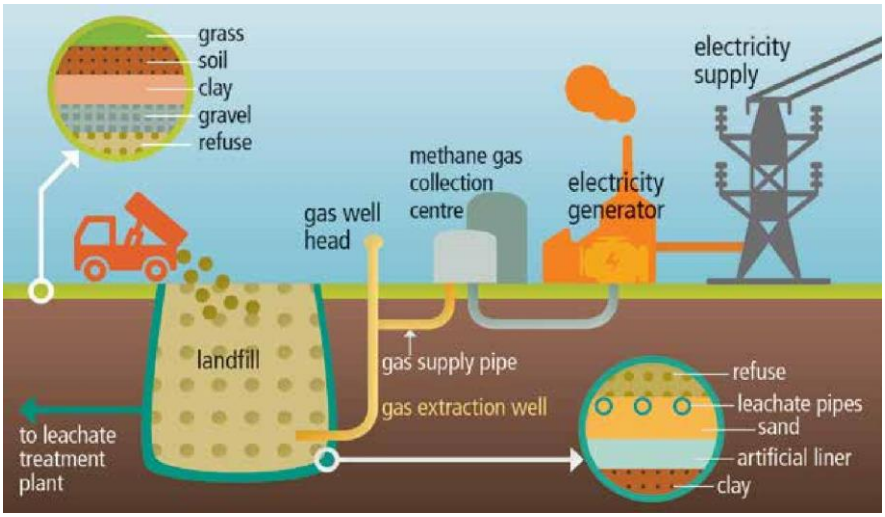


Figure 4.5: *Landfill illustration*
Source: Stiftung, H.B. (2016)

According to Parkin (undated), the MLC is set apart from the traditional landfill in order to reduce any damaging impact on the community. Generally, a landfill causes harmful and unwanted pollutants to enter the atmosphere, jeopardising the community's well-being when located in an urban context. However, this is not the case with the Mariannhill landfill, the reason being that it challenges this reality and aims to control gas from the disintegrating waste in order to produce electricity (Land Conservancies, 2010).

The MLC inhabits 4,4 million cubic meters and collects 850 tons of compact waste daily. The soil is rich and the landfill embodies many units of land which are used in sequence, thus, as one unit has reached its limit of waste disposal, the next cell is arranged and set up to receive the following load (Moodley, 2014). Research by Moodley (2014) states that additionally there is a Plant Rescue and Rehabilitation Unit and a nursery, which was introduced for the reutilisation of indigenous plants and soil. The consumed plants and soil from one unit of the landfill are used for regenerating the other units as well as the newly grown plantation in the nursery. The process works by replacing the removed plantation from an active unit with the nursery plants to rehabilitate those units, which consequently transforms into a forested environment.

According to the Land Conservancies (2010), the Mariannhill conservancy's principle objectives are: to manage, protect and develop the area's ecology; to eliminate alien vegetation; to educate the public and bring awareness to environmental issues; to encourage waste minimisation, recycling and reuse; to supervise waste disposal; to reduce landfill effects on the environment; to reduce pollution; to counteract soil erosion; to monitor intended developments in the surrounding area; and to conserve and rescue local plantations.

In addition to the principle objectives is the environmental management plan of the Mariannhill Landfill, as seen in **Figure 4.6**. The plan outlines copious ways to deal with the ecology of the area, with strategic methodologies to rehabilitate and reuse the environmental resources on site.

Figure 4.6: *Environmental Management Plan by MLC*
Source: Author (2018)

Apart from the landfill and nursery, the MLC also introduced bird life onto the location. Thirty hectares of the storage zone consists of forests, wetlands and associated bird life. Due to the size of the plantation zones, the landfill site located on Bisasar Road in Durban also uses plants from the MLC for treatment and rehabilitation of their landfill. The wetlands have performed a vital function in the MLC due to their beneficial outcomes, which include disrupting the momentum of storm water energy, counteracting erosion and eliminating toxic materials. It has also become a refuge for bird life, with 118 documented bird species making use of the area (Moodley, 2014).

Figure 4.7: *Waste Management Optimisation Pyramid*
Source: Author (2018)

4.1.4 Theoretical and Conceptual Analysis

Sustainability

Landfills are essential in every city due to the uncontrollable increase of waste production in society. Through the approaches mentioned in section 4.1.3, it is apparent that sustainability is the driving force behind the initiative. With the residential areas being in proximity to the landfill, in a typical scenario the area would have had to deal with unwanted odours and hazardous chemicals; however, the MLC prevents these issues. The waste compost generated by the site has proven to be extremely cost effective as the methane gas produced is converted into electricity, which is exceptionally self-sufficient (Impumelelo Social Innovation Centre, 2016). Providing educational tours to involve the public in its initiatives displays the diversity that the MLC offers, including the diversity of operations provided on site. Through the establishment of its nursery and associated job creation, it has provided employment opportunities on site, positively benefiting the economy. Thus, by combating industrial conflicts by integrating environmental and communal participation, it reveals that the conservancy exhibits environmental, social and economic sustainability. In relation to the Sustainable Development Goals Act (refer to Figure 2.12), the following acts were accounted for in the development of the Mariannhill Conservancy: good health and well-being; clean water and sanitation; affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure; sustainable cities and communities; responsible consumption and production; and life on land. This

demonstrates that eight out of the seventeen acts were acted on, generating a high rate of 48% on the sustainability scale in accordance to the SDGs.

Perception

The natural environmental aspects of the conservancy imply a healthy ecology, concealing the reality that beneath the flourishing forests are underlying landfills. The odours that would stereotypically be the most apparent giveaway are masked by odour-preventing sprays, encapsulating the gas-generated odours and transforming these into a pleasant aroma. According to the Impumelelo Social Innovation Centre (2016), every week one group of students from a different school tours the site for educational purposes and is made aware of the conservation, biodiversity, recycling and waste management of the facility. These groups range from high schools to universities, as well as women's groups and the general public who have an interest in the matter. Overall, there are between 60 to 120 learners accommodated for weekly, which indicates how established the MLC has become.

Environmental Agenda

Through the use of green initiatives, resilience and the ability to promote a cleaner neighbourhood through the reduction of air pollution from the landfill, the MLC has displayed use of the New Urban Agenda. This is achieved through the reduction of greenhouse gases, use of energy renewal, reduction of waste, increase of vegetation and use of energy-efficient devices, thereby managing the natural resources provided in the area. The concept of the Environmental Agenda is evident in the organisation's strategies due to the execution of pollution control, private lands and agriculture, wild living resources, protected land systems, international responsibilities, and energy strategies (refer to **Figure 2.1**). The process of Landfill gas to energy goes through a process of treatment, sorting techniques and outputs towards preparation for market, as seen in **Figure 4.8**.

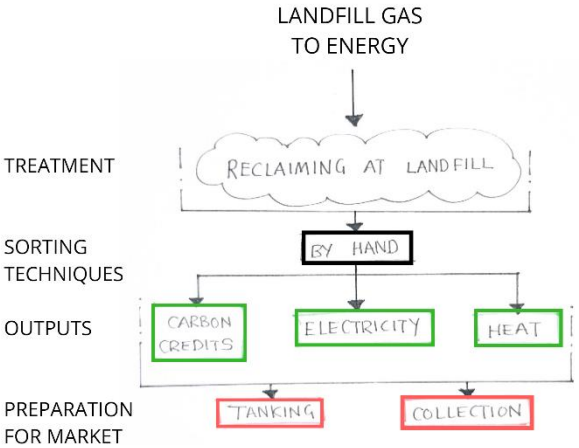


Figure 4.8: *Landfill gas to energy process*
Source: Author (2019)

Conceptual Analysis

The process of a landfill-to-gas operation considers multiple environmental and technical systems. **Figure 4.9** is an illustration showing the different operations used in order to achieve a successful landfill operation. This procedure models a conceptual guideline as to how excess waste can be transformed, which will serve as an underlying response in the design proposal of this research.

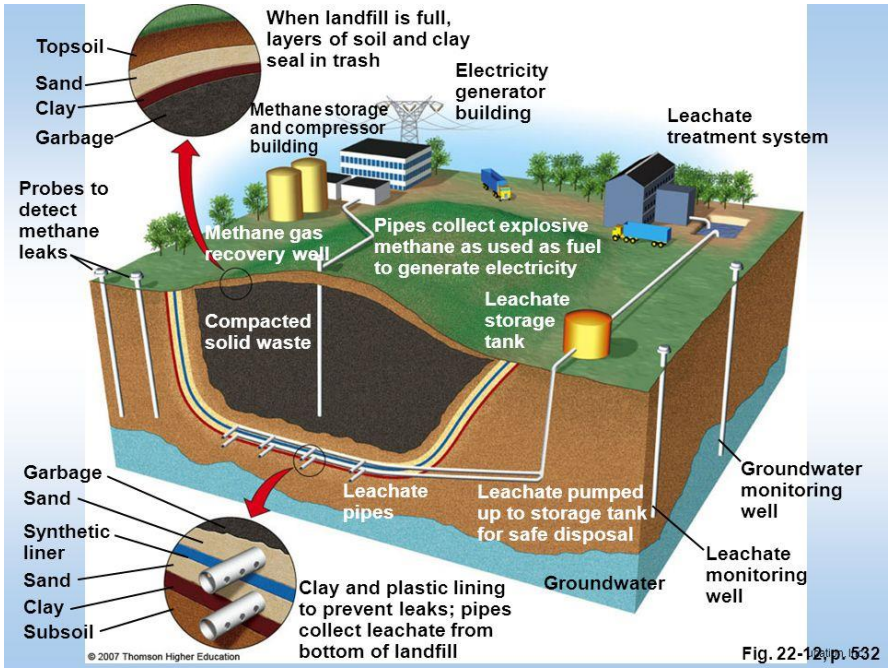


Figure 4.9: *Illustration showing natural ventilation and light into the building*
Source: Burlingham (2014)

According to Moodley, *et al* (2014), eThekwini municipality's landfill gas project was Africa's first registered Landfill Gas to Electricity Clean Development Mechanism since the year 2000. The Department of cleansing and Solid Waste (DSW) found that the horizontal gas extraction wells (HGW) were most effective due to the cost efficiency, uncomplicated construction procedures, and congruency with existing landfill processes. Therefore, the HGW was the way forward when implementing wells into the Mariannhill Land Conservancy. The pockets of wells are distributed around selected areas around the MLC site, shown in **Figure 4.10**. The yellow signifies the vehicular routes taken around the site and the red signify the landfill zones where the HGW's are installed.

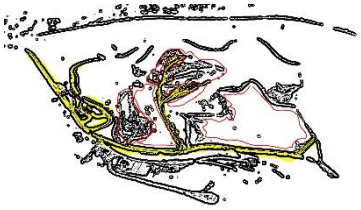


Figure 4.10: *Site illustration showing vehicular access and landfill zones.*
Source: Author (2019)

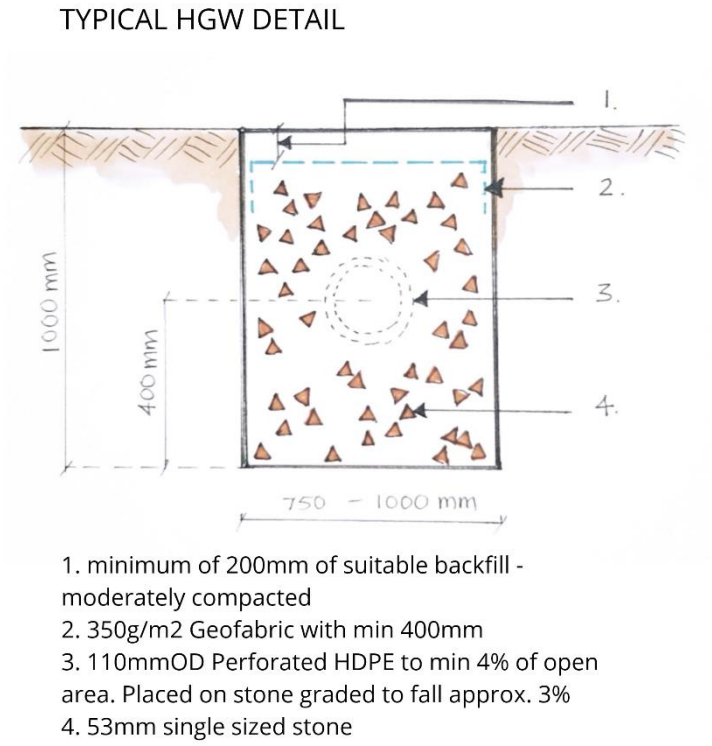


Figure 4.11: *Illustration showing a typical HGW detail*
Source: Author (2019)

As illustrated in **Figure 4.11**, the horizontal gas extraction wells are used underground for landfill functions. However, although construction is simple, the emissions which are created in order to construct deep wells of 1000mm caused for a surplus of odour pollution, directly affecting the residential areas in close proximity (Moodley, et a. 2014). According to Moodley (2014), there were multiple complaints from the residents about the unwanted odour.

4.1.5 Conclusion

As a result of the objectives and environmental planning of the Mariannhill Landfill it is evident that the theoretical and conceptual approaches explored in this study connect and relate to the MLC substantially. In relation to the research issues of the study, architectural solutions such as waste-to-energy systems and public awareness tactics as demonstrated in the MLC can be utilised in the design of the waste incineration and eco-educational facility to improve quality of life to the SDB. The MLC has considered its surrounding context and environmental facets to establish an organisation that connects nature to machinery, and involves human scale interaction into a movement that would typically elude contact with the

public. However, due to the odours and construction emissions, having on-site HGW's in the surrounding context is unadvisable, and excess ash and compost should be transferred to new or existing landfills to proceed with such operations. Nevertheless, it is essential for similar methodologies to be implemented to reduce waste and pollution issues, as this could subsequently have positive effects on the SDB environment. It will also have an impact on the community in terms of health and lifestyle, being a social and learning environment that will increase public awareness of the waste issues at hand. The following case study, the Durban ICC, has also been investigated along a similar course of analysis in relation to the MLC.

4.2 DURBAN INTERNATIONAL CONVENTION CENTRE

4.2.1 Background and Urban Context

In the heart of the Durban Central Business District (CBD), KwaZulu-Natal, lies the Durban International Convention Centre (ICC), which officially launched in 1997. It is located centrally to the CBD and is within walking distance to the Durban beaches and many well-known hotels. The ICC is a functionally constructed development that hosts three convention halls which are interconnected. The venue is fully air-conditioned and is an operative space providing for numerous types of programmes, including conferences, congresses, exhibitions, weddings, concerts, entertainment performances and social events, among many others. The ICC is set up in an appealing environment surrounded by trees and greenery, which softens the commercial feel of a typical convention centre. The ICC has been acknowledged as a job-creating mechanism, being accountable for creation and maintenance of an accumulative number of over 93,000 jobs (Durban ICC, 2018). Accordingly, the ICC is regarded as a socio-economic organisation and, in addition, is an award-winning venue. According to the Durban ICC (2018), the venue has had a 30% growth in profits annually with a 7% growth in turnover, regardless of the immobile economy and challenging trading system.

Figure 4.12: *Urban context of the Durban International Convention Centre*
Source: SA-Venues (1999)
Figure 4.13: *Elevation of one of the main entrances to the Durban ICC*
Source: SV Architects (2006)

4.2.2 Justification for the study

The Durban ICC supports community projects and empowers the lives of the public through accommodating for and supporting programmes that are intended to encourage the youth and those who are working in the direction of the hospitality industry (Durban ICC, 2018). Justification for the study of the Durban ICC is due to the implementation of responsible building design, functioning sustainability, energy-efficient methods and environmental and cultural representations which are embodied in the centre. Through the project objectives and planning, the various sustainable methodologies will be examined.

Figure 4.14: *Road view of the ICC arena signage*
Source: Author (2018)
Figure 4.15: *Main entrance steps into the convention centre*
Source: Author (2018)

4.2.3 Project Objectives and Planning

The ICC aims to meet the needs of international conferences whilst implementing sustainable architecture through ongoing green initiatives (Durban ICC, 2018). In so doing, the centre's dedication to environmentally conscientious methods substantially meet global needs. As specified by the Durban ICC (2018), in an attempt to accomplish a green sustainable environment, both internally and externally, revolutionary technology, advanced materials and developed skills have been incorporated as a part of the project's objectives, which in succession reduces harmful effects on the environment. Having three conference halls that are interconnected but also independent allows for the venues to have various arrangements through the use of detachable walls, as illustrated in **Figure 4.16**. Due to this, the venues can be used either as multiple rooms or as one large venue. According to SA Venues (1999), having the convention hall as one large common space allows for 7,000m² of unrestricted floor space and the ability to seat up to 5,000 persons. Adjacent to the ICC is the Durban Exhibition Centre, a self-sufficient hall space which also provides for all types of programmes. However, the spaces are also combined and operated as two functional spaces as a part of one convention, which allows for accommodation of 10,000 persons, which is double that of the ICC alone, with easy access provided to connect the two venues. The programmes operated in support of the youth include student and graduate programmes to allow for those interested in hospitality to gain experience and benefit from gathering skills and knowledge about the business. There are also cooking schools that have benefited through many events hosted at the ICC, which provides opportunities for the disadvantaged to acquire a qualification in cookery, which could also lead to permanent employment opportunities once graduated. Apart from hosting significant convention spaces, operating programmes for the youth and incorporating sustainable methodologies in the centre, the Durban ICC is a substantial income earner and has had four consecutive clean audits, thereby contributing to the sustainability to the organisation since the centre was launched, and also contributing considerably to the tourism industry in Durban by becoming a major attraction in South Africa (Durban ICC, 2018).

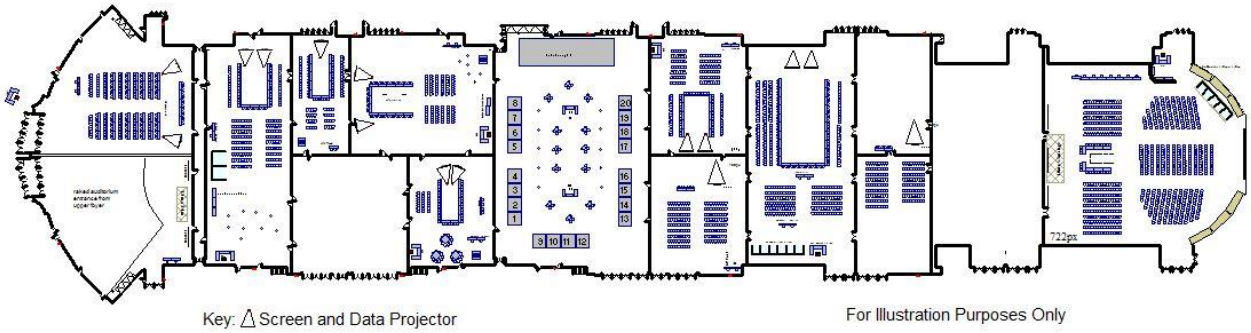
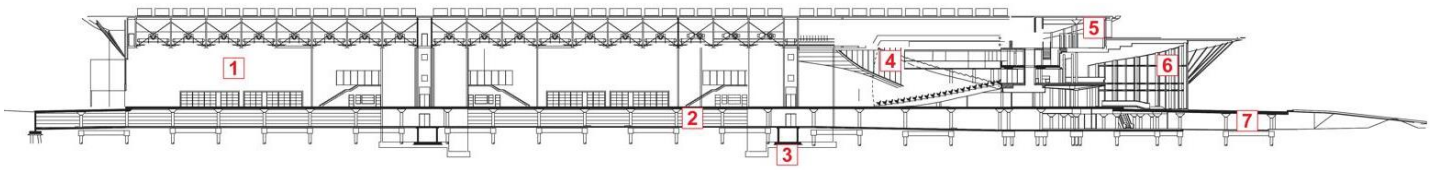


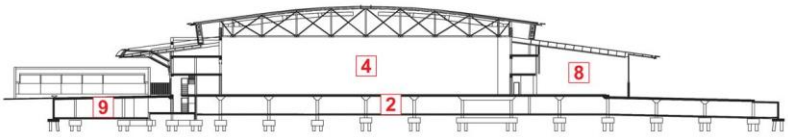
Figure 4.16: *Illustrative plan of the Durban International Convention Centre*
Source: SV Architects (2006)



Longitudinal Section

1. Meeting halls 2 and 3
2. Parking (350 bays)
3. Service Tunnels
4. Plenary hall
5. Offices
6. Entrance foyer
7. Basement foyer
8. Concourse
9. Workshops and stores

Figure 4.17: *Illustrative longitudinal section of the Durban International Convention Centre*
Source: SV Architects (2006)



Cross Section

1. Meeting halls 2 and 3
2. Parking (350 bays)
3. Service Tunnels
4. Plenary hall
5. Offices
6. Entrance foyer
7. Basement foyer
8. Concourse
9. Workshops and stores

Figure 4.18: *Illustrative cross section of the DICC*
Source: SV Architects (2006)

> *"Just as we have led the way in growing the meetings, conventions and exhibitions sector in South Africa, we look forward to making history in the next 20 years and beyond… The self-sustaining entity of the eThekwini Municipality which thrives on maintaining world-class standards reinvests profits into the facility to ensure it continues to remain the venue of choice for local and international visitors*" - *Durban ICC CEO, Lindiwe Rakharebe*

4.2.4 Theoretical and Conceptual Analysis

Sustainability

A huge driving factor in the ICC is sustainability. Through green building design, structural elements including natural lighting and glass facades have been used in order to reduce the need for artificial lighting during the daytime. The building also uses energy-efficient air-conditioning systems which accumulate ice build-up overnight, with the result that by the next day it can be utilised for cooling the building. Other sustainable implementations include the escalators, which only move once stepped on via a step-activation tool, thereby eliminating unnecessary movement and electricity usage (Durban ICC, 2018). With regard to the landscaping, responsible building design is also used in terms of the irrigation, as the building uses local plants which constrain the amount of irrigation systems needed (Refer to **Figures 4.19** – **4.21**). The water usage systems used for the toilets are also sustainably efficient technologies, and similar to the escalators, the taps in the bathrooms have sensors in order to reduce consumption of water. In terms of lighting, the Durban ICC (2018) states that energy-efficient lighting has been installed as of late and is expected to reduce the existing overall demand by 7%. Operationally, sustainability also plays a major role in the convention centre. As mentioned previously, the culinary department is supported by the ICC through organisations and programmes, but it does not stop there. The ICC kitchens use cooking herbs that are grown by the culinary department, as well as bio-degradable cutlery and food crucibles. The intention of reducing waste goes further in relation to when events are hosted. Instead of water bottles, jugs filled with tap water are supplied as well as water dispensers to reduce the usage of plastic and

Figure 4.19: *Elevation of the innovative exterior pathway roofing of the ICC and natural lighting into the building*
Source: Author (2018)

Figure 4.20: *Elevation illustrating the organic form of roof*
Source: Author (2018)

Figure 4.21: *Elevation illustrating the greenery and aesthetics of the ICC*
Source: Author (2018)

unwanted waste, and through the implementation of waste reduction, recycling is also encouraged at the ICC, separating waste into the different recycling containers. This initiative has proven to be effective and has reduced the waste from the ICC by 40%, according to the last assessment conducted on waste reduction at the centre. In comparison to the Sustainable Development Goals Act, the Durban ICC has implemented the following: quality education; clean water and sanitation; decent work and economic growth; industry, innovation and infrastructure; sustainable cities and communities; and responsible consumption and production.

Figure 4.22: *Public space on the exterior of the ICC building*
Source: Author (2018)
Figure 4.23: *Murals illustrated by the public, showing artistic expression in Durban*
Source: Author (2018)

Perception

Regarding perception, the Durban ICC is represented as a cultural and aesthetically functional building, which through sustainable design has made it an inviting attraction to both local and international communities. As illustrated in **Figure 4.23**, the exterior facades surrounding the convention centre have been artistically muraled by locals and left untouched by government authorities. This demonstrates a local touch to the building and represents the Durban culture, which is perceived as wholesome. Though the general convention centre is portrayed as a commercial and concrete environment which hosts formal and inorganic activities, the ICC eliminates this stereotype. The organic form of the building not only adds to the ambience of the structure, but the cultural heritage icons displayed around the building also catch the attention of passers-by. These icons include Baobab trees and the life-size White Rhino statue exhibited outside the facility. The Baobab trees are indigenous to South Africa and are planted in the front entrance garden, with the ICC café being named after the native trees, the Baobab Café. These trees are said to symbolise the strength that remains in the province's many different cultural groups (Durban ICC, 2018). The White Rhino statue holds major significance to the ICC as it is an icon that symbolises conservation. Through the possible extinction faced by the White Rhino species, it represents the need for preservation. Thus, the building has taken many steps to incorporate symbolism into the convention centre in order for it to be distinguished as envisioned, i.e. as a culturally sustainable multi-purpose building.

Environmental Agenda

This iconic structure is an immaculate example of a building that makes use of an urban environment through the use of cultural background, international responsibilities, waste control and energy strategies. It represents the fundamental aspects of its locale, whilst also interpreting modern strategies to produce a structure that displays use of the GEA. This can also be recognised through the New Urban Agenda approaches incorporated, including acknowledgement of climate, encouragement of a clean environment, use of resources, utilisation of green public spaces, equal opportunities provided for the local citizens, resilience and the overall incorporation of green initiatives.

Conceptual Analysis

The Durban ICC focuses primarily on sustainable methods, and as illustrated in the Brundtland's Report, economics, ecology, politics and culture are components which contribute to creating a socially and eco-efficient sustainable environment. The Circle of Sustainability, as shown in **Figure 4.24**, demonstrates these four dynamics to examine the critical levels of each influence towards design implementations.

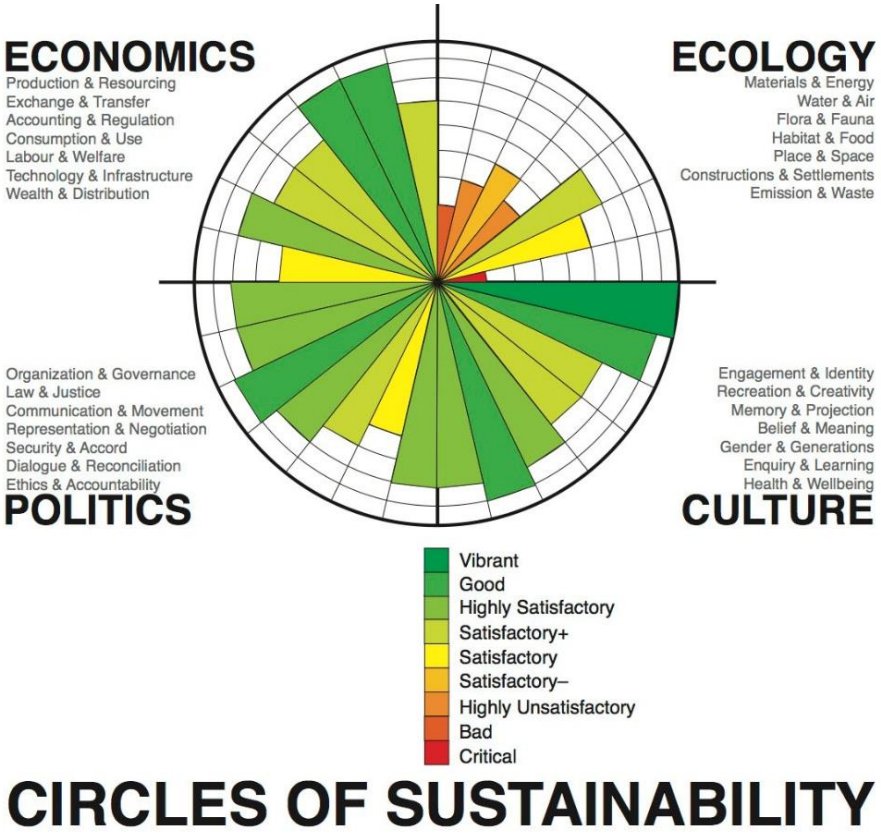


Figure 4.24: *Illustration of the Circles of Sustainability towards economics, ecology, politics and culture*
Source: Circles of Sustainability (2013)

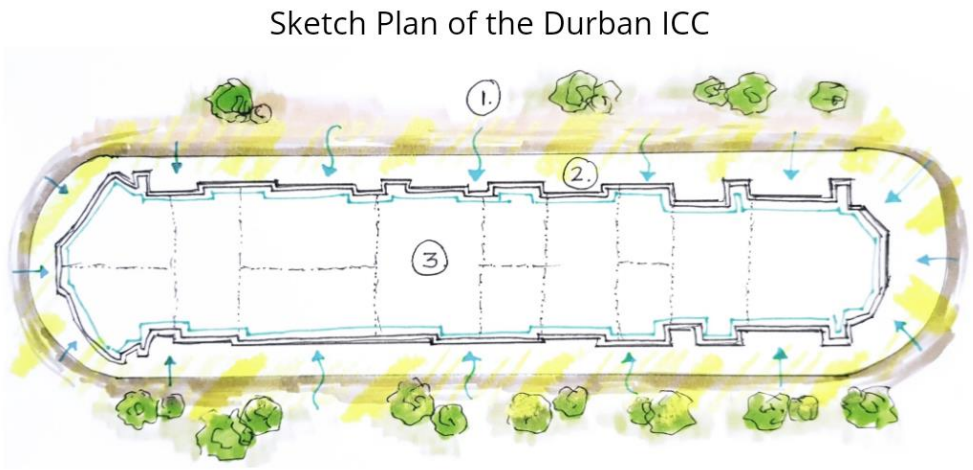


Figure 4.25: *Sketch Plan of the Durban ICC illustrating the flow of natural lighting and ventilation, as well as the placement of air-conditioning.*
Source: Author (2019)

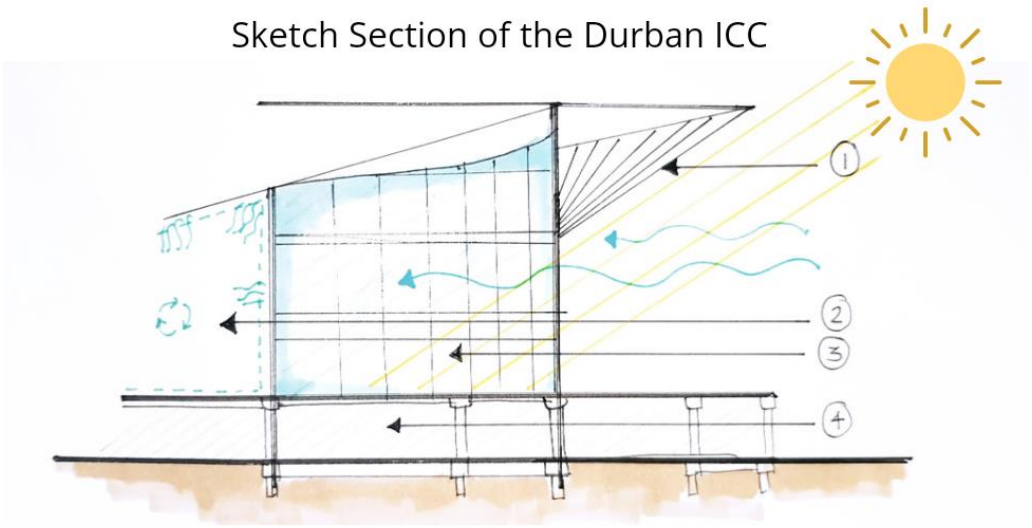


Figure 4.26: *Sketch Section of the Durban ICC illustrating the flow of natural lighting and ventilation, and the airconditioned spaces depth from the exterior to interior*
Source: Author (2019)

Apart from the sustainable examples mentioned previously, natural lighting and ventilation are the elements implemented in the construction of the building which has the largest spans and influence on the ambiance of the convention centre. The large glass fenestrations and expansive structural shading devices provides an effective contrast of interior and exterior shading, including a change of environment from the internal air-conditioned spaces to an open space which encapsulates an operative indoor/outdoor relationship and effect.

4.2.5 Conclusion

The Durban ICC holds many qualities that reflect sustainability, perception and environmental agenda, articulating detailed methodologies in every aspect of the building to demonstrate the accomplishment of creating a diversified structure. Through waste consumption and sustainable design, it is a remarkable illustration of a successful environmental initiative and holds significance to the entire city of Durban. The South Durban Basin can use the ICC as guideline in regard to waste consumption and environmental planning and could thereby demonstrate effective operations if employed correctly, particularly due to the fact that the ICC and the SDB are both set in Durban and share the same locale. These answers the research question of what architectural solutions can be used in the design of a waste incineration and eco-educational facility to improve quality of life to the SDB.

Both the case studies examined have had influencing factors which have contributed to the design proposal of this research. The strategies examined have been adopted with a strong contrast between three defining elements in each of the existing architectures; nature, machine and human. These factors have largely motivated the concept of the proposed design in response to the research problem. Following the study of existing organisations and structural designs, empirical data had been undertaken to accumulate further research on the topic through community responses. The next chapter breaks down the data collected, the findings, analysis of the data and recommendations in relation to the research topic.

CHAPTER 5: DATA COLLECTION AND ANALYSIS

5.1 CHAPTER OUTLINE

The aim of this chapter is to present the empirical findings through qualitative data collection. In gathering qualitative data, interviews were conducted, questionnaires were handed out and observations were recorded in the South Durban area. Empirical data in the form of set interviews makes up this chapter of the research. Eighty-eight participants from the Durban area were involved, many of whom have experienced first-hand effects of the pollution in the South Durban Basin (SDB), while many others are aware of the implications caused by the contamination issues. By reason of awareness of the environmental issues being a primary driver in assisting the design proposal, respondents from all areas of Durban were requested to partake in the interview process, to gain an understanding of whether the environmental issues in the SDB are exposed knowledge to the public or limited to the surrounding area in proximity to the issues. This feedback would then have an impact on the design response and determines the need and scope of educational accommodation required in the proposed typology. The participants were all of different ages, races and genders, enabling a variation of responses. The interview questions included subject matters in relation to awareness, recycling, transportation, and water and energy consumption in the SDB and Durban, which will be highlighted in this chapter through the research data collected. An analysis of the findings will then be elaborated along with a comparison of the data collected in relation to the primary research questions, followed by recommendations derived from the study.

5.2 DATA COLLECTION AND ANALYSIS OF FINDINGS

5.2.1 Awareness

According to the data documented, 96% of users were aware of the existence of environmental issues in the area, whilst 4% were completely unaware of any such issues faced. The participants were asked what they believed was the most detrimental environmental issue in their

neighbourhood in Durban. The data recorded highlighted the following matters: **Waste**, **Air Pollution**, and **Energy and Water Usage**.

In terms of **Waste** and litter, 39% of the participants found that waste was the most detrimental issue in the area, with waste effecting our oceans due to the illegal dumping of refuse and lack of separation of recyclable and non-recyclable waste, while the lack of waste removal in many areas leads to unwanted odours. One respondent stated that the Durban Waste Centre is not effective in containing the unwanted odours, whilst another stated that due to the refuse not being collected timeously this has led to poor street maintenance. The respondents also acknowledged that the shacks in proximity to the SDB residential areas produce more waste due to the lack of sewage systems, as well as from passers-by (i.e. non-residents) who wander outside residential property or from protesters at the residential entrance of Isipingo Hills.

Air Pollution in Durban was viewed as the most detrimental contribution to the environment by 35% of the participants. Many of these respondents were aware of the contributing factors towards air pollution, including: the refineries in the Isipingo area, smoke pollution from cars and trucks transporting cement and sand, smoking in public, burning of waste, dust from the cement quarry in Bellair which borders the Bluff and Clairwood, and debris from buildings under construction.

Relative to **Energy and Water Usage**, 9% of the participants regarded energy and water issues as the most harmful influencing factors. A lack of solar panels and energy consumption instruments were acknowledged by certain users, whilst water flooding due to heavy rains was recognised by others. An identifiable issue pointed out was the water wastage from pipework constantly being dug up, and that overall there is an overuse of energy and water consumption, and lack of energy and water conservation.

Other influencing factors were documented by the remaining 17% of participants, including the following: noise pollution from developments; the industrial areas and cars; invasive vegetation; damaging of ecosystems and wildlife; and urban development as a whole, with too many buildings

taking up land space. In addition, the participants were asked what they believed were contributing factors specifically to the South Durban Basin, including the Bluff, Clairwood, Isipingo, Lamontville, Merebank and Wentworth area.

The data documented resulted in the following:
Lack of Trash/Littering Recycling was the foremost influencing factor at 64,77% of the participants. Following this, 54,55% of respondents viewed *Air Pollution* as a primary contribution. *Water Issues* were mentioned by 35,23% of the respondents, *Energy Issues* were recognised by 26,14%, and 20,45% opted for *Global Warming*.

5.2.2 Recycling

In terms of recycling, the participants were asked how frequently they recycle products in their homes, and according to the data collected, 30,68% stated that they always recycle, 55,68% sometimes recycle and 13,64% never recycle products in their homes. When asked how frequently they recycle products in the work space and recreational facilities, 35,23% said that they always do, 50% declared that they sometimes do, and the remaining 14,77% admitted to never recycling.

The participants were then questioned about the types of items they recycle regularly, and the following data was gathered: 64,77% recycle *newspapers*, 63,64% recycle *bottles/cans*, 50% recycle *mixed paper*, 44,32% recycle *cardboard*, and 5,68% stated other materials, such as bread tags and plastics.

Data collected regarding how convenient the locations of recycle bins are in their neighbourhoods revealed the following: 5,68% stated that recycle bins are in *very convenient* locations, 31,82% found that they were *somewhat convenient*, 45,45% of participants stated that recycle bins are *not very convenient*, and 18,18% confirmed that recycle bins are *not at all convenient*.

Lastly, in relation to recycling, the participants were asked what they believed the best ways are to encourage the community to recycle more often. According to the participants: 65,91% agreed that *avoiding plastic packaging* would be an effective way, 50% stated that a great way would be to *use reusable plates*, 45,45% suggested *carrying a reusable bottle or coffee mug*, 30,68% stated that *using double-sided copies* when printing or writing would be effective, and 18,18% mentioned other methods. These alternative methods include: programmes to educate the community; storing used paper that can be reused; avoiding the use of plastic items completely; emailing instead of paper wastage; introducing a penalty in the form of a fine to those who do not recycle; more awareness brought to communities of the drop-off locations in every neighbourhood through marketing and posters; more accessible recycling stations to encourage convenience; distributing leftover food to those in need rather than wasting food; using shopping bags instead of purchasing plastic grocery bags; upcycling into usable items; and separating recycling bins and bin bags at home to encourage recycling in the household.

5.2.3 Transportation

In relation to transportation, the participants were asked how frequently they use public transportation, if they ever carpool to work, and if they are interested in participating in carpooling.

The data collected from the interviews relating to how frequently they use public transportation revealed that 5% use public transportation often, 12,5% use it sometimes, and 82,5% never use public transportation.

When questioned if they ever carpool to work and if they are interested in participating in carpooling, the following data was collected: 14,77% *do* carpool; 39,77% *do not* carpool but *are* willing to participate in carpooling in the future; 38,64% *do not* carpool and *are not* willing to participate, and 7,95% gave other reasons as to why they do and do not carpool. This included a few users who stated that they *do not* carpool because their job does not allow for it, another participant who stated that they *do* carpool due to their colleague not having a car (and therefore having to share), and

others revealing that they work from their households so there is no need for it.

5.2.4 Water and Energy Consumption

Following the transportation questions, the participants were then asked how frequently they try to reduce the energy and water usage at work. The information gathered displayed the following: 42,53% attempt to do so *once a day or more*; 29,89% attempt to *two or more times a week*; 11,49% attempt to *three or fewer times a month*, and 17,24% never do.

The users were then questioned about the ways in which they conserve water where they live. The data gathered disclosed that: *limiting shower time* was executed by 53,41% of users; *turning off the sink whilst teeth brushing, hand washing, shaving etc.* was performed by 81,82% of the participants; 73,86% of the users *only wash full loads of laundry*, and 9,09% stated other methods. These methods included: monitoring water usage when watering the garden; reducing the flushing of toilets using the rule "If it's yellow let it mellow, if it's brown flush it down"; using water collected from the clothes dryer to hand wash clothes; placing washing machine outlet drains into a bin for garden use; using JoJo tanks, and the usage of small tub baths instead of showers for little kids.

Similarly, the participants were asked how they conserve energy where they live. The following data was collected: *use of a clothing rack to dry* was performed by 70,45% of the users; *turning off the lights when not in use* was executed by 92,05% of the participants; 78,41% of the users *turn off electronics when not in use*; 53,41% of participants *use compact fluorescent light bulbs*; *lowering or switching off air-conditioners when leaving the room for the day* was performed by 70,45% of users; and 5,68% stated other methods. Included in these methods were: monitoring geyser timers, using solar energy for geysers and using gas stoves instead of electronic stoves.

Lastly, in relation to water and energy conservation, the participants were asked what features they found to be relevant and important for new

building construction. Through the data collected, the following information was gathered:

Water Conservation was considered an important factor by 78,41% of participants; *Energy Conservation* was a relevant feature to 76,14% of users; 64,77% opted for *Alternative Energy Use*; 59,09% considered *Low Impact Design* (including noise pollution, rain gardens, porous parking lots, etc.); *Sustainable Materials* (recycled content, previously used materials, etc.) were considered relevant by 64,77% of participants; 30,68% of users opted for *Sustainable Site Selection* (ex. Use of brownfields); and *Other* features were considered by 3,41% of the participants. These features include self-sustaining actions, and design implementations which allow for natural lighting and ventilation.

5.2.5 Observations

Observations of the SDB area were undertaken along streets on a few different occasions, in proximity to the old Durban Airport, as well as the industrial zones and residential areas nearby the Durban harbour, particularly in Umbilo and Umlazi. Each time, observations were conducted midday, between approximately 12:00pm and 14:00pm on week days. Through these observations, the following behaviours were recorded:

There were numerous cars, taxis and buses in the area which provides transportation for many to commute to and from work. However, the influx of transportation in the area provided insight into the excess amount of car emissions created, and the lack of pedestrianisation and walkability in the area. Many pedestrians were seen walking on the streets, across the roads, along unpaved concrete side-walks, and this created a disorderly environment. The pedestrians also failed to acknowledge the waste bins provided around them, and litter was seen in multiple spots on the streets (Refer to **Figure 5.1**).

In regards to vegetation, particularly in the Umbilo area along the R102 highway, there is absence of greenery in the area. In plain sight, there are miles of concrete and brick buildings on either side of the streets, with

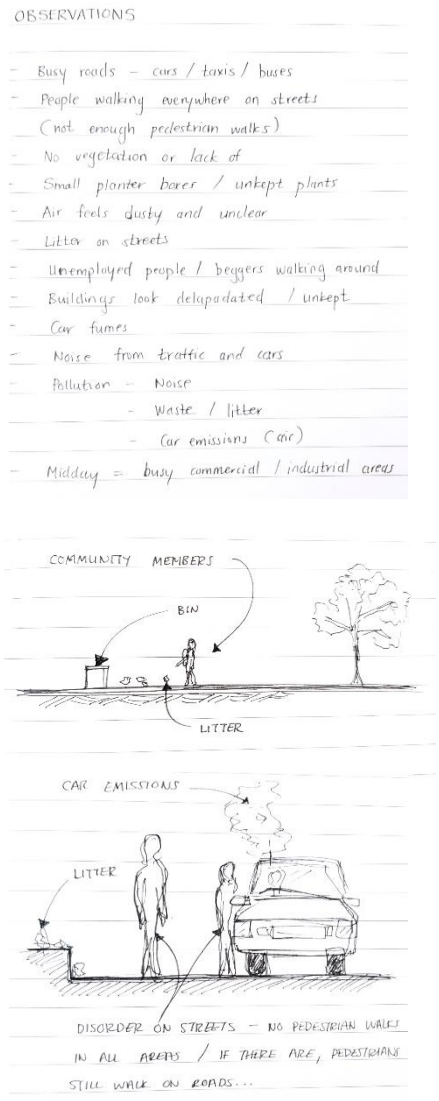


Figure 5.1: *Recorded illustrations of observations but researcher in the SDB*
Source: Author (2018)

minimum plant life along these unkept roads. The streets, although active with cars and pedestrians throughout the day, lacks vibrancy, life, and echoes emptiness.

The SDB communities could have a lot of potential if redeveloped. There is such a lack of so many aspects, hence, introducing vegetation and improving the environment's appearance will not only create an unrecognisable biosphere, it will also have many benefits to the health and productivity of the community. Creating an environment which encourages pedestrianisation will bring back life and energy to the streets, promote social interactions, and furthermore, provide room for economic growth in an existing commercial environment.

5.2.6 Conclusion

Through the data collected as a result of the questionnaire, it has been found that majority of the city's residents are aware of the pollution issues in Durban and the SDB specifically. The participants were able to acknowledge that Waste, Pollution in all forms, Energy and Water Usage issues were all detrimental factors that contributed to the pollution concerns in the city. The users were eager to give their opinions about what methods were believed to be most effective in improving environmental conflicts and creating awareness.

Regarding recycling, the data collected from the questions indicate that a large number of the community makes an attempt to recycle in some form, and many of those who do not partake in recycling would do so if recycling drop-off zones were situated in close proximity to their neighbourhoods. The participants enthusiastically shared their insights regarding alternative methods to encourage the community to recycle, apart from the options provided to them, as mentioned above.

Regarding transportation, it has been found that a large number of citizens have access to private cars from all parts of the city. Although there is a great number of citizens (predominantly from low-income areas) who do use public transportation through taxis – a large and divisive business in

Durban, many citizens have no choice but to drive on their own as a part of their job requirement due to employers increasingly demanding mobile employees. A low percentage of the participants do carpool, and a great number of users would be open to participating in carpooling; however, a large number of the users are not willing to participate in sharing transportation. This reveals that the majority of the city's citizens contribute to pollution from vehicle emissions and are ignorant of the consequences thereof, an issue made worse due to the need for convenience and individuality in today's society. This relates back to how the industrial age differs from the digital age, with networking being highlighted due to modernisation.

The analysis established from the data in relation to water and energy consumption reveals that the participants are aware of different methodologies and processes that can be used in reducing wastage of water and energy and increasing conservation of both. The users stated the type of actions taken in contribution to reducing water and energy consumption, and were candid about alternative methods that can be used to make a positive impact. In comparison to recycling and transportation, it was found that the participants were most receptive to the questions regarding water and energy, which reveals that they are conscious of the implications as a result of the overconsumption of both.

The quantitative data includes the questionnaire outcomes and the existing research gathered. Key factors have influenced the design proposal from the data collected, including: the spacial requirements due to the required accommodation sizes, to contain and successfully run a waste incineration; the magnitude of the problem and the extent of community involvement that is required for an operative responsive design; and the political legislations which could influence the design in a positive way.

The following chapter concludes the findings from the interviews and questionnaires, as well as the literature and theoretical framework investigated through Chapters Two to Four. Recommendations are derived from the study and elaborated on to assist the development of the design proposal.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This study has aimed to analyse sustainable environmental solutions in order to minimize multiple forms of pollution through an evolving relationship between nature, machine, and man. Through modern urbanist concepts, an approach of new urban reality has been adopted to encompass these contemporary solutions. Through the study of the Amager Bakke Powerplant, the Marianhill Land Conservancy, and the Durban ICC, it has been found that there are numerous comparable urban problems and solutions. These challenges are due to our ever-changing biosphere and the change of political and environmental policies, which can now be differentiated as Urban Reality versus New Urbanist Ideas, as illustrated in **Figure 6.1**.

URBAN REALITY vs NEW URBANIST IDEAS

PROBLEMS	SOLUTIONS
Urban spaces are designed more for cars and less for people	Design for the community
Decay of inner cities and town	Restoration
Depletion of natural resources as cities and towns are built	Conservation
Imported built technologies and skills	Preservation
Policy of urban vulnerable displacement and social economic segregation	Inclusive Policy
Limited citizen-based participation projects	Community Involvement
Automobile dominant cities and towns	Reclaim the streets
Lack of understanding of historic patterns/urban form and their origin	Respect the precedents set by history

Figure 6.1: *Illustrative displaying problems and solutions found between Urban Reality and New Urbanist Ideas*
Source: Author (2019)

Through the study of the South Durban Basin (SDB), and the examples of organisations which represent the theories and concepts of *Sustainability*, *Perception* and *Environmental Agenda*, conclusions have been drawn from the studied paradigms that hold similar values and intentions. The interviews conducted through data collection of participants in the SDB and Durban area contribute to the understanding of the extent of environmental impacts on cities due to pollution and waste disposal.

Regarding *Sustainability*, a positive environmental impact could be generated through the viability of conserving water and energy, and recycling waste efficiently. If each household and business contributed to the process of elimination of excess waste it would lead to a feasible outcome of waste reduction, and subsequently a reduction of pollution. However, this would need to be in conjunction with ecological energy-efficient technologies such as solar panels (on a small scale), and (on a large scale) a waste-to-energy system.

The attempt to create public awareness and community participation is where *Perception* is a vital contribution to the phenomenon. As discussed in section 2.4 (Theory of Perception), there are many contributing factors that influence a user's experience of a space. Displaying a stereotypical industrial environment leads to a decrease in community participation due to the lack of social interaction in such environments. A typical waste recycling drop-off zone can be perceived as an unwelcoming and inconvenient space, which directs the community to shy away from disposing their waste resourcefully. Convenience is a major influencing factor as to why majority of the community do not contribute to recycling. Changing the perception of an area to one recognised as an appealing social space could distinguish a change in the process of waste elimination by the community, if effectively and successfully managed.

The research has also revealed stipulations in relation to the *Environmental Agenda*. A large number of participants interviewed disclosed that they practice energy and water conservation, and that they would be more receptive to recycling if provided with the right means. These statements are in conjunction with what the New Urban Agenda and GEA propose

through systematic efforts, including that they aim to: provide basic services; promote green public spaces and initiatives; deal with energy strategies; toxics and pollution control; and encouragement of a clean environment through the use of the city's resources. A positive outcome of these initiatives could be achieved if merged with the community's involvement.

Through the study, pollution management has been applied in different forms, and through the research, there have been fundamental management methods which can be embraced in the design response. These pollution management alternatives have been summarised and divided into primary and secondary pollution and waste prevention, and waste management, as illustrated in **Figure 6.2**, which could be implemented into educating the community through the educational facilities provided.

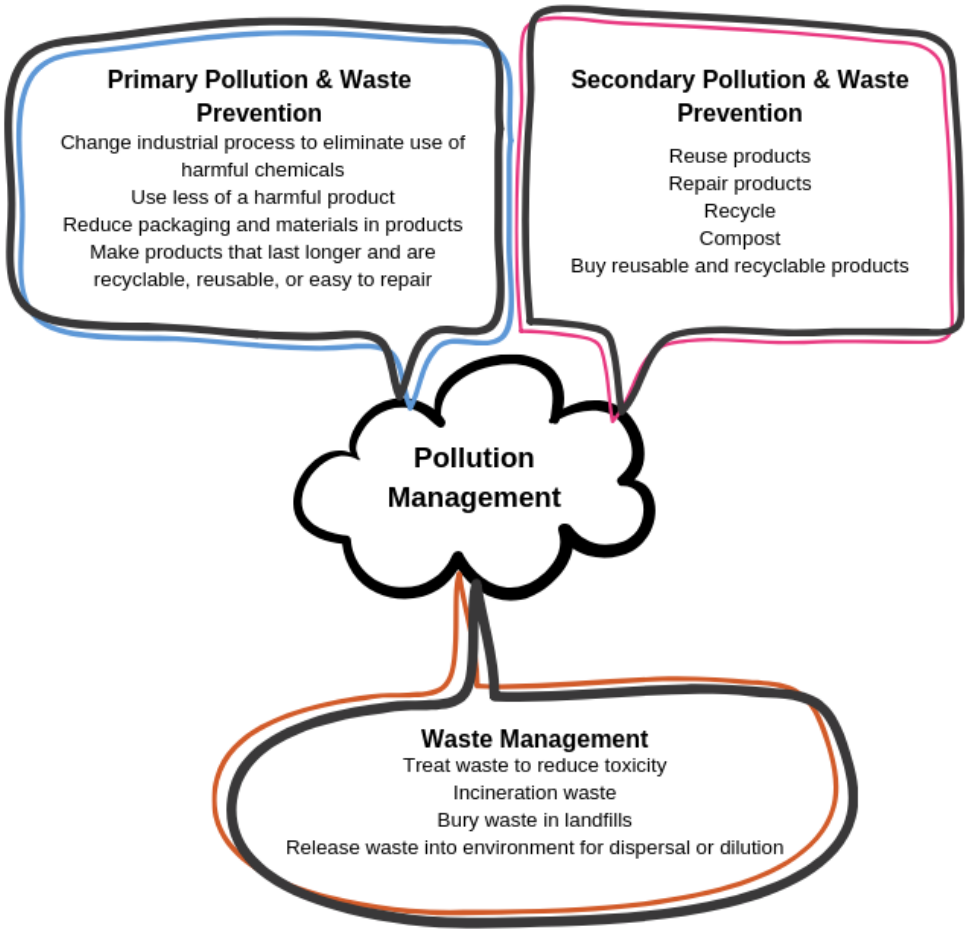


Figure 6.2: *Pollution Management Prevention*
Source: Author (2019)

Addressing the Research Questions

The data collected with regard to the environmental conflicts in the SDB have provided relative insights to the research questions. In response to what type of architectural solutions could be used to improve quality of life for the people in the area, methodologies can be adopted concerning recycling, waste, energy and water, as mentioned by the participants in section 5.2.1 to 5.2.4. Public participation would also be encouraged through strategic planning concerning awareness in the design approach. The issues brought into consideration are all influences that have contributed to the decrease in environmental well-being in the region.

Secondary Questions

Answering the question as to why is it essential for a waste incineration and eco-educational facility to be implemented in the SDB, and what drives the need, is the high pollution levels and excess amount of waste in the area which has impacted the environment negatively, causing a declination in the area's biosphere, further triggering health implications to community members. The community's concerns have contributed to this demand, due to the growing awareness of how their daily lives and health are affected. Factors which have contributed to the decrease in environmental well-being include the high demand of industrialism in the area causing more air pollution every day, as well as the placement of residential and industrial zones situated adjacent to one another, leaving no filter between the two. A waste incineration and an educational facility will have an impact on the community and society due to the prospective knowledge shared with the public, which would raise awareness of the concern surrounding the waste issues not only in the SDB, but in the entire city as well. Consequently, through practice of recycling and conservation methodologies, there will be an improvement in the health and lifestyle of the community as a whole.

6.2 RECOMMENDATIONS

In response to the conclusions of the study, the recommendation is to adopt a design approach that embodies fundamental characteristics of each theory and concept, and methodologies derived from the different examples studied. The approach also needs to take into consideration the relationship between the industrial and residential surroundings, the urban context, and how the proposed development will impact these areas.

The key components in the design approach should be to create awareness, to recycle and to reuse. The design development is recommended to stand as a landmark in the city in order to create awareness to the building, not only physically, but through the programme of the development. In so doing, the site location becomes a vital element. It is recommended that the site selection is in a visible area and has easy vehicular and pedestrian access by the South Durban community and the rest of Durban to the site.

The digital age utilises networking as a major strategy that influences industrial development towards a system of process, representing a cycle of elimination, production and reuse. This paradigm that revitalises the city should be a key driver to bring in waste, transform the waste into energy, and incorporate public and social interaction into the process and thereby lead to education in this regard. This will bring awareness to the development whilst reducing emissions on land and in the air.

As mentioned previously, the Urban Reality versus the New Urbanist Ideas approach has been a fundamental methodology which has materialised as the way forward through this research. Designing for the community, restoration, conservation, preservation, inclusive policy, community involvement, reclaiming the streets and respecting the precedents of the history of a space are key factors to consider regarding the design response. Another approach which has derived from the study is the impact of architectural, natural and human ecologies. Architectural Ecology considers industrialism. This entails that an industrial ecology should aim towards an eco-efficient response architecturally, which would consequently influence form and space when designing. Technologies and

mechanical factors are also influencing elements toward the design response. Material selection impacts the Natural Ecology, due to environmental perception deriving from the sensations felt in a natural environment. The disposal and reuse of the form and flow of a natural ecology plays a major role in the technical planning of a typology, whilst using a locations biosphere to determine the natural processes. When dealing with Human Ecology, the approach is the answer to basic human needs of disposal, which is where the relationship and link between all three ecologies come together to form a system.

The 'system' which would be the most influential towards this design response is the system of recycling. Through this study, recycling has been highlighted as a key element as a way forward in reducing excess emissions in multiple forms. There are three forms of recycling which are recommended to respond to the research problem. These recycling forms include Hydropower recycling, Water recycling and Waste recycling, as illustrated in **Figure 6.2**.

- Hydropower recycling uses the flow of water in an ecology to generate energy through motion and current.

- Water recycling uses a natural organic recycling machine to purify and regenerate water particles. The recycled water can then be reused for irrigation, stormwater management and the flushing of toilets.

- Waste recycling, as mentioned previously, can be used to create energy in a "waste-to-energy" system. The burned metals are often recycled and reused, while the rest of the left-over ashes are used in landfills. There is a use for each particle created from a waste incineration, whether it is ashes, regenerative metal or the steam particles from the burners which are generated in turbines to create energy and electricity.

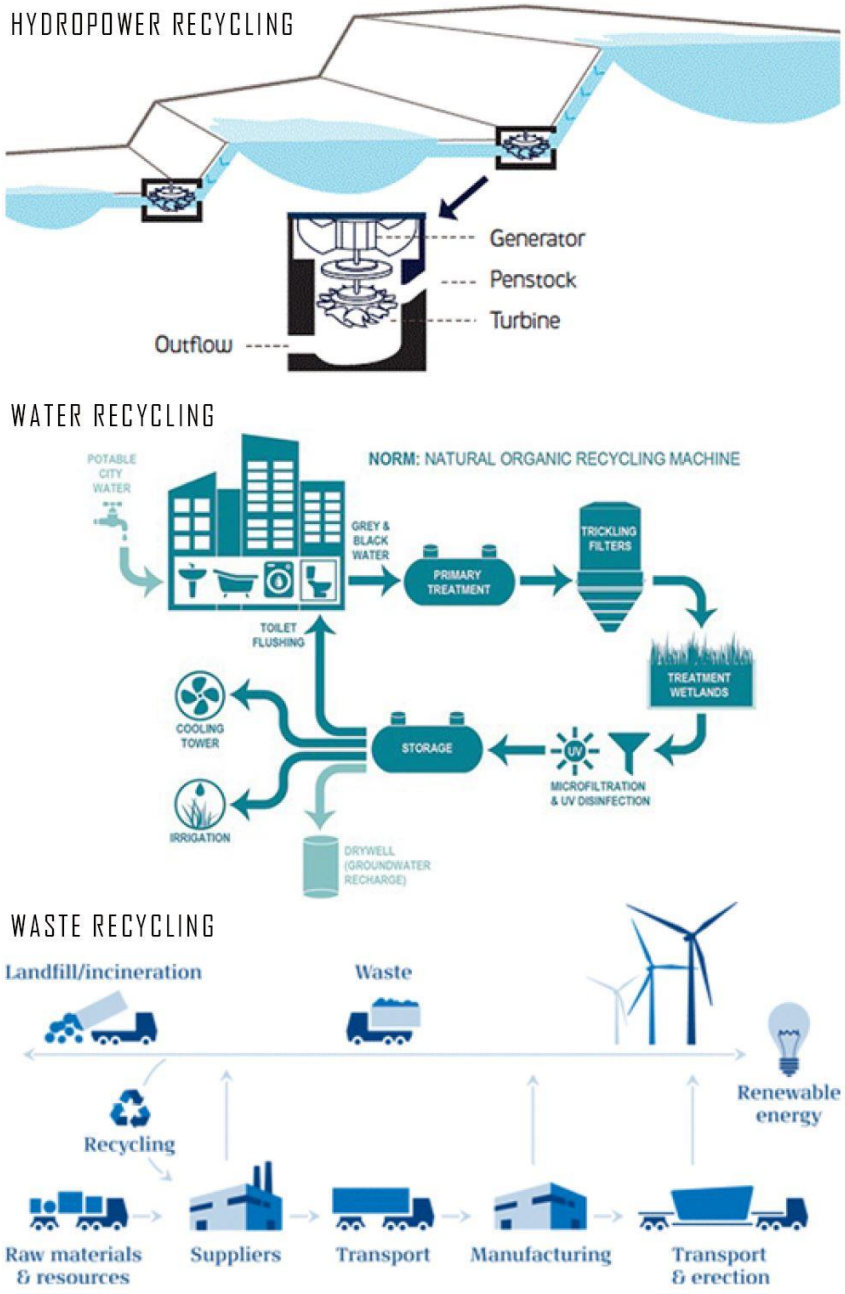


Figure 6.3: *Illustration displaying recycling processes: Hydropower recycling, Water recycling and Waste recycling*
Source: Author (2019)

Through these sustainable technologies and methodologies, urban agenda approaches, and intricate planning of spaces through spatial integrity, material choice, scale and form, the design development could represent a global prototype. Consequently, it could lead to economic, social and environmental growth, which will transform waste and pollution in Durban from what is currently a problem into a resource in the future.

CHAPTER 7: DESIGN DEVELOPMENT

7.1 Project Description

7.1.1 Who

The architectural response targets the surrounding neighbourhoods in Merebank, Isipingo and Mobeni, including all household members, students from surrounding educational facilities, and professionals from the nearby commercial zones. This aims to provide for the community as a whole, providing education and incentive to all.

7.1.2 Why

As mentioned in Chapter one, creating awareness is a fundamental aim in this research, which justifies the building typology from an architectural point. Simultaneously, the typology aims to address the profusion of waste in the area, whilst providing economic and social interfaces.

7.1.3 How

By considering the modern technologies and global design principles studied in this research, the underlying ideologies will be used to create ecological architecture, integrating the relationship between man, nature, and machine. In doing so, this will respond to the precinct's issues, operating with the aid of the environment's energy.

7.2 Proposed Client

The design typology required entails governance by the eThekwini Municipality in Durban, through the DSW, Electrical, Water and Sanitation, and Environmental Planning and Climate Protection departments. DSW holds the position as the primary department, while Transnet holds the position of the secondary client, required for their engineering, rail, port and pipeline services.

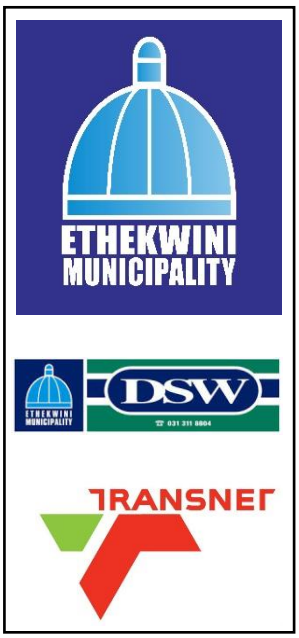


Figure 7.1: *Illustration of Client Logos*
Source: Author (2019)

7.3 Project Brief and Accommodation Schedule

According to the clients, the prerequisite is for an architectural design proposal in response to the surplus of waste in the South Durban Basin. Additionally, creating awareness to the typology is a necessity, which requires the selected site to be situated in an accessible and visible location. The design proposal is also required to consider the theoretical research, the concept of integrating a relationship between the technologies incorporated, the natural biosphere, and the industrial and residential surrounding components, also providing an integration of social amenities. It is essential for the proposed typology to contain the following accommodation:

The primary accommodation includes:

- A recycling educational centre – to bring awareness and educate students, host seminars and bring about cognizance of the pollution and waste issues to the community.
- A waste incineration system – that effectively reduces waste whilst creating energy.
- A recycling facility – to recycle goods on-site, allowing educational tours to experience the process of recycling goods.
- An informal trading market – to allow economic growth within the community, allowing for a trading space of recyclable goods to be resold and reused.
- Conference rooms – which will provide meeting spaces to host seminars and conferences to discuss the environmental issues at hand, as well as to provide economic turnover to surrounding commercial organisations, offering hired spaces for business purposes which will allow more professional interaction with the typology.
- A gymnasium facility with power-generating equipment – which will provide human-powered equipment. This will generate power on a human scale and promote healthy living to the community.
- Offices – which will bring economic revenue to the proposed building.

- A sky café – that can be used as a hired venue to host events with a breathtaking view, which will encourage social interaction.
- A sky garden – to enhance the natural biosphere of the building at a global standard, introducing another form of social amenities and relations to the typology.

The secondary accommodation consists of:

- A research centre – to provide skills development, environmental research an additional educational interface, by researchers, environmental organisations and scientists.
- A recycling collection drop-off facility - which provides a drop-off zone for the community to participate in on-site drop-offs of waste, bringing community involvement into the process and encouraging them to participate in recycling.
- Educational tours of the waste incineration – to allow for public and social interaction with the technological services of the typology. This will offer new-found knowledge to the public.
- A proposed harbour recreational space – to encourage public use of amenities and social interaction on site.
- An urban park – to provide a natural recreational space for the informal traders' market to intersperse. Tennis courts will be incorporated to allow sport-based activities as an incentive to the urban response. This will further promote healthy living and exercise to the community, encouraging match games to be held, correspondingly creating social events.
- Admin offices – to provide private working space to run the facility and to provide more on-site job opportunities to the community members.
- A staff cafeteria – which will be utilised by all staff in the building to encourage communication between all departments.

Lastly, the tertiary accommodation includes the waste incineration control rooms, kitchens, public toilets facilities and service areas throughout the building, including multiple fire escapes.

7.4 Site Selection

7.4.1 Site Criteria

In choosing a site for the responsive typology, the research is considered using key factors in terms of sustainability, perception, and urban agenda theories. Through the concept of sustainability, the criteria required includes: preservation; durability; conservation; industry and innovative infrastructure; among responsible production and consumption. Through the Theory of Perception, the site location requires accessibility, visibility, and essentially needs to be in close proximity to the South Durban Basin industrial and residential zones. Lastly, the New Urban Agenda response aims to rectify toxics and pollution control providing energy strategies, protected land systems, water resources and deals with urban environments on a large scale.

7.4.2 Location and Linkage

The chosen site for the design scheme is the old Durban airport in the South Durban Basin. The site has been utilised by Transnet, which is a South African rail, port and pipeline company, for offices, container storage and trucking services since the closure of the airport, as well as multiple car dealerships. Transnet has also proposed to implement a harbour port extension from the existing Durban harbour port, for more container terminals, proposed for the year 2030. This design scheme has included the proposed harbour extension for future use, in the case of the harbour renovation coming to fruition. Linkage in the scheme indicates that there is a coordinate dialog between the different scales of the urban intervention, and shows how distribution and collection are all inter-relating. Pedestrian movement is a contributing factor in the design to determine the placement of the interventions within the site, and to determine the landscaping design and routes. Walkability to the design promotes healthy living and lessens car emissions in the area, therefore, a linkage bridge has been included in the scheme from the site to the residential area in proximity to the site.

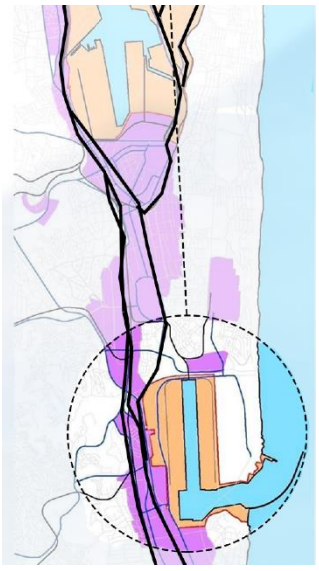


Figure 7.2: *Site Location*
Source: Author (2018)

7.4.3 Urban Response

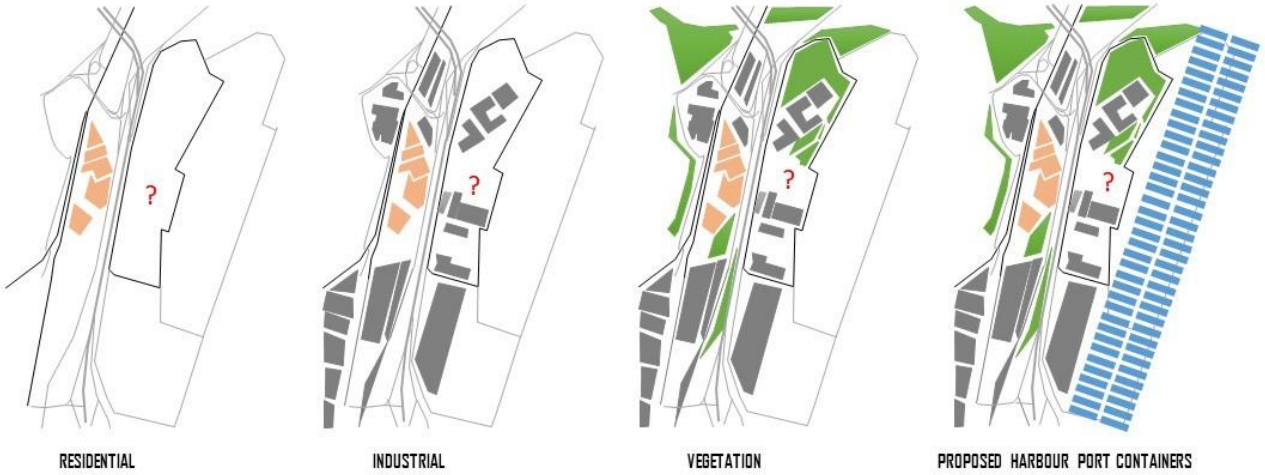


Figure 7.3: *Site Location Layers*
Source: Author (2018)

Micro

On a micro scale, the site is linked to the proposed harbour port expansion, with a water extension developed into the site. The original entrance to the site has been used, and the building is responsive to the orientation of the site, with the Northern areas designed encompassing recreational and public facilities. The Southern side of the site is then used for the service facilities. Climatically, the arrangement of the building considers orientation so that the public commercial and trading areas face north and east, escaping the western sunlight. Due to this, there is natural light and cross ventilation, so there is a reduction for the need mechanical systems to assist in these aspects, resulting in a decrease of maintenance of the building. This is a factor which would assist in the increasing value of the building over time due to its sustainability. A systematic approach has been used reflecting the cycle of systems in the proposed building, which corresponds with the vehicular and pedestrian movement. The recreational spaces around the building are designed in response to the existing green spaces provided, and are expanded from those areas. The existing parking and surrounding buildings have been taken into consideration and remain on site, to be included in the vehicular and pedestrian flow of the proposed design, with the system and process of a waste incineration forming the building movement and the place making of surrounding areas.

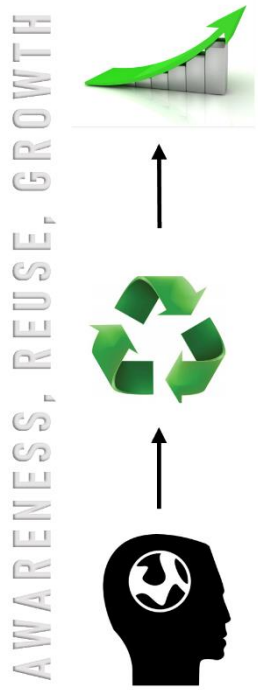


Figure 7.4: *Concept Illustration*
Source: Author (2018)

Macro

On a macro scale, the proposed building is connected to the existing residential area and it is linked to the context through a pedestrianised bridge link over the N2, as shown in **Figure 7.6**. The N2 Freeway forms accessibility which is an advantage because through visibility of the building, awareness will be brought to the site. The surrounding car dealerships, trucking and container storage remains and contributes to the waste incineration, and the surrounding area of the South Durban Basin and the entire Durban community will have access to bring in waste and recycled goods for resources to be transformed. The proposed harbour port by Transnet will also bring in more pollution to the site, including air pollution, waste pollution and noise pollution, so having the waste incineration in direct access to the port will be beneficial to the area because disposal will be immediate.

Figure 7.5: *Waste Intake & Energy Distribution*
Source: Author (2018)

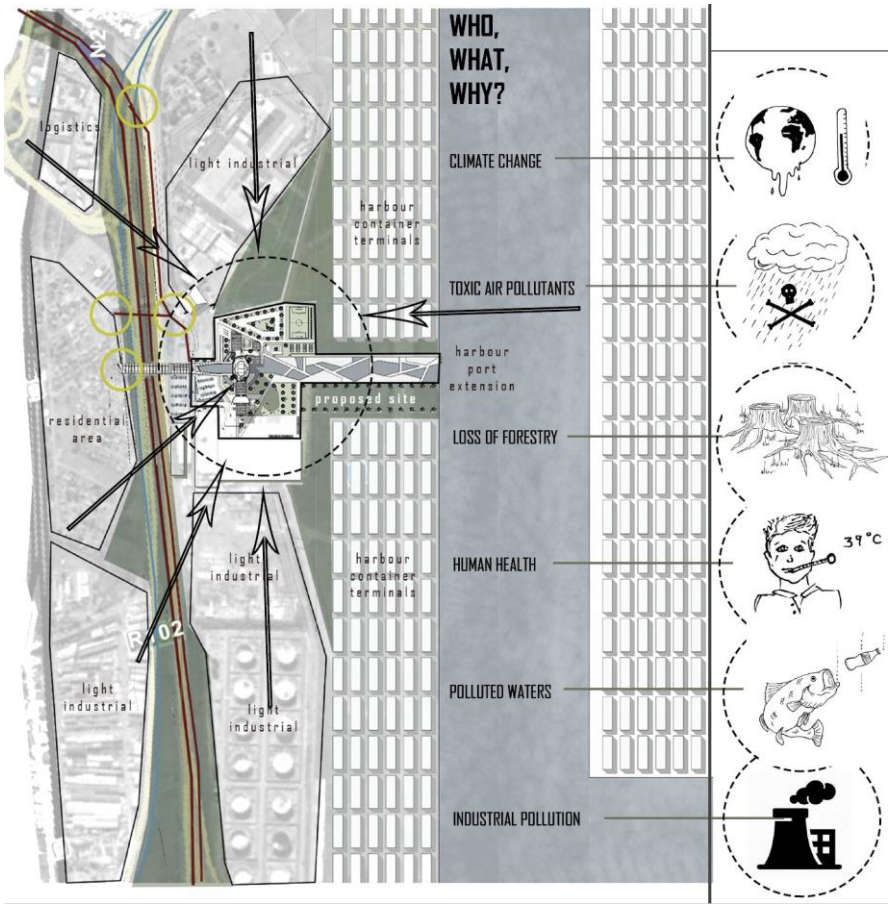


Figure 7.6: *Illustration showing the Urban context on a Macro scale, and the environmental issues in the area*
Source: Author (2018)

7.4.4 Proximity/Density & Connectivity

The way in which the scheme has considered and developed ideas around densification, is by incorporating public facilities and densifying the site with outdoor recreational facilities, such as the informal traders' market, harbour port public space, and tennis courts. The facilities are all in close proximity to each other which allows densification of public interaction on site. This urban response provides a stimulus of communication between man and nature. A proposed pedestrian bridge collaborates with the scheme as an urban response incentive, allowing walkability to the site through surrounding neighbourhoods.

7.5 Design Development

Design of the built form reflecting design intent

The process of space is designed through the proposed solutions. Each solution forms the different typology of spaces. The key issues include: excess waste; air pollution; a lack of vegetation; a lack of awareness; and a lack of electricity. Solutions to these issues include: a waste incineration plant; a bio-industrial park; and an educational centre to create awareness. The conceptual aim is to produce energy, through an analogy and relationship between machine, nature, and humans, using waste as a resource. Key informants which contributed to the design intent include: The flow and form of the waste incineration plant, using a systematic approach through the technical services; expressing the relationship between machine, nature and humans; the flow of the harbour extension in relation to the hydropower system using water to create energy which creates a bio-industrial facility; and the waste incineration plant which is designed to be visible but incorporated in an enclosure for safety reasons. This is for protection of emissions from the systems, allowing access in and around the incineration to act as a human-scale entity. The proposed typology is a metamorphosis using energy as a driver of change, acting as a hybrid living machine, and using the human body and effects on human health as a representation of a living system (See **Figure 7.7**). This also allows an integration of Public, Semi-Public and Semi-Private spaces.

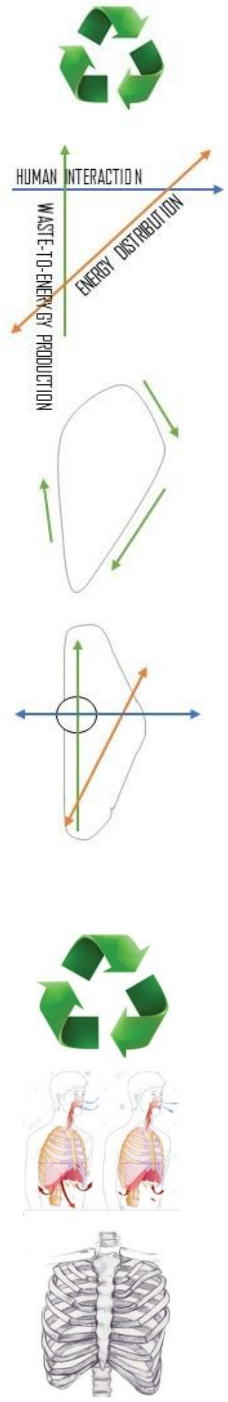
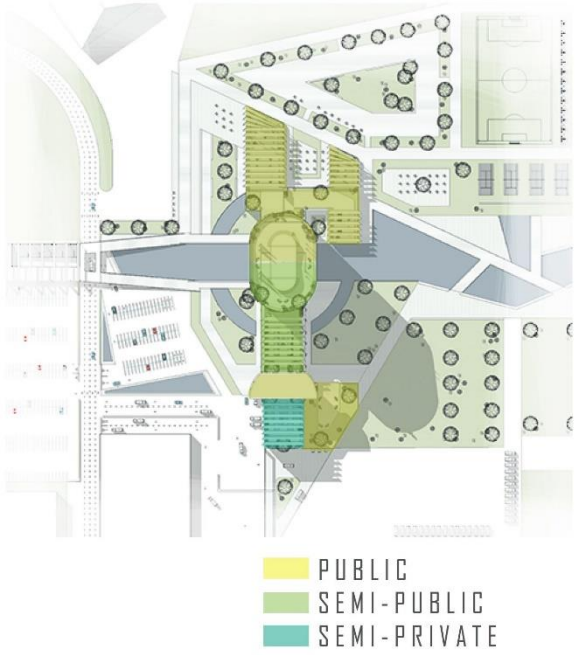


Figure 7.7: *Illustrations showing different forms of Conceptual Development, using the symbol of recycling as a driver*
Source: Author (2018)



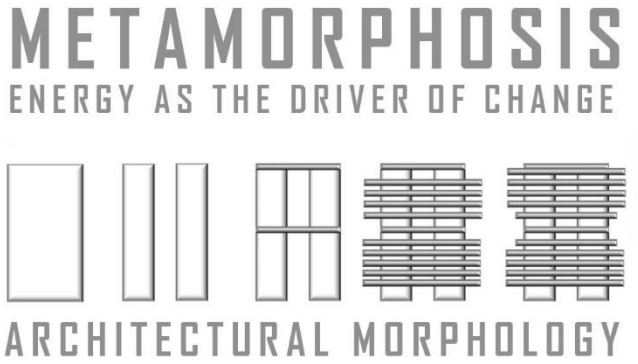


Figure 7.8: *Public, Semi-Public & Semi-Private zoning of the proposed typology.*
Source: Author (2018)

Figure 7.9: *Architectural Morphology displaying the Transformation and form making of the proposed typology*
Source: Author (2018)

7.6 Materials and Treatments

In relation to materials, the following materials and treatments have been chosen for the design:

1. Timber – to bring a natural textured element to soften the building's exterior. Protective coated treatments would be required to avoid deterioration over time.
2. Hempcrete – for its sustainable and durable qualities. It is a bio-composite material used for insulation and construction.
3. Glass – to allow in maximum natural lighting and visibility into and out of the building.
4. Lamdaboard – for its expansive and insulative qualities
5. Steel – for stability and unrestrained expanses. Recycled metals will be a predominant material for the structural framing of the building

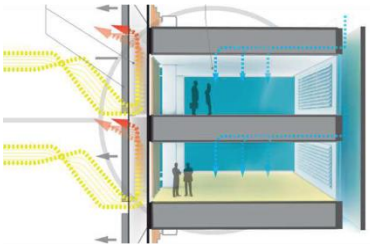


Figure 7.10: *Double Façade Shading Device Illustration*
Source: Gensler (2016)

Double Façade Coverings will be integrated due to double layered façades providing buildings with passive thermal protection, with solar panels that provide a considerable contribution to the building's energy self-sufficiency, as illustrated in **Figure 7.10**. Steel angled fin structures will be used for shading, aesthetics and exposure of the recycled metal elements. Glass facades will be used for visibility of the systems and visibility from

the inside for the public to have an outdoor connection. Glass shapes our spaces, and can act as a defining design element. The natural light it creates shapes our moods, and the view provides a connection to the outside world beyond, changing the public's perception of the industrial environment. The West façade treatments will be recycled steel and high-performance tinted glass. Lastly, a butterfly roof structure is used from the sky garden for water collection.

Responsive Technological Development

Structurally, the aim is to create a landmark to bring visibility and consciousness to the typology, creating a rather distinct and strong visual presence in the city's skyline. On a machine, nature and human scale, the technologies have been divided into varying energy generating systems as follows:

Machine - Energy generators are incorporated in the form of the Waste-to-energy system.

Nature - Wind Turbines and a hydropower system uses water from the harbour to generate energy, which is then recycled and reused within the building.

Human - Power generated equipment are to be installed in the gymnasium facilities to urge community members to indorse.

> *"Bionic Arch, a new iconic landmark of sustainability, is a pioneering building design concept that has been specially created with a goal to symbolize the dynamics of economic, social, political and cultural achievements. It combines the nine major indicators that require a building to be called as Green by law, planting green, water conservation, daily energy efficiency, carbon dioxide reduction, waste reduction, water resources, wastewater and garbage improvements, protection and biodiversity, and refinement of the interior environment, making it exactly what future accommodations needed to be."- (Tuvie. 2013)*

The scheme has considered the built and natural environment as an integrated whole, because the building has ecological systems which will promote ecological functioning to preserve and assist in self-maintenance. Sustainable methods in lighting, shading, ventilation, and rainwater collection are incorporated and waste is used as a resource to be collected and transformed into energy and redistributed to the area. As a result of the waste elimination, and through cleaned toxic gases, it will significantly reduce the pollution produced whilst reducing waste.

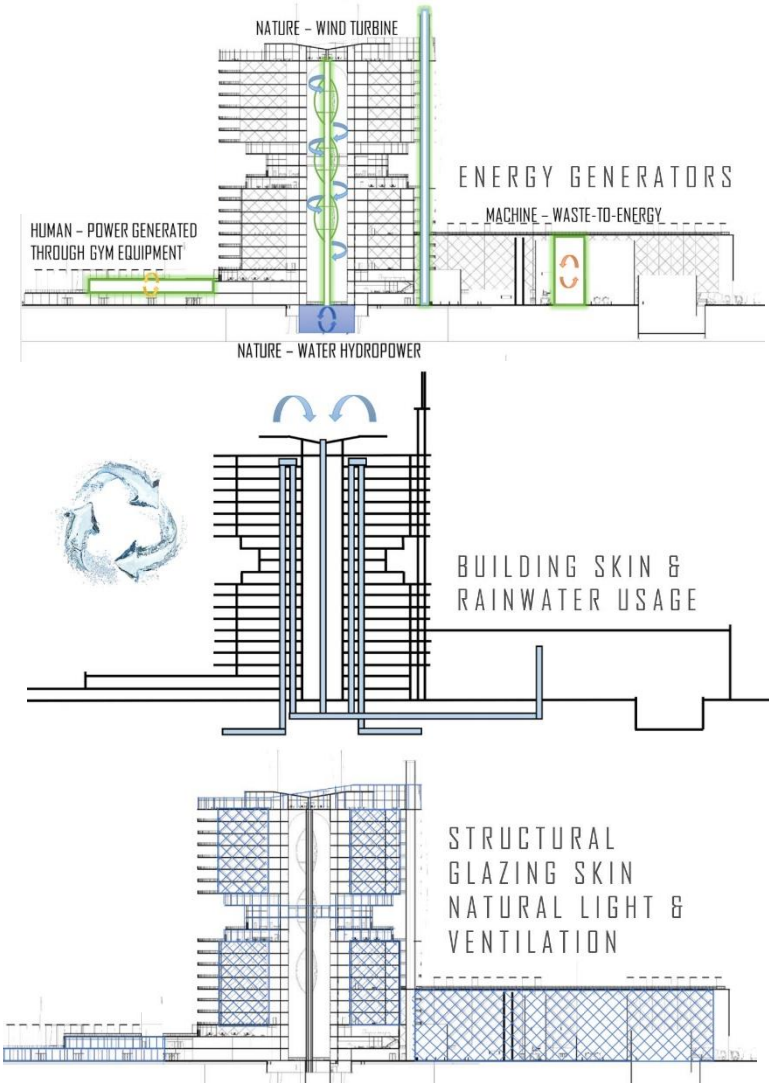


Figure 7.11: *Illustration of the design response displaying the use of Energy Generators, Building Skin, Rainwater Usage, Structural Glazing Skin and Natural Light and Ventilation*
Source: Author (2019)

In further detail, the Waste-to-energy technical systems and services include recycling machines, a waste bunker, boilers, turbine generators, cooling flue gas machines, baghouses, stacks, wind turbines, hydropower generators, electricity poles, the gym-generating equipment, and solar panels. A rain harvest system is also used because this design combines a recirculating water feature with a sub-surface rainwater harvest storage

system. Rainwater, or an overflow of water from the harbour, will be collected and stored underground. The water is constantly recirculated and filtered preventing stagnation and growth of bacteria. The stored nutrient rich rainwater can then be used to irrigate the landscape, as well as the flushing systems in the public toilet facilities, whilst the rest of the water will be used for the cooling steam systems in the waste incineration and for the hydropower generators.

7.7 Conclusion

The primary problem of this research is pollution in the form of excess waste and air pollution, among others. There is a lack of a healthy biosphere in the South Durban Basin, and consequently, deterioration of human health in the area. The design and planning of the proposed scheme has used fundamental attributes from each literature review studied, each concept and theory, precedent study, case study, and through the data collected amongst the interviews conducted. The current demand for urban development has taken modern-day policies, agendas and new age lifestyle to re-conceptualise urban landscaping. There has been a transformation from rigid, static shells, to breathing, dynamic and sustainable cityscapes. The new urban approach embraces nature and replicates typologies into versatile organisations, which is the urban response taken through this proposed design development. Nature and mechanisms are now intertwined to encapsulate a new world approach of a regenerative biosphere. The technological development of this design response incorporates vigor into a once stagnant area, creating a self-sustaining and repairing typology which will benefit the surrounding area's atmosphere, with a potential ripple effect to gain regeneration throughout the entire city. Overall, the building reduces waste, creates energy, self-sustains and brings in social culture into an industrialised environment which will spread awareness amongst the community. By reducing emissions, it will gradually improve environmental facets and air quality over time. Adopting the various methodologies and technologies studied, including the consideration of political and global policies, has led to a design proposal which has been transformed into a responsive typology and urban scheme of the study, demonstrated in Appendix 3.

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APPENDIX 1

Environmental Awareness Questionnaire

Umbuzo Wezinkinga Wokuqwashiswa Kwezemvelo

1. What is the most important environmental issue in your neighbourhood, in your opinion?

Lyini inkinga ebaluleke kakhulu engokwemvelo endaweni yakho, ngokubona kwakho?

_____

_____

2. What environmental initiatives are most important for the South Durban Basin?

Yimiphi imizamo yezemvelo ebaluleke kakhulu eSouth Basin eThekwini?

- □ Trash/Litter Recycling / Udoti / Ukwenziwa kabusha kwe-Litter
- □ Water Issues / Izinkinga zamanzi
- □ Air Pollution / Pol Ukungcola komoya
- □ Energy Issues / Is Izinkinga Zamandla
- □ Global Warming / W Ukufudumala Kwemhlaba Wonke
- □ Other (please specify) / Okunye (sicela ucacise)

_____

3. How frequently do you recycle products in your home? Explain.

Uvame kangakanani ukubuyisela imikhiqizo ekhaya lakho? Chaza.

- □ Always / Njalo
- □ Sometimes / Ngezinye izikhathi
- □ Never / Neze

_____

4. How frequently do you recycle products in the work space or recreational facilities? Explain. Uvame ukuphinda usebenzise kabusha imikhiqizo esikhaleni somsebenzi noma ezindaweni zokuzilibazisa? Chaza.

- □ Always / Njalo
- □ Sometimes / Ngezinye izikhathi
- □ Never / Neze

_____

5. What types of items do you regularly recycle? Yiziphi izinhlobo zezinto ozivuselela njalo?

_____

_____

6. What types of items do you regularly recycle at home? Yiziphi izinhlobo zezinto ozijwayele ukuzenza ekhaya?

- ☐ Newspapers / Amaphephandaba
- ☐ Bottles/Cans / Bottles Amabhuku / Amathini
- ☐ Mixed Paper / Paper i-Mixed Paper
- ☐ Cardboard / iKhodibhodi
- ☐ Other (please specify) / Okunye (sicela ucacise)

_____

7. How convenient is the location of recycling bins in your neighbourhood? Kulula kangakanani indawo yokubuyisela amabheji endaweni yakini?

- ☐ Very convenient / Conveni Kulula kakhulu
- ☐ Somewhat convenient / Kulula kakhulu
- ☐ Not very convenient / Akuyona elula kakhulu
- ☐ Not at all convenient / Akuyona neze elula

8. What is the single best way to encourage the community to recycle more often? Iyiphi indlela engcono kakhulu yokukhuthaza umphakathi ukuba uvuselele kaningi?

- ☐ Use double sided copies / Sebenzisa amakhophi ahlangene kabili
- ☐ Use reusable plates, cups, or utensils / Sebenzisa amapuleti avuselelayo, izinkomishi, noma izitsha
- ☐ Carry a reusable bottle or coffee mug / Yenza ibhodlela eliphindaphindiwe noma ikhofi yekhofi
- ☐ Avoid plastic packaging / Gwema amaphakethe epulasitiki
- ☐ Other (please specify) / Okunye (sicela ucacise)

_____

9. How frequently do you use public transport? Usebenzisa kangaki izithuthi zomphakathi?

_____

10. Do you carpool to work? Ingabe u-carpool usebenza?

- ☐ Yes, I carpool. / Yebo, ngine-carpool.
- ☐ No, I don't carpool but am willing to participate. / Hhayi, anginayo i-carpool kodwa ngizimisele ukuhlanganyela.
- ☐ No, I don't carpool and am not interested in participating. / Cha, angiyi-carpool futhi anginaso isithakazelo ekuhlanganyeleni.
- ☐ Other (please specify) / Okunye (sicela ucacise)

_____

11. How frequently do you try to reduce your energy and water use at work? Uzama kaningi kangakanani ukunciphisa ukusetshenziswa kwakho kwamanzi nokusetshenziswa kwamanzi emsebenzini?

- ☐ Once a day or more / Kanye ngosuku noma ngaphezulu
- ☐ Two or more times a week / Times Izikhathi ezimbili noma ngaphezulu ngesonto
- ☐ Three or fewer times a month / Times Izikhathi ezintathu noma ezimbalwa ngenyanga
- ☐ Never / Neze

12. In which of the following ways do you conserve water where you live? Yiziphi izindlela ezilandelayo ogcina amanzi lapho uhlala khona?

- ☐ Limit shower time / Nciphisa isikhathi sokugeza
- ☐ Turn off the sink while teeth brushing, hand washing, shaving, etc. / Vimbela inkomishi ngenkathi amazinyo ehlanza, ukugeza izandla, ukushefa, njll
- ☐ Only wash full loads of laundry / Geza kuphela imithwalo egcwele yokugeza
- ☐ Other (please specify) / Okunye (sicela ucacise)

_____

13. In which of the following ways do you conserve energy where you live? Ngayiphi yezindlela ezilandelayo ogcina amandla lapho uhlala khona?

- ☐ Use a clothing rack to dry clothes / Sebenzisa ijaji lokugqoka ukuze ume izingubo
- ☐ Turn off lights when not in use / Vala izibani uma zingasetshenziswa
- ☐ Turn off electronics when not in use / Vala i-electronics uma ingasetshenziswa
- ☐ Use compact fluorescent light bulbs (CFLs) / Sebenzisa ama-light compact fluorescent (ama-CFL)
- ☐ Lower or switch off air-conditioner when leaving the room for the day / Ngaphansi noma cisha umoya-moya uma usuka ekamelweni usuku
- ☐ Other (please specify) / Okunye (sicela ucacise)

_____

14. In your opinion, what features are important for new building construction? Ngokombono wakho, yiziphi izici ezibalulekile ekwakhiweni okusha kokwakhiwa?

- Water Conservation / Cons Ukugcinwa kwamanzi
- Energy Conservation / Cons Ukugcina Amandla
- Alternative Energy Use / Alternative Energy Use
- Low Impact Design (noise pollution, rain gardens, porous parking lots, etc.) / Design Low Impact Design (ukungcoliswa komsindo, izdimu zemvula, indawo yokupaka eyingozi, njll)
- Sustainable Materials (recycled content, previously used materials, etc.) / Izinto eziphathekayo (okuqukethwe okusetshenziselwe kabusha, izinto ezisetshenziswa ngaphambilini, njll)
- Sustainable Site Selection (ex. use of brownfields) / Sele Ukukhethwa Kwendawo Yokwakhiwa (isib. Ukusetshenziswa kwama-brownfields)
- Other (please specify) / Okunye (sicela ucacise)

_____

15. Are you aware of the health implications that the surrounding industrial area causes to you? Uyakwazi yini ukuthi impilo yendawo yezimboni izungeze kanjani?

- Yes / Yebo Yebo
- No / Hhayi

16. Do you suffer from any health implications due to the pollution in the area? Explain. Ingabe unenkinga yempilo ngenxa yokungcola endaweni? Chaza.

_____

_____

17. Do any of your family member suffer from any health implications due to the pollution in the area? Explain. Ingabe noma yiluphi ilungu lomndeni wakho libhekene nanoma yiziphi izinkinga zempilo ngenxa yokungcola endaweni? Chaza.

_____

_____

18. In your opinion, would a Recycling Centre benefit the neighbourhood? Explain. Ngokombono wakho, i-Recycling Center ingazuzisa yini indawo? Chaza.

_____

_____

19. What type of recycling facilities do you think should be implemented into the centre? Ucabanga ukuthi yiluhlobo luni lwezikhungo zokuvuselela kabusha okufanele zenziwe ngaphakathi?

_____

_____

20. Do you think that a waste incineration and eco-educational facility can improve the pollution in the area? Ucabanga ukuthi ukuvuselelwa kabusha kungathuthukisa ukungcola endaweni?

_____

_____

APPENDIX 2

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

07 August 2018

Ms Kiyara Sewraj (212503471)
School of Built Environment & Development Studies
Howard College Campus

Dear Ms Sewraj,

Protocol reference number: HSS/0525/018M
Project title: Architectural response to environmental conflicts caused by pollution: Towards a recycling educational centre within the South Durban Basin

Approval Notification – Expedited Approval

In response to your application received on 22 May 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

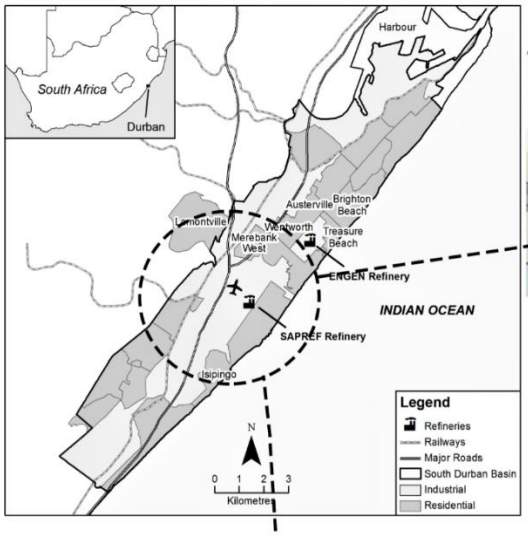
.....
Professor Shenuka Singh (Chair)

/ms

Cc Supervisor: Mr Juan Solis-Arias
Cc Academic Leader Research: Professor Oliver Mtapuri
Cc School Administrator: Ms Angeline Msomi

APPENDIX 3

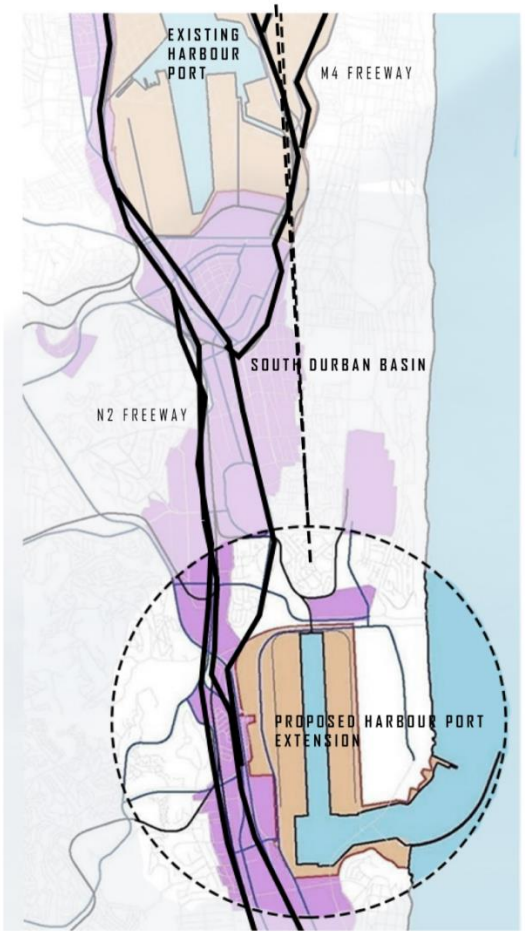
ARCHITECTURAL RESPONSE TO ENVIRONMENTAL CONFLICTS CAUSED BY POLLUTION: Towards a waste incineration and eco-educational facility in the South Durban Basin



Year	Back of ports ha required
2011	150
2014	179
2017	204
2019-2037	628
2037-2050	878

OPEN SPACE STRUCTURE
- COASTAL CORRIDOR & DUNE SYSTEM
- RIVER CORRIDOOR & CANAL SYSTEM
- CONSERVATION / PASSIVE RECREATION
- ACTIVE RECREATION
- CORRIDOR PLANTING STRATEGY
- PLACES OF SIGNIFICANCE
- CEMETERY

LAND USE STRUCTURE
- INTERFACE AREA (office, service industry)
- MIXED US/COMMERCIAL (Retail, services, offices, residential
- SHOPPING
- LIGHT INDUSTRIAL (light industrial,services, offices)
- LOGISTICS (distribution, assembly, warehousing, offices)
- GENERAL INDUSTRY (manufacturing, warehousing, distribution)
- OFFICES
- NOXIOUS INDUSTRY
- RESIDENTIAL
- INSTITUTION



PROBLEM STATEMENT

Residential zone in proximity to the industrial areas of the SDB, causing environmental implications on the health and well-being of the community.

KEY QUESTIONS

What architectural solutions can be used in the design of a recycling centre to improve quality of life to the SDB?
Why is it essential for a recycling educational centre to be implemented in the South Durban Basin?
What drives this need?
What influences has caused the SDB to need a recycling educational centre?
What has contributed to the decrease in environmental well-being?
What impact will a recycling centre have on the people of the SDB community and society?
Will there be an improvement in the health and lifestyle of the community?

OBJECTIVES

The key objective of this research is to provide an environmental catalyst to revitalize the city, which will dynamically avoid the consequences caused by the industrial developments in the South Durban Basin.

To showcase social, economic and environmental sustainability within the South Durban Basin, providing an informative experience for the local people and visitors to the city, whilst providing recycling facilities for the area.

To create a recycling educational centre in order to encourage recycling and to raise public cognizance of the consequences of pollution on human health and the environment.

LOCATION

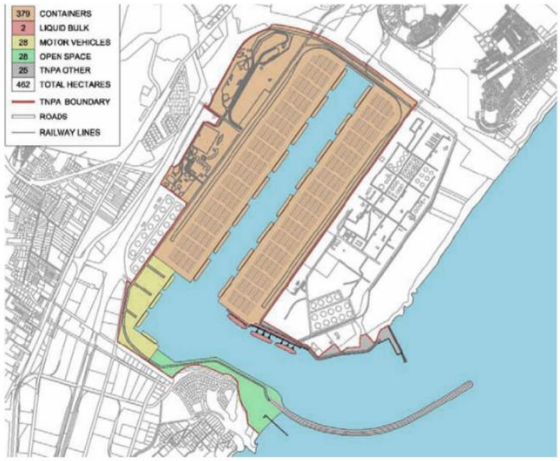
The site selection is located at the former Durban Airport, which is South of Durban. The location is also right off the N2 heading south, which is surrounded by many residential areas and industrial zones, including Isipingo, Merebank, Lamontville and Wentworth. The old Durban Airport was a major contributing factor which raised the levels of air pollution, which reflected a negative perception by the community, therefore, in choosing this location, the aim is to counteract a negative outlook and transform it into a positive one.

DURBAN HARBOUR EXPANSION

The Durban Harbour expansion has been set to use the old Durban Airport and transform it into an extension of the existing harbour port which is north of proposed location. Endorsing these not only increases Durban's port capacity/activity but creates cost-efficacious, environmentally sustainable, reliable and productive ports, internationally competitive minimising externality, congestion and user costs. "A significant area will be displaced, compensation may require remaining areas of coastal grassland such as the racecourse in addition to significant areas outside the area. The loss of habitat associated with port development may not be replaceable in the location. It may be necessary to conserve other areas within the Municipal Area."

GRID NETWORK & SPATIAL QUALITY

The grid network of the Isipingo site is according to an existing implemented grid, alongside the N2 South bound, the residential and industrial areas of the SDB, and the proposed Durban harbour port expansion. The western side of the site is where majority of the grid network exists, which will determine the spatial quality of the proposed site, the boundaries, and designated buildable area, narrowing down the selected site area to the western area of the entire land. The existing building is currently the old Durban airport, so the construction on site does not have extensive flexibility. This will allow a smaller part of the site to be used to build a multiple story building, bring more awareness and site of the intended building.



MOTIVATION / PROBLEMS

Excess waste
Air pollution
Lack of awareness
Lack of electricity
Loss of vegetation

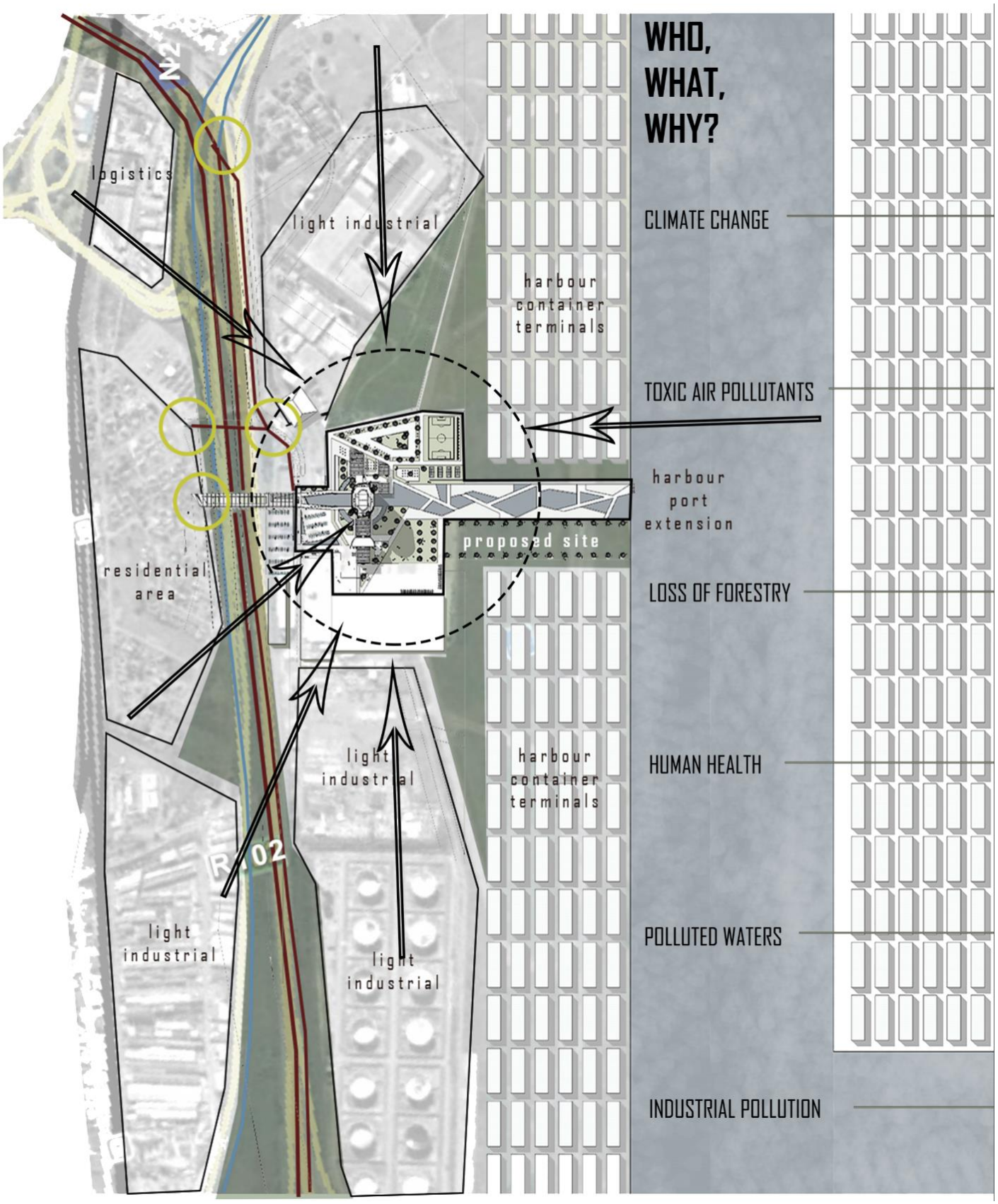
→

SOLUTIONS

Waste-to-energy
Reduce air pollution
Create awareness
Create energy
Increase vegetation

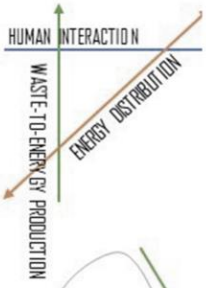
→

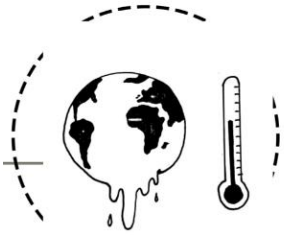
DECREASE WASTE
INCREASE ENERGY

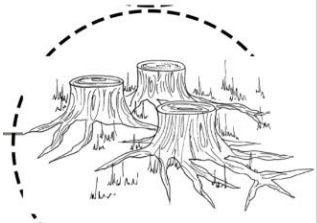

WHO,
WHAT,
WHY?
CLIMATE CHANGE
TOXIC AIR POLLUTANTS
LOSS OF FORESTRY
HUMAN HEALTH
POLLUTED WATERS
INDUSTRIAL POLLUTION
N2
R.02
logistics
light industrial
harbour container terminals
harbour port extension
proposed site
residential area
light industrial
harbour container terminals
light industrial
light industrial

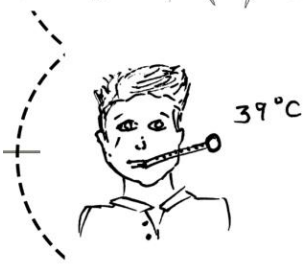
RESEARCH AND DESIGN APPROACH

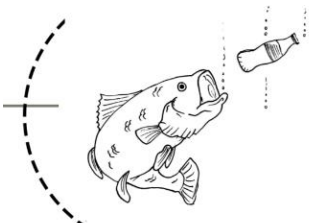
ENVIRONMENTAL HEALTH
ENVIRONMENTAL EXPOSURE
SOCIO ECONOMIC FACTORS





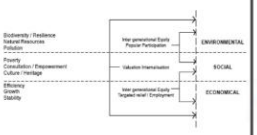






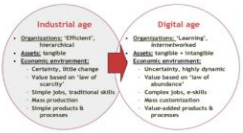
SUSTAINABILITY

Using sustainable approaches and services in the SDB will allow for an improvement of the natural bionetwork, which will have a positive impact on the industrialised atmosphere. Although a drastic change will not occur or completely diminish all pollution overnight, it will slowly reduce the emissions in the air and gradually improve environmental facets and air quality.

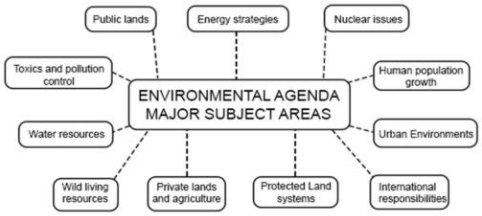


THEORY OF PERCEPTION

Justification in using this approach is due to using the approach of including the varying parties to contribute to the SDB design proposal, as well as including the general public as an additional party to participate in the network of recycling and being educated about it through a modern industrialized approach.



NEW URBAN AGENDA

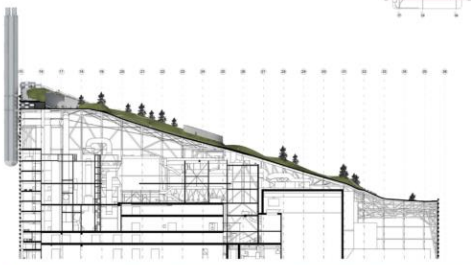


PRECEDENT STUDY

THE AMAGER BAKKE - BJARKE INGELS

Amager Bakke is a megaproject which has aimed to transmute a large amount of waste to benefit a substantial area in Amager and Copenhagen by providing energy to the community and reducing waste.

Provide clean energy to 60,000 households with electricity annually;
supply district heating to 120,000 households annually;
consume steam data

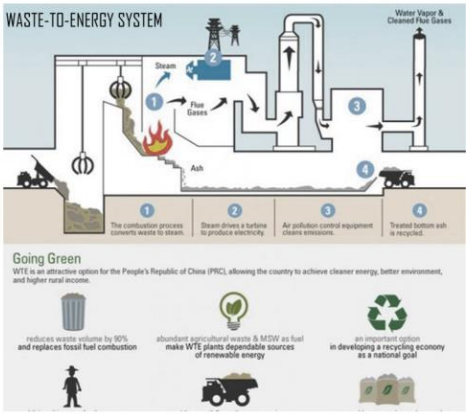


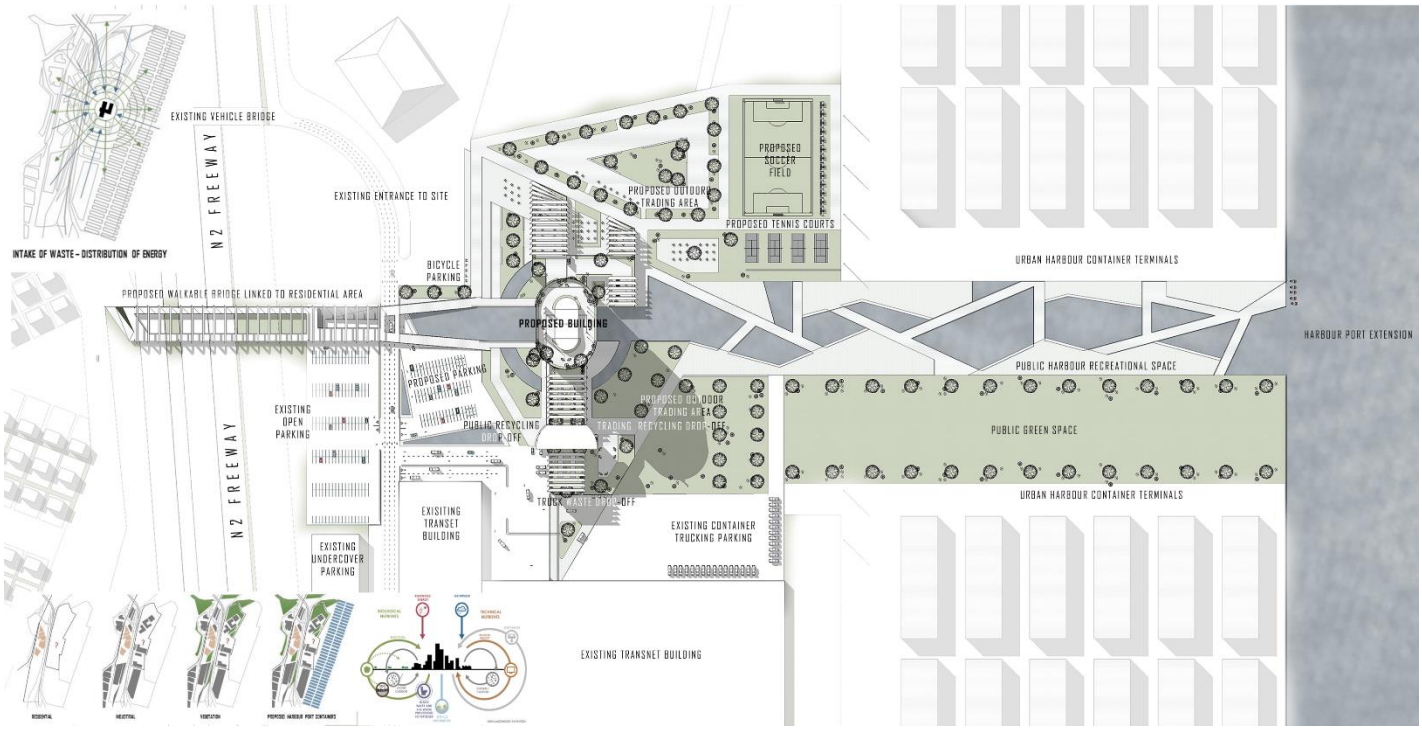
CASE STUDY

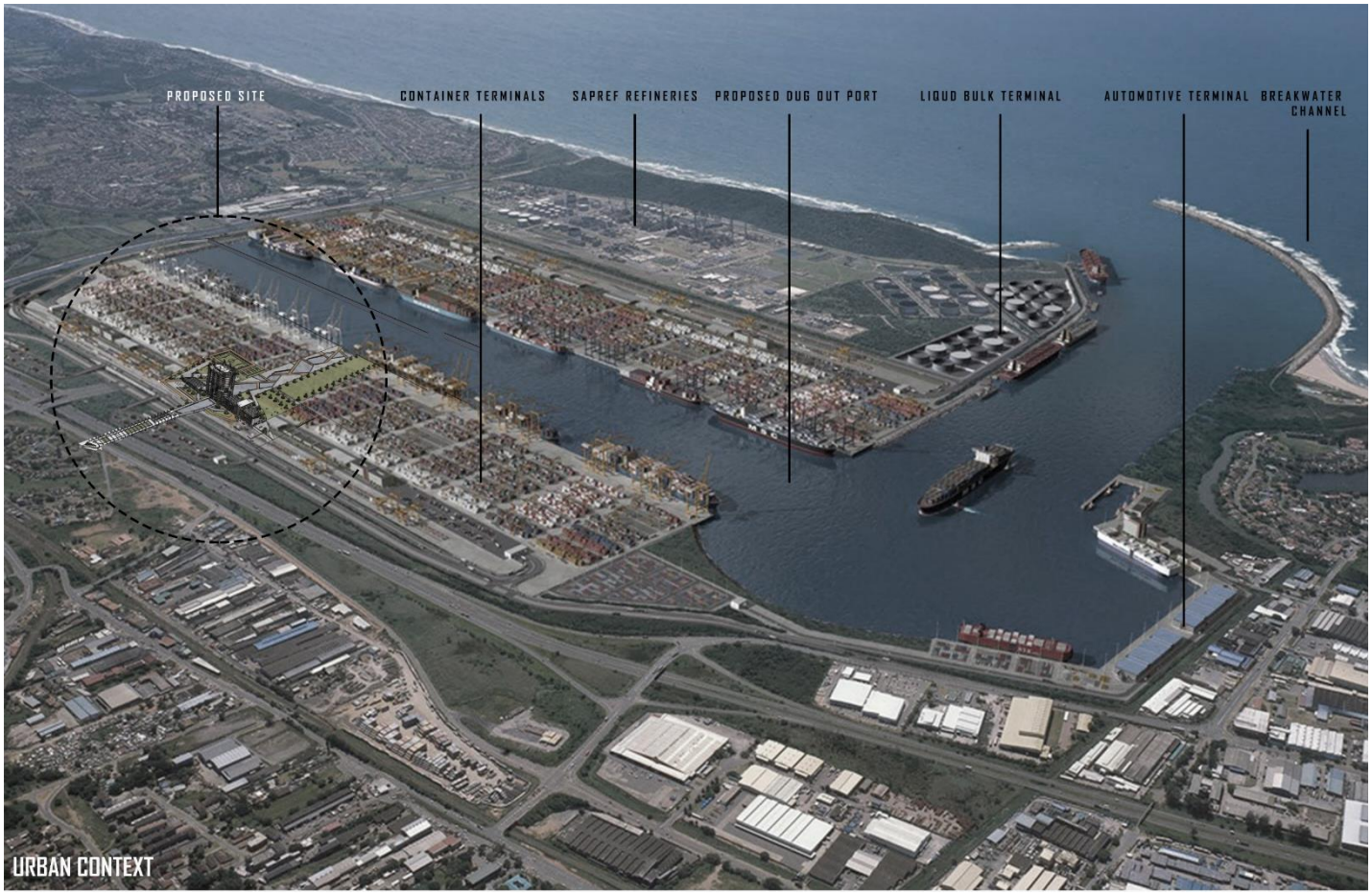
THE MARIANNHILL LANDFILL CONSERVANCY

The primary objective of the MLC is to:
Reduce emissions of greenhouse gases
efficient and sustainable technology,
community participation,

to promote recycling and educate
to reduce waste and pollution issues
have an impact on the community in terms of health
being a social and learning environment



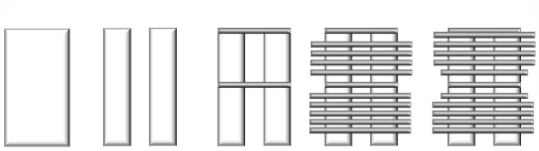

EXISTING VEHICLE BRIDGE
N2 FREEWAY
EXISTING ENTRANCE TO SITE
INTAKE OF WASTE - DISTRIBUTION OF ENERGY
PROPOSED SOCCER FIELD
PROPOSED OUTDOOR TRADING AREA
PROPOSED TENNIS COURTS
URBAN HARBOUR CONTAINER TERMINALS
BICYCLE PARKING
PROPOSED WALKABLE BRIDGE LINKED TO RESIDENTIAL AREA
PROPOSED BUILDING
HARBOUR PORT EXTENSION
PROPOSED PARKING
PUBLIC HARBOUR RECREATIONAL SPACE
EXISTING OPEN PARKING
PUBLIC RECYCLING DROP-OFF
PROPOSED OUTDOOR TRADING AREA
TRADING RECYCLING DROP-OFF
PUBLIC GREEN SPACE
TRUCK WASTE DROP-OFF
EXISTING TRANSET BUILDING
EXISTING CONTAINER TRUCKING PARKING
URBAN HARBOUR CONTAINER TERMINALS
EXISTING UNDERCOVER PARKING
EXISTING TRANSNET BUILDING


PROPOSED SITE
CONTAINER TERMINALS
SAPREF REFINERIES
PROPOSED DUG OUT PORT
LIQUD BULK TERMINAL
AUTOMOTIVE TERMINAL
BREAKWATER CHANNEL
URBAN CONTEXT

CONCEPTUAL FRAMEWORK

METAMORPHOSIS

ENERGY AS THE DRIVER OF CHANGE



ARCHITECTURAL MORPHOLOGY

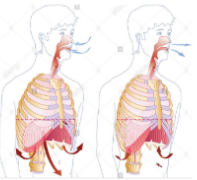
HYBRID LIVING MACHINE

RECYCLINNG

In relation to recycling f waste, is the reuse of elements. The reuse of stromwater will be used for the flushing systems in the toilet facilities, and the harbour water will be used in a hydropower generator to produce electricity and reused for the steam and cooling systems in the WTE system.

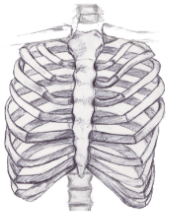
HUMAN HEALTH

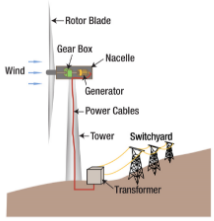
Due to the intensity of air pollution and health concerns in the South Durban Basin, in KwaZulu-Natal, it is the most investigated region in South Africa, therefore, within the SDB neighbourhoods, there have been many studies explored regarding these issues . In addition to f air pollution, is the negative impact which it haS on health, which focuses on particular illnesses which contributes to the general lack of well-being by many of those affected in the area. Health issues associated with the effects of air pollution include respiratory and heart problems, cancer, among other restraints to the body.



STRUCTURAL REPRESENTATION

The human body, rib cage and lungs representing a living system, a structural system and wind and oxygen.





NATURE – WIND TURBINE

ENERGY GENERATORS

MACHINE – WASTE-TO-ENERGY

HUMAN – POWER GENERATED THROUGH GYM EQUIPMENT

NATURE – WATER HYDROPOWER

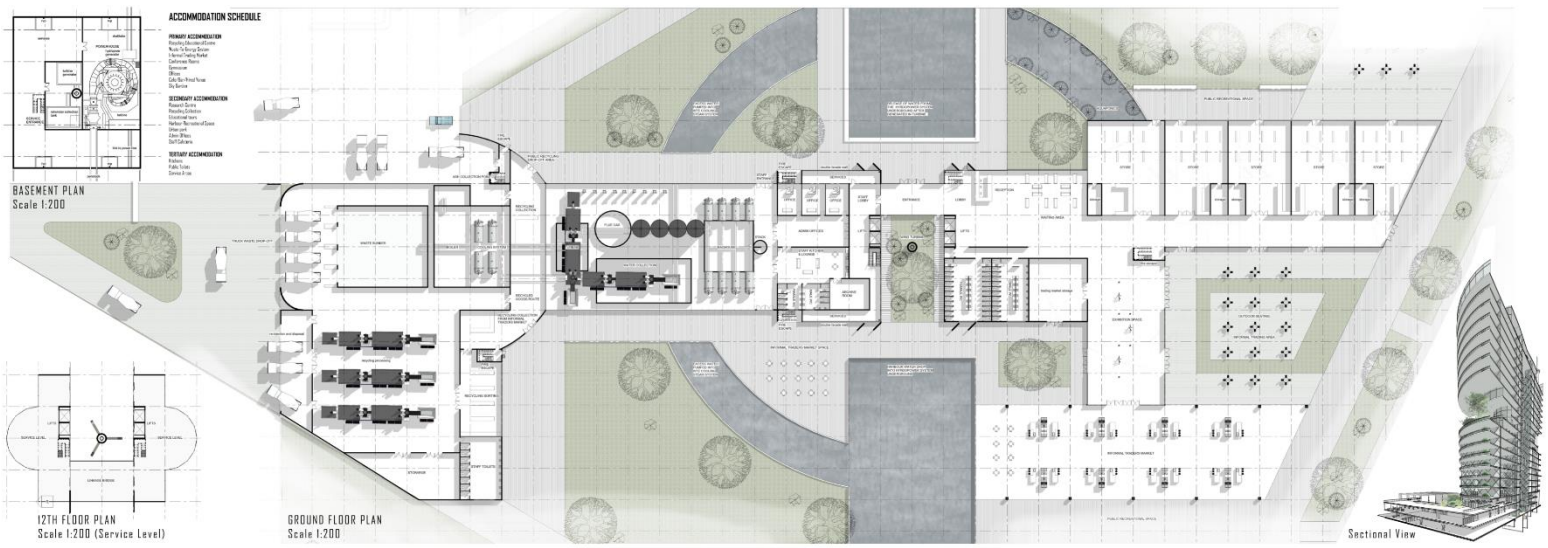
BUILDING SKIN & RAINWATER USAGE

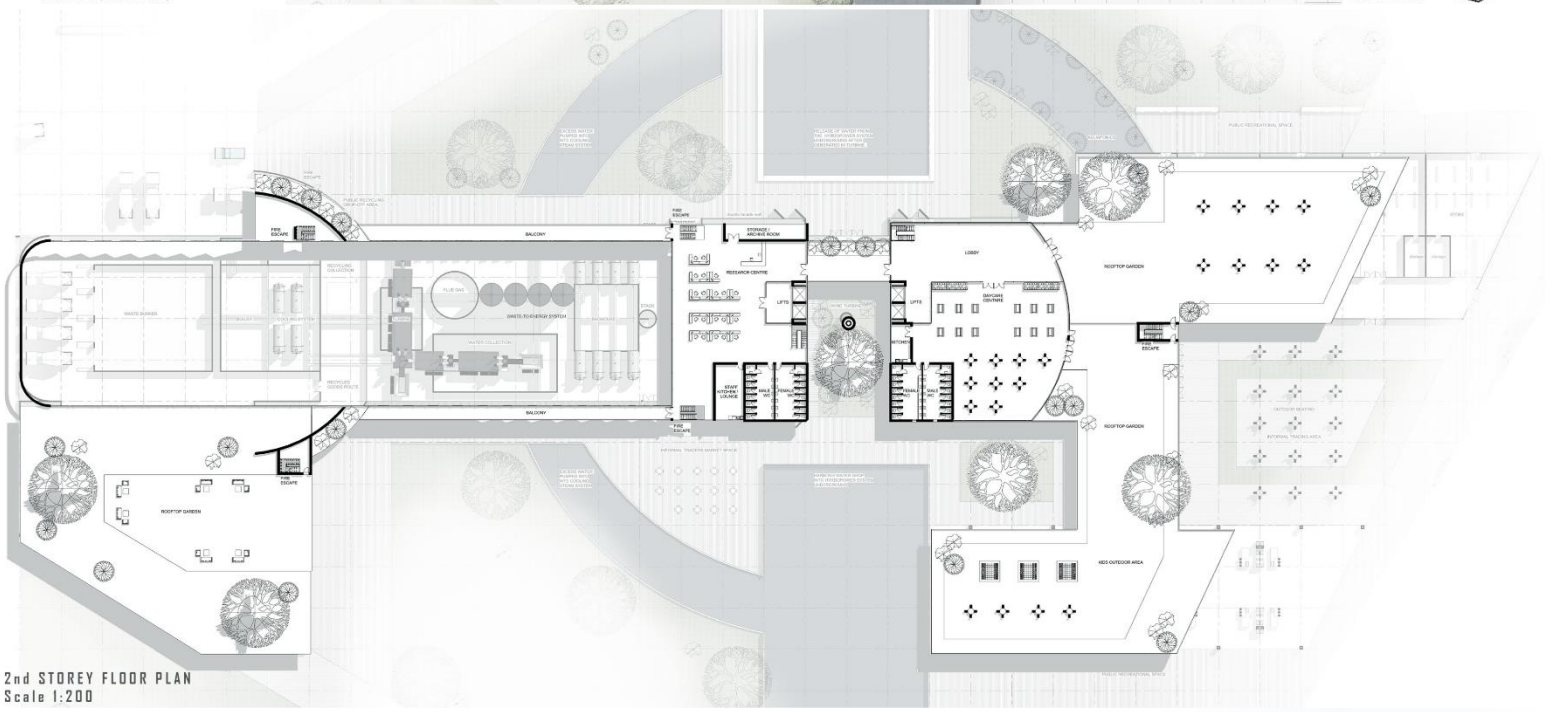
STRUCTURAL GLAZING SKIN NATURAL LIGHT & VENTILATION

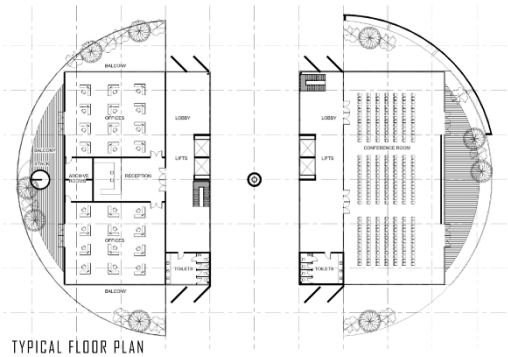
Bionic Arch is a pioneering building design concept that has been specially created with a goal to symbolize the dynamics of economic, social, political and cultural achievements. This groundbreaking design combines the nine major indicators that require a building to be called as Green by law, planting green, water conservation, daily energy efficiency, carbon dioxide reduction, waste reduction, water resources, wastewater and garbage improvements, protection and biodiversity, and refinement of the interior environment, making it exactly what future accommodations needed to be.

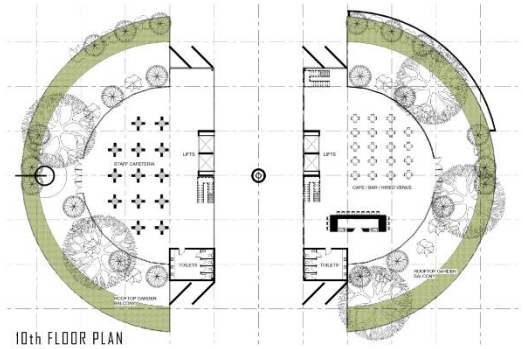
The active inclusion of mechanisms for producing sustainable energies like solar or wind generated power combined with botanical and bio-technologies, the building is 100% self-sufficient from any aspect of eco-living. This unique and innovative Bionic Arch building concept features park, green lands, vertical green platforms, living facades and sky gardens, that will help developing the eco awareness among mass people and help the environment to sustain.

The Waste Collector Skyscraper concept is a new typology for highly polluted cities around the world. It is conceived as a recycling plant in the middle of the city. The Waste Collector Skyscraper addresses these problems through the potential recycling of 400 tons of MSW daily, in a comprehensive, clean, and self-sufficient process without intensive land use. It also raises awareness in the population by its distinct and strong visual presence in the city's skyline.

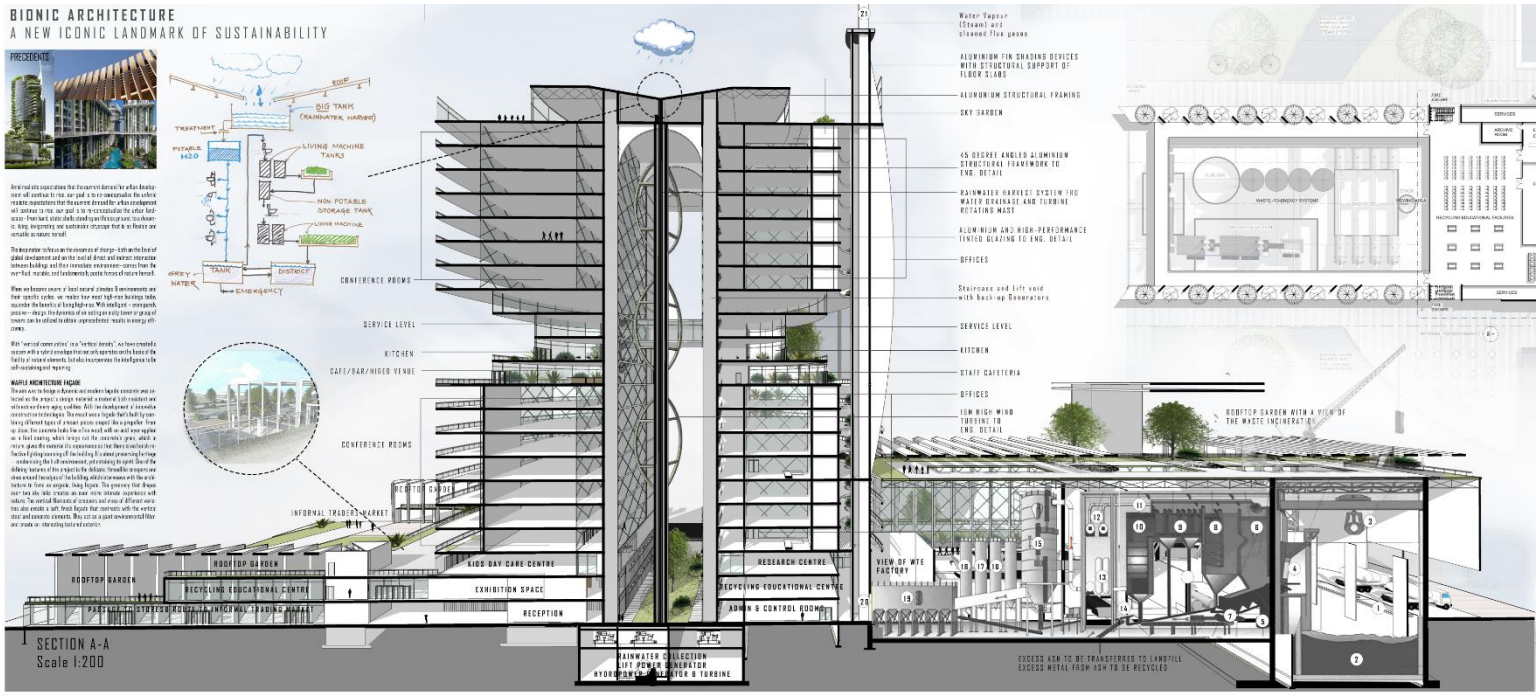

ACCOMMODATION SCHEDULE
PRIMARY ACCOMMODATION
SECONDARY ACCOMMODATION
TERTIARY ACCOMMODATION
BASEMENT PLAN
Scale 1:200
12TH FLOOR PLAN
Scale 1:200 (Service Level)
GROUND FLOOR PLAN
Scale 1:200
Sectional View

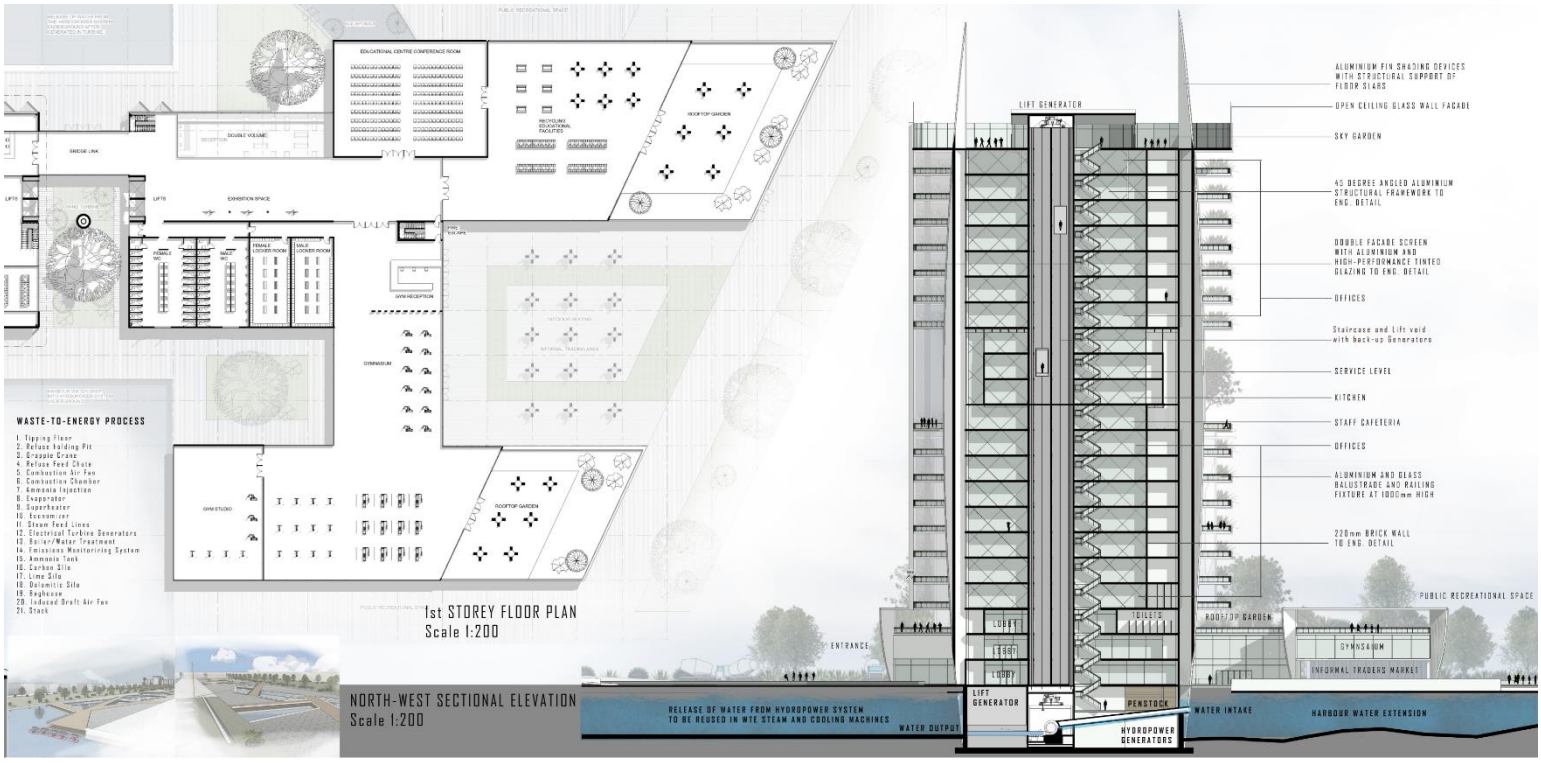

2nd STOREY FLOOR PLAN
Scale 1:200


TYPICAL FLOOR PLAN
Scale 1:200 (Levels 3, 4, 5, 7, 8, 9, 14, 15, 16, 17, 18, 19, 20

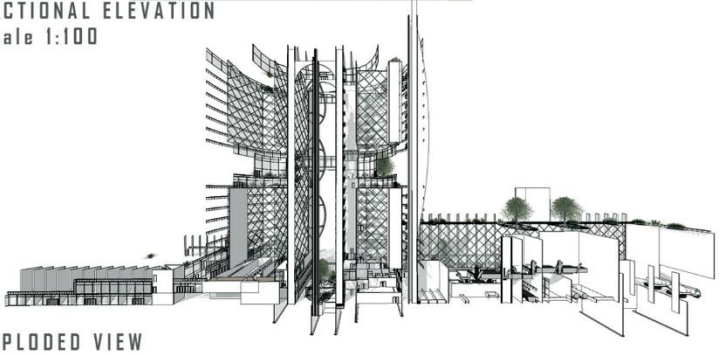

10th FLOOR PLAN
Scale 1:200


SOUTH WEST ELEVATION
Scale 1:200


BIONIC ARCHITECTURE
A NEW ICONIC LANDMARK OF SUSTAINABILITY
PRECEDENTS
ROOF
BIG TANK (RAINWATER HARVEST)
TREATMENT
POTABLE H2O
LIVING MACHINE TANKS
NON POTABLE STORAGE TANK
LIVING MACHINE
TANK
DISTRICT
GREY WATER
EMERGENCY
CONFERENCE ROOMS
SERVICE LEVEL
KITCHEN
CAFE/BAR/MIXED VENUE
CONFERENCE ROOMS
ROOFTOP GARDEN
INFORMAL TRADERS MARKET
ROOFTOP GARDEN
ROOFTOP GARDEN
RECYCLING EDUCATIONAL CENTRE
PASSENGER STORES ROOM & INFORMAL TRADERS MARKET
KIDS DAY CARE CENTRE
EXHIBITION SPACE
RECEPTION
RESEARCH CENTRE
RECYCLING EDUCATIONAL CENTRE
ADMIN & CONTROL ROOMS
RAINWATER COLLECTION
LIFT POWER GENERATOR
HYDROPOWER GENERATOR & TURBINE
Water Vapour (Steam) and cleaned flue gases
ALUMINIUM FIN SHADING DEVICES WITH STRUCTURAL SUPPORT OF FLOOR SLABS
ALUMINIUM STRUCTURAL FRAMING
SKY GARDEN
45 DEGREE ANGLED ALUMINIUM STRUCTURAL FRAMEWORK TO ENG. DETAIL
RAINWATER HARVEST SYSTEM FOR WATER DRAINAGE AND TURBINE ROTATING MAST
ALUMINIUM AND HIGH-PERFORMANCE TINTED GLAZING TO ENG. DETAIL
OFFICES
Staircase and Lift void with back-up Generators
SERVICE LEVEL
KITCHEN
STAFF CAFETERIA
OFFICES
15M HIGH WIND TURBINE TO ENG. DETAIL
ROOFTOP GARDEN WITH A VIEW OF THE WASTE INCINERATOR
VIEW OF WTE FACTORY
EXCESS ASH TO BE TRANSFERRED TO LANDFILL
EXCESS METAL FROM ASH TO BE RECYCLED
SECTION A-A
Scale 1:200


WASTE-TO-ENERGY PROCESS
1. Tipping Floor
2. Refuse holding Pit
3. Grapple Crane
4. Refuse Feed Chute
5. Combustion Air Fan
6. Combustion Chamber
7. Ammonia Injection
8. Evaporator
9. Superheater
10. Economizer
11. Steam Feed Lines
12. Electrical Turbine Generators
13. Boiler/Water Treatment
14. Emissions Monitoring System
15. Ammonia Tank
16. Carbon Silo
17. Lime Silo
18. Dolomitic Silo
19. Baghouse
20. Induced Draft Air Fan
21. Stack
1st STOREY FLOOR PLAN
Scale 1:200
ALUMINIUM FIN SHADING DEVICES WITH STRUCTURAL SUPPORT OF FLOOR SLABS
OPEN CEILING GLASS WALL FACADE
SKY GARDEN
45 DEGREE ANGLED ALUMINIUM STRUCTURAL FRAMEWORK TO ENG. DETAIL
DOUBLE FACADE SCREEN WITH ALUMINIUM AND HIGH-PERFORMANCE TINTED GLAZING TO ENG. DETAIL
OFFICES
Staircase and Lift void with back-up Generators
SERVICE LEVEL
KITCHEN
STAFF CAFETERIA
OFFICES
ALUMINIUM AND GLASS BALUSTRADE AND RAILING FIXTURE AT 1000mm HIGH
220mm BRICK WALL TO ENG. DETAIL
LIFT GENERATOR
PUBLIC RECREATIONAL SPACE
ROOFTOP GARDEN
GYMNASIUM
INFORMAL TRADERS MARKET
ENTRANCE
LOBBY
LIFT GENERATOR
PENSTOCK
HYDROPOWER GENERATORS
WATER INTAKE
HARBOUR WATER EXTENSION
RELEASE OF WATER FROM HYDROPOWER SYSTEM TO BE REUSED IN WTE STEAM AND COOLING MACHINES
WATER OUTPUT
NORTH-WEST SECTIONAL ELEVATION
Scale 1:200

SECTIONAL ELEVATION
Scale 1:100

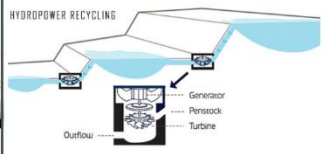


EXPLODED VIEW

BIO-INDUSTRIAL FACILITY WITH SYSTEMATIC CIRCULATION

PUBLIC
SEMI-PUBLIC
SEMI-PRIVATE

HYDROPOWER RECYCLING



WATER RECYCLING

WASTE RECYCLING

ROOFTOP GARDENS

22nd FLOOR SKY GARDEN PLAN
Scale 1:500

6th STOREY FLOOR PLAN
Scale 1:500

SHADING DEVICES

DOUBLE FACADE GLASS

PHOTOVOLTAIC FACADES

GREEN ARCHITECTURE & INTEGRATION OF FRONTIER TECHNOLOGY DESIGN CONCEPTS

DOUBLE FACADE SHADING

GREEN FACADE WALLS

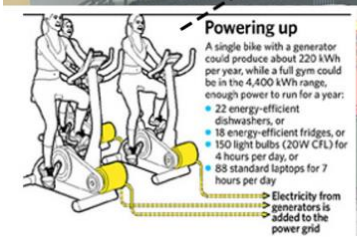
MODERN WIND TURBINES

RAINWATER REUSE & HARVESTING

MATERIALS

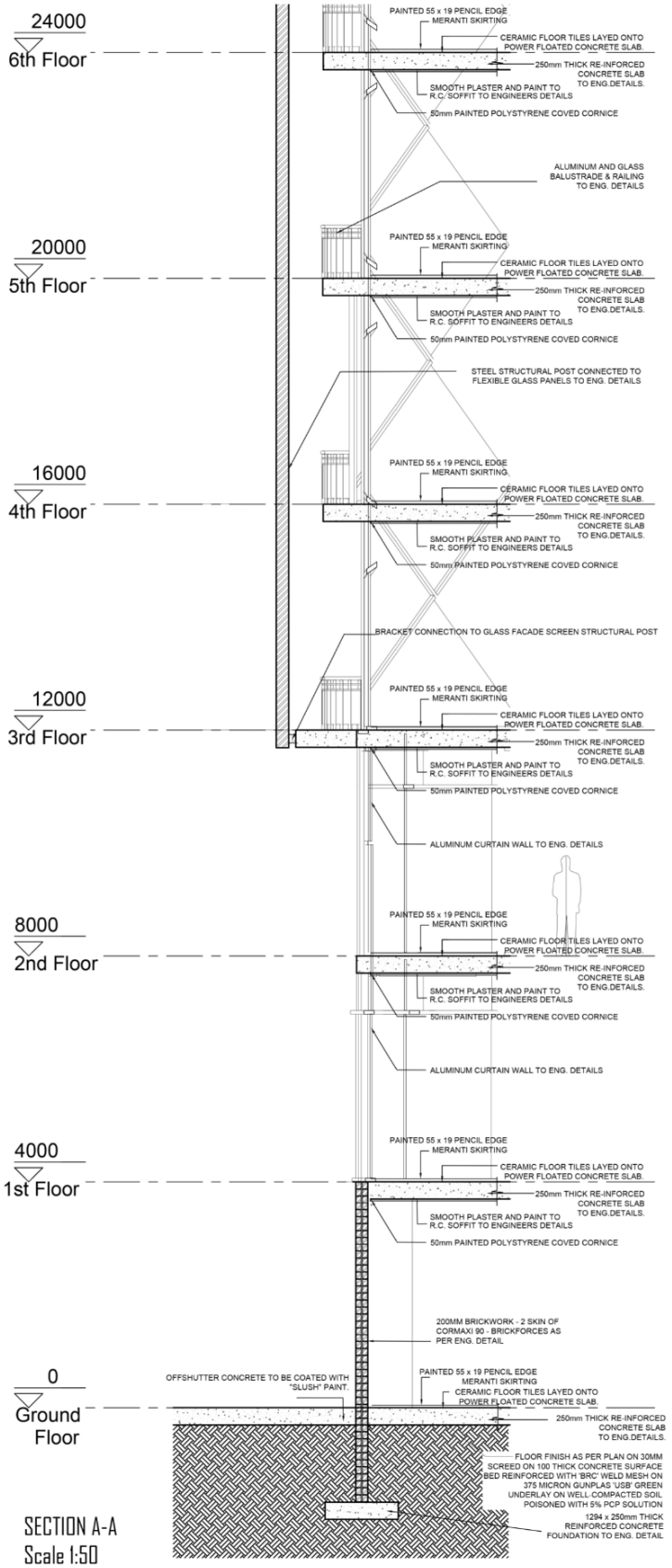
SOUTH EAST ELEVATION
Scale 1:200


ENTRANCE VIEW
HARBOUR EXTENSION & INFORMAL TRADING MARKET
PEDESTRIAN ACCESS
SKY GARDEN
TRUCK WASTE DROP-OFF

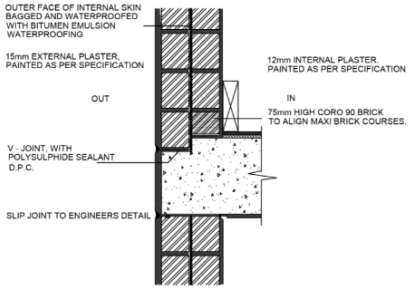

Powering up
A single bike with a generator could produce about 220 kWh per year, while a full gym could be in the 4,400 kWh range, enough power to run for a year:
22 energy-efficient dishwashers, or
18 energy-efficient fridges, or
150 light bulbs (20W CFL) for 4 hours per day, or
88 standard laptops for 7 hours per day
Electricity from generators is added to the power grid


Paper products and empty paper containers
Empty plastic containers, Styrofoam, plastic material and metals
Food waste and paper napkins
Bottles and aluminum cans
Non-recyclable waste and mixed materials

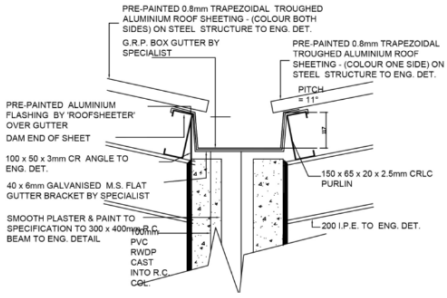

REYCLING EDUCATION CENTRE
FOR THE COMMUNITY



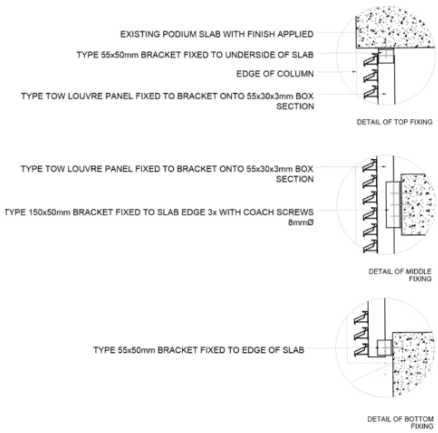
SECTION A-A
Scale 1:50



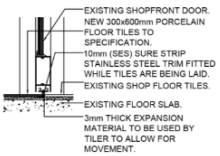
DETAIL 01 - Wall & Slab
Scale 1:10



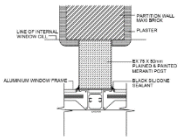
DETAIL 02 - Roof Drainage
Scale 1:10



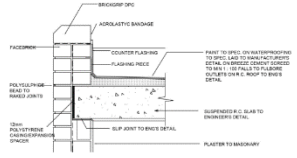
DETAIL 03 - Double Facade Fixture
Scale 1:10



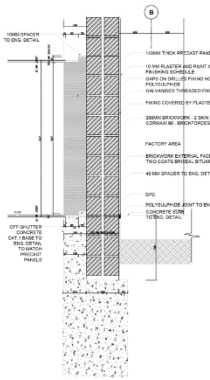
DETAIL 04 - Curtain Wall Fixture
Scale 1:10



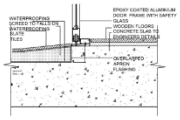
DETAIL 06 - Wall into Curtain Wal Fixture
Scale 1:10



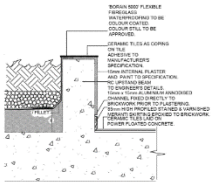
DETAIL 06 - Roof Waterproofing
Scale 1:10



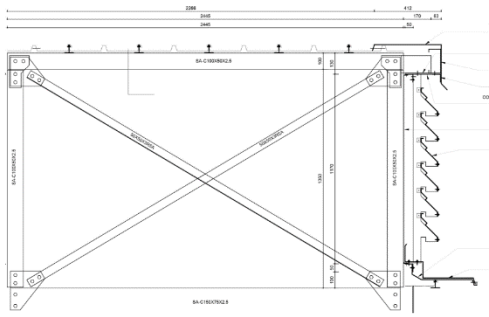
DETAIL 09 - Waste Bunker Concrete Precast Panel
Scale 1:10



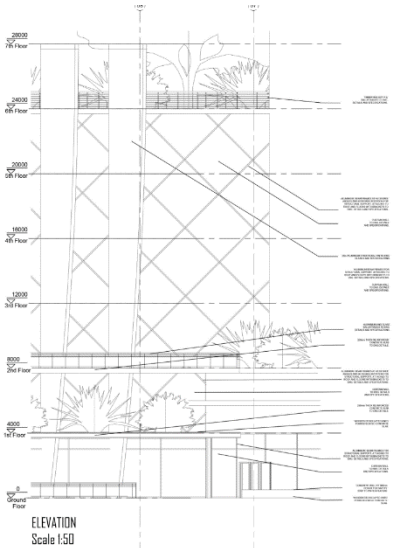
DETAIL 07 - Exterior Curtain Wall Fixture
Scale 1:10



DETAIL 08 - Rooftop Garden Planting
Scale 1:10



DETAIL 10 - Waste-To-Energy Factory Roof Fixture
Scale 1:10



ELEVATION
Scale 1:50

GENERAL NOTES

All work to comply with SANS 10400

All work to comply with the design and development guidelines as laid down by eThekwini Municipality

Architectural drawings are to be read in conjunction with engineers drawings.

Corner beacons to be located and exposed before work on site commences.

Cleaning eyes to be provided to stoer water pipes to comply with part H.

Flashing to comply with part L

Contractor to check all dimensions on site and report any discrepancies to the DESIGNER/OWNER.

All written dimensions to be taken in preference to scaling.

All reinforced concrete, slabs, foundations, column details, beams, stairs, and retaining walls are to be built strictly in accordance with professional engineers detail and under his supervision.

Banks to be cut to a maximum of 30 degrees

Contractor to ensure that no changes is levels are made over local authority servitudes or underground services unless permission has been given in writing by the local authority.

The contractor is to inspect the official approved copies of the drawings to ensure that all amendments have been taken into account.

The attention of the owner is drawn to the fact that changes to the plan and/or specification after official approval is lively to invalidate that approval

All foundations to be taken down below natural ground level

If on excavation the site is found to contain expansive clay, shale, ground water or other suspect soil conditions, then all foundations are to be built to professional engineers details & under his supervision

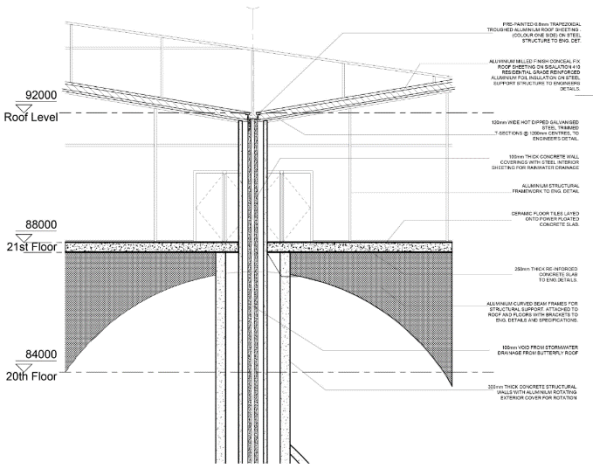
Natural ground line in approximate position only and no claim can be made for any discrepancies on site

375 mic DPC to be provided to walls at slab level, under all cills & to parapets

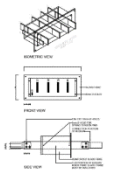
glazing to comply with part N of SANS 2010

fibre cement barge boards & fascias - aluminium gutters & down pipes fixed in accordance with manufacturers

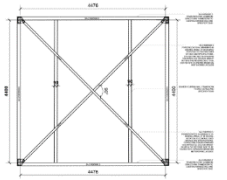
two courses of brickwork to be reinforced with brickforce both below wall plate level, above window head height & below window cill level



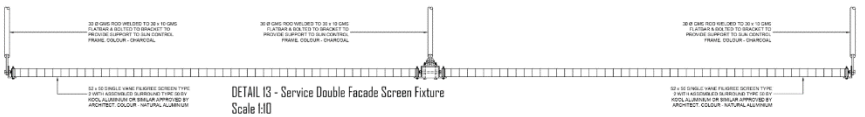
SECTION B-B
Scale 1:50



DETAIL 11 - Generator Busbar Unit
Scale 1:10



DETAIL 12 - Curtain Wall Framework
Scale 1:100



DETAIL 13 - Service Double Facade Screen Fixture
Scale 1:10