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MAINSTREAMING SUSTAINABILITY IN PUBLIC SPACE: FORMULATING ENERGY STRATEGIES THROUGH URBAN DESIGN IN GABORONE, BOTSWANA

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DECLARATION

I, Thabang Tumo PUSO, hereby declare that this thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material, and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

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DEDICATION

I would like to thank my entire family, my mother Catherine Dithuso Puso and my grandparents for the support they have shown me throughout my master's studies and during this research particularly during the challenging times of the COVID-19 pandemic.

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LIST OF ABBREVIATIONS

BERA	Botswana Energy Regulatory Authority
BOBS	Botswana Bureau of Standards
BPC	Botswana Power Corporation
CFL	Compact Fluorescent Light
DCC	Development Control Code of 2013
DOE	Department of Energy
GCC	Gaborone City Council
IP	Implementation Plan
IPP	Independent Power Producer
kW	Kilowatt
MW	Megawatt
MMGE	Ministry of Mineral Resources, Green Technology and Energy Security
MLWS	Ministry of Lands, Water and Sanitation Services
NEES	National Energy Efficiency Strategy 2018
NEP	National Energy Policy 2021
RTS	Rooftop Solar
VAT	Value Added Tax

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MAINSTREAMING SUSTAINABILITY IN PUBLIC SPACE:

FORMULATING ENERGY STRATEGIES THROUGH URBAN DESIGN IN GABORONE, BOTSWANA

ABSTRACT

As cities embrace climate change adaptation and mitigation, it has become critical to address energy issues in public spaces in the quest to achieve sustainable urban development. However, sustainability projects in the built environment primarily utilise “techno-fixes” and often neglect the placemaking and socio-economic benefits of responsible energy consumption. Energy strategies are treated as an afterthought that comes as a retrofit in the design of the public realm (Ozgun, 2020). Urban design is defined as the art of making better places for people and public life. It involves a thought process of arranging spaces and infrastructure in the built environment to create functional places for human activity (Abd Elrahman & Asaad, 2020). This study asserts that sustainable communities do not come about accidentally but are thoughtfully created. The current trend in the design of public spaces by built environment experts in Botswana undervalues the usefulness and ability of energy to improve the sustainability of these places. However, if seen as a self-organising state where people congregate to interact and gain knowledge from their environment, the public realm provides a powerful ground to shape and direct society towards a sustainable energy lifestyle (Ozgun, 2020). Through urban design interventions, this study proposes a design framework to rethink energy strategies in the public realm, that address environmental issues relating to renewable energy transition; economic issues relating to cost saving; social issues relating to a vibrant lifestyle; and placemaking issues relating to functionality and aesthetics.

1. INTRODUCTION

1.1. Background

Botswana is a landlocked country at the heart of southern Africa. It is bordered by South Africa to the south, Namibia to the west and north-west, Zambia to the north and Zimbabwe on the north-east as shown in Figure 1 below (One World Nations Online, 2020). According to World Bank (2019) the population of Botswana was 2.3 million in 2018 consisting of 48.3% males and 51.7% females.

The country is sparsely populated as up to 70% of its 581 730km^2 is covered by the Kalahari Desert, to the west and south-west. Nonetheless, 38% of its total land area is dedicated to environmental conservation in the form of national parks, reserves and wildlife management areas making it one of the most coveted unspoiled wildernesses in Africa.

According to World Bank (2020), Botswana was classified one of the poorest countries in the world at the time of gaining independence from Britain in 1966. It quickly became one of the world's development success stories actually becoming the world's fastest growing economy for 31 years and being amongst the fastest growing for 40 years between 1965/1966 and 2005/2006 (Maipose, 2008). Major mineral (diamond) wealth, good governance practices, careful economic management and a relatively small population have made it an upper middle-income country with an agenda of becoming a high-income country by 2036.

The country had a Gross Domestic Product (GDP) of USD18.616 billion in 2018. The GDP Per Capita was USD8 031 which ranked it fifth (5th) in Africa. The diamond exports are the single largest contributor to government revenues and account for 80% of export earnings (World Bank, 2019). Other key export commodities include other gems, precious metals, electrical machinery, equipment and meat etc.

Botswana's Human Development Index value for 2019 was 0.728— which put the country in the high human development category. This ranked it 94 out of 189 countries and territories. The rank is shared with Saint Vincent and the Grenadines. Life expectancy at birth is 69.3 (United Nations Development Programme, 2019).

Figure 1.1: Map of Africa Showing the Location of Botswana **Source:** (Magombo & Fabre, 2009)

1.2. The problem

Current trends in the design and development of public spaces by urban designers, urban planners, architects and landscape architects in Botswana undervalues the significance of energy by neglecting its social, economic, environmental and placemaking usefulness and ability to improve the sustainability of these places. The problem statement therefore is that the design of public spaces in Gaborone does not address sustainable development aspects, particularly energy issues, thereby resulting in limited human activity.

The study area for this research is BBS Mall located in the neighbourhood of Broadhurst. BBS Mall was chosen since unlike majority of the modern shopping malls in the city that are enclosed complexes where shopping and other activities are done indoor, it is an open precinct with a bustling outdoor life/public realm.

2. LITERATURE REVIEW

2.1. Energy and urbanism

Cities account for over 70% of global carbon emissions related to energy as a consequence of the usage of fossil fuels and accommodating more than half of the world's population. Therefore, it has become imperative to incorporate energy planning at local-scale into the national hierarchy of energy systems. This requires taking into account modern energy dynamics such as decentralised generation, renewable energy transition, clean energy, energy efficiency, mobility and public awareness in response to climate change (Yazdanie & Orehounig, 2021). According to Ozgun (2020) energy strategies (and generally sustainability initiatives) are commonly treated as a technological supplement. An afterthought! These initiatives usually come as a retrofit in the design of public spaces.

Despite being the main contributors to climate change, cities have great influence in mainstreaming solutions to achieving sustainability. This heavily relies on inner-city interventions particularly within the public realm (Alexandrakis, 2021).

2.2. The public realm

The public realm (public spaces) is defined as places publicly owned or of public use, accessible and enjoyable, by all for free and without a profit motive. This includes streets, sidewalks, parks, open green spaces, civic squares, plazas et cetera. Public spaces are a vital component of society's individual and collective wellbeing, interaction with nature, cultural pluralism and a foundation for a shared identity (United Cities and Local Governments, 2016).

Considering the social element of the public realm as spaces where people congregate to interact and gain insights or knowledge from their environment and each other, it can be said that public spaces do not exist as inert, lifeless physical entities but rather as constellations of ideas and activity. Therefore, the public realm acts as a powerful ground to shape and direct society towards a sustainable energy lifestyle when used as an educational and transformation platform. If seen as a self-organising state, public space can be designed to instil and normalise a culture and mindset of sustainability. One integral part of spatial planning is to promote a

symbiotic relationship between the public and energy in order to strike a balance between production and consumption for holistic sustainability (Ozgun, 2020).

For this study, public space as a hub of a wide range of activities, is chosen as opposed to non-places, such as large hotels, department stores, enclosed shopping malls, banks, and office buildings among others which according to John (2010) *"have no soul."*

2.3. Urban design

The spatial and environmental quality of public spaces is a critical aspect of urban culture (La Malva et al., 2015). Ideologies in urban planning as a discipline have undergone transformation from being focused on planning spaces for visual appeal to an approach that considers and addresses holistically other ways that people perceive their environment (Calleri et al., 2015).

Dias et al., (2014) define urban design as the art of making places in an urban context which involves designing groups of buildings, the spaces and landscapes between them and further the creation of frameworks for successful development. It is further defined as the art of making better places for people and public life. This involves a thought process of arranging spaces and infrastructure in the built environment to create functional places for human activity. It is a problem-solving tool for the city with a great responsibility towards the people, place and environment (Abd Elrahman & Asaad, 2020).

At its infancy, the principal mandate of urban design was city beautification. Today sustainability is embedded in urban design by aiming to enhance socio-economic and environmental life in the city through creating three-dimensional forms and spaces that are functional for people. It does this economically by creating opportunities for employment, socially by providing active open spaces and recreational facilities and environmentally by ensuring clean air, clean rivers and beautiful places to live, work and play. Therefore, developing purposeful and effective places through urban design requires understanding and addressing human needs and behaviour including the physical environment in a local context (Dias et al., 2014).

Despite the fact that it addresses the daily needs of the public and solving material problems,

urban designers are often overlooked as powerful decision makers in urban development planning let alone the energy sector as they are overshadowed by other professions that operate at higher levels of policy formulation (such as urban planning and environmental management) and those concerned with infrastructure development (such as architecture, landscape design, civil engineering and transport planning etc). All these disciplines and urban design have a mandate of shaping the built environment and neither can afford to neglect the other (Abd Elrahman & Asaad, 2020).

This study realises that the intended outcomes of urban design can be harnessed as a tool to shape the built environment towards overall sustainable development as according to Ozgun (2020), this can teach the public about a sustainable energy lifestyle and improve environmental-friendliness thereby resulting in an active and vibrant public realm.

3. THEORETICAL CONCERNS / SITUATING THE STUDY IN THE FIELD

3.1. Sustainable development

Sustainable development is defined as the use and exploitation of today's resources in such a manner that these resources will be available for use by future generations. In other words, consumption today with tomorrow in mind (Redclift, 1992).

The damaging impact of human activity on the environment has jeopardised the existence of the Earth and future generations. This in turn has necessitated the need for behavioural change towards more rational and efficient management of natural resources to minimise environmental impact. This shift towards responsible consumption to ensure the survival of future generations demonstrates and gave birth to the concept of sustainable development. Sustainability aims to achieve a balance with respect to its triple bottom line pillars of environmental, economic and social development. Amongst the actors that contributed to the formulation of the concept, the United Nations (UN) is the most significant one (Klarin, 2018).

The UN launched the 2030 Agenda for Sustainable Development in 2015 to eliminate poverty, ensure world peace, prosperity and opportunity for all on a healthy planet. Under it, issues relating to energy, urban development, climate change and responsible consumption form part of the 17 Sustainable Development Goals (SDGs) (United Nations, 2020). These are summarised in Table 1 and Figure 2 below:

Table 3.1: *The sustainable development goals relevant to the study*

Source: (United Nations, 2020)

Number	Goal
7	Ensure access to affordable, reliable, sustainable and modern energy for all.
9	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.
11	Make cities and human settlements inclusive, safe, resilient and sustainable.
12	Ensure sustainable consumption and production patterns.
13	Take urgent action to combat climate change and its impacts.

Figure 3.1: *The official icons and shortened SDGs relevant to this study.*
Source: (United Nations Department Of Global Communications, 2020)

3.2. Placemaking

Places of different sizes and character within the built environment form the urban grain and urban fabric of cities. A place is defined as a small, three-dimensional space that is cherished and valued by the people who inhabit it for what it means to them (John, 2010).

Placemaking is defined as a collaborative process by which we can shape our public realm in order to maximize shared value by strengthening the connection between people and the places they share. The characteristics of a sustainable place as depicted by Figure 3 are summarised in four categories being sociability i.e. street life, inclusiveness and stewardship; uses and activities i.e. retail, celebration, local economy and vitality; comfort and image i.e. good building conditions, walkability, greenery and safety; as well as access and linkages i.e. connectivity, pedestrianisation/walkability and readability (Project for Public Spaces, 2007b).

Drawing on the practical placemaking experiences of Storring & Walker (2016) from working on public spaces in "innovation districts," the principles relevant this study towards developing a framework and a design are discussed below.

3.2.1. Innovation - Making innovation visible and public

This involves putting more focus on creating a sense of place by developing energy strategies that are cost-effective and meaningful.

3.2.2. Diversity - Mixing innovation with a variety of uses

Innovative solutions should not only be based on being eco-friendly, energy-conscious and

economical but they should also provide convenience and leisure to the users.

3.2.3. Mobility

Interventions should promote walkability and reduce car dependence.

3.2.4. Sociability - Bringing people together through places and programming

Energy strategies should promote comfort and accessibility to provide an inviting environment that people are constantly drawn to, to come and meet over and over again. This will foster social cohesion.

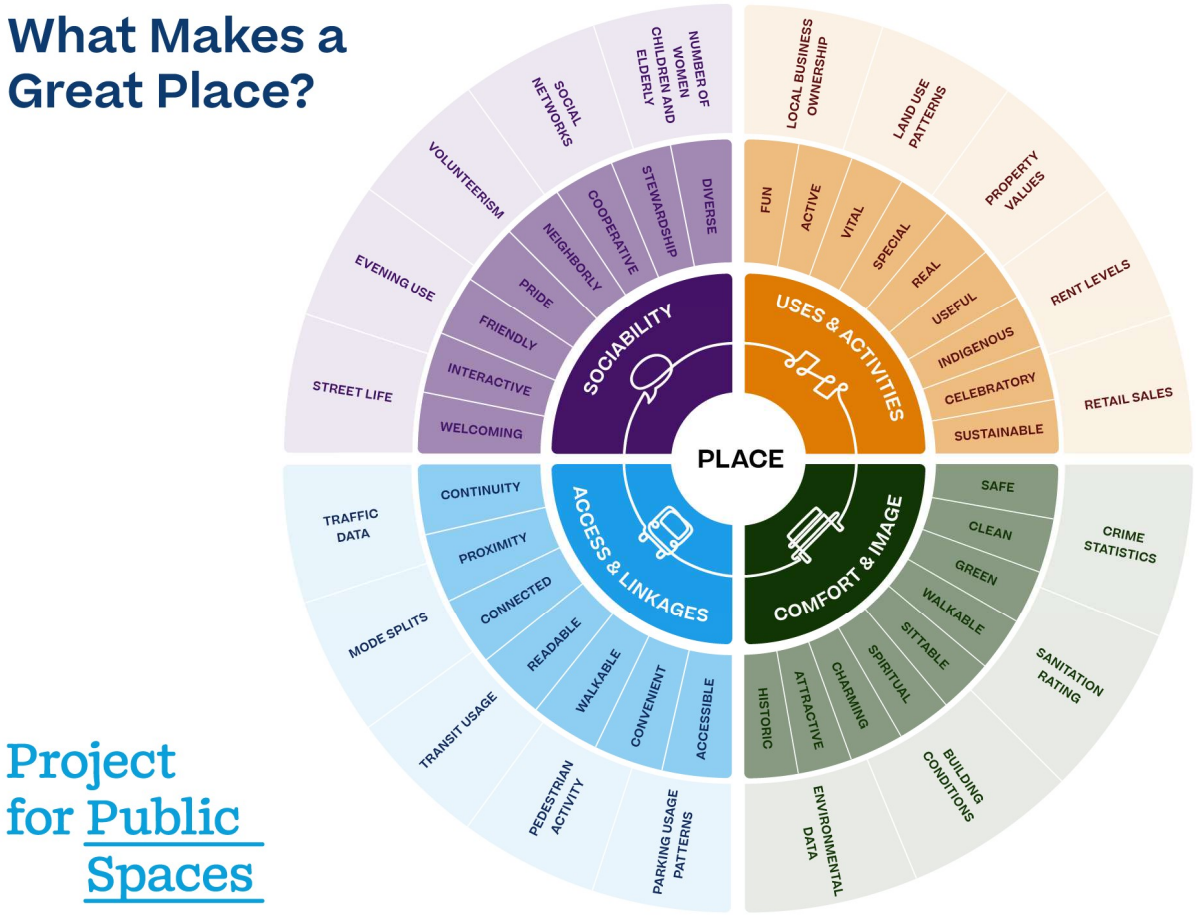

Figure 3.2: *Characteristics of a sustainable place*

Source: (Project for Public Spaces, 2007b)

4. RESEARCH QUESTIONS AND THE WORKING HYPOTHESIS

4.1. Questions

i. How do policies that guide urban development promote sustainable energy strategies in Gaborone city's public spaces?
ii. How does the current morphology and management of BBS Mall's public space address socio-economic and environmental aspects of sustainable development particularly energy issues?
iii. How can urban design interventions be adopted for developing energy strategies that will enhance sustainability in BBS Mall's public spaces and ultimately the city's public realm?

4.2. Working hypothesis

Urban design, a concept in spatial planning, can be harnessed as an instrument for devising energy strategies that will activate and achieve sustainability in the public realm. This study proclaims that sustainable communities/places do not come about accidentally but are a conscious effort and are thoughtfully created.

4.3. Research objectives

To:

i. Analyse how policies that guide urban development in the city promote sustainable energy strategies in public spaces.
ii. Assess how the current morphology and management of BBS Mall's public space address socio-economic and environmental aspects of sustainable development particularly energy issues**.**
iii. Develop a public space energy strategy framework to aid the formulation of detailed urban design guidelines and schemes incorporating energy strategies with an overall goal of achieving sustainability in the public realm.
iv. Propose a design intervention for a sustainable public space in the city, using the proposed framework in objective number three above.

4.4. Relevance of the study

The aim of the study is to conceptualise and promote energy-conscious urban design in the form of a design framework comprising energy strategies to facilitate the development of detailed urban design guidelines and schemes in future. In addition, the same framework should be able to be used by urban designers, urban planners, architects and other sustainable development experts, both public and private, in assessing and measuring the sustainability of existing public spaces particularly with regard to energy issues at local scale.

Furthermore, the same instrument should be applicable to entire city/spatial development plans and urban master plans (which operate at a much higher strategic level); local area plans and site plans; urban design schemes; as well as architectural and engineering layouts/plans.

5. METHODOLOGY

5.1. Data collection

Primary data collection methods being site observation, a mini public survey and partially-structured interviews with experts in urban planning and renewable energy policy and engineering were used in this research. Secondary methods included a desktop study of publications from government, parastatals, non-governmental organisations and private institutions.

5.1.1. Observation, interviews & questionnaires

The interview questions captured the following topics; design intentions, policy and institutional framework, challenges to achieving sustainability in the city and the triple bottom line (TBL). Site observation was employed to appreciate the built environment as well as the nature and extent of activities taking place in the public realm of the mall. This encompasses how energy strategies and sustainability have been incorporated in the spatial planning and design of the spaces as well as how people interact with one another and energy.

Economic sustainability was assessed by looking at whether there are practices or behaviours that are aimed at reducing money spent on energy usage. Cost-saving practices ultimately lead to responsible consumption. It also relates to energy efficiency which is strongly tied to the environmental perspective as well.

Environmental sustainability was assessed in three aspects being renewable energy transition & clean energy; energy efficiency strategies; and eco-friendly materials. Renewable energy transition is whether the energy used is from renewable sources such as solar or bio-gas et cetera. This can be generated either on or off the site. Clean energy refers to the use of sources such as liquefied petroleum gas (LPG). Energy efficiency was assessed looking at whether there is energy wastage and the kind of appliances/equipment. Eco-friendly materials refers to the kind of materials within the built space for example building cladding and ground cover.

For the social aspect, mobility/accessibility was assessed looking at the ease of reaching the

public space under study and whether it encouraged walking and cycling as they do not consume energy in the form of fuel as opposed to motor vehicles. In addition, sustainability awareness was assessed considering how knowledgeable the public is about issues of sustainability particularly energy issues and climate action.

Placemaking as a design-based theme was assessed looking at aesthetics that is, whether visual appeal is considered when developing public spaces so as to create a certain image and character for the place. Functionality, still under placemaking, was assessed looking at how practical the place is considering the site layout as it influences how energy is accessed and used.

Figure 5.1: *Indicators for investigating the triple bottom-line and placemaking*

Theme	Strategy
Economic Assessment	Cost-saving Mechanisms
Environmental Assessment	Renewable Energy Transition & Clean Energy
	Energy Efficiency Strategies
	Eco-friendly Materials
Social Assessment	Mobility/Accessibility
	Sustainability Awareness
Placemaking Assessment	Aesthetics
	Functionality

5.1.2. Desktop study

A range of public documents in the energy and urban development sectors were studied and analysed. These included:

i. Official government publications i.e. policies, strategies, roadmaps and regulations
ii. Annual reports of parastatals
iii. Thematic/topical reports of international organisations such as the United Nations
iv. Websites of private organisations, parastatals and other agencies
v. Articles from trusted journals such as Energies; Sustainability; Transportation Research

Interdisciplinary Perspectives et cetera

5.1.3. Google Earth

Google Earth Pro was used to obtain the aerial imagery for mapping purposes. The aerial imagery provided clarity understanding the surveyed line map to get the extent of physical developments on the ground as shown by Figure 5.2.

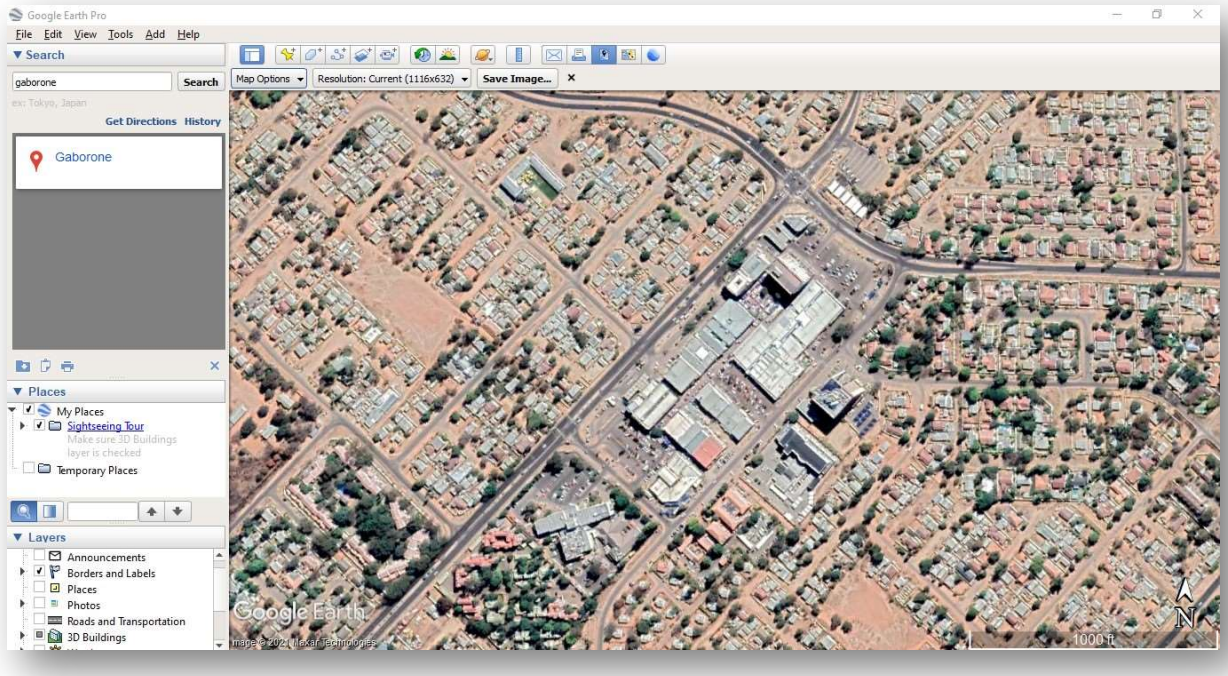

Figure 5.2: *An aerial image of BBS Mall*

5.2. Data processing

The following methods were used to analyse and synthesise data:

5.2.1. AutoCAD 2018

As a design, architectural and engineering software, AutoCAD was used for producing the base map for the study area from the city's overall land parcels' layout/map as shown by Figure 5.3. The base map was then used as a foundation for producing different thematic maps for site analysis.

Furthermore AutoCAD was used to create a layout/site plan to demonstrate how to mainstream sustainability in the BBS Mall public space.

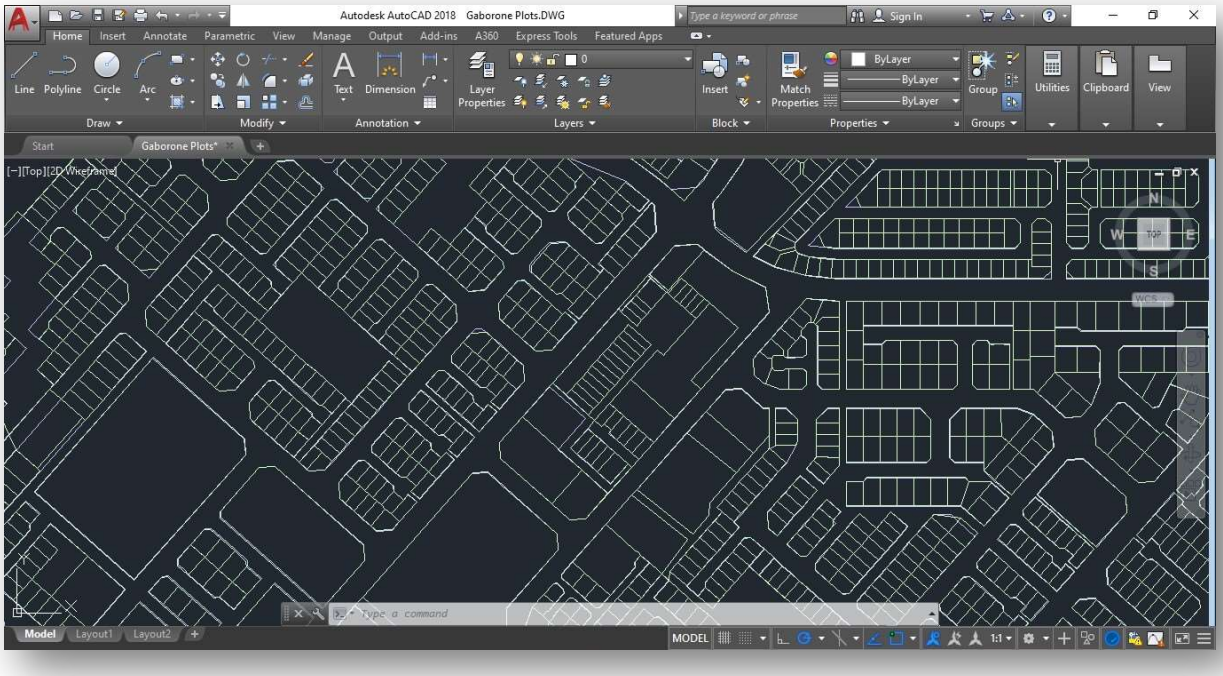

Figure 5.3: *Layout of land parcels of BBS Mall and surrounding lots.*

5.2.2. SketchUp Pro 2021

SketchUp Pro 2021 was used to develop a base model of the existing built-up area and the spaces in between as shown by Figure 5.4. This was derived by feeding the plain (line-drawing) site plan from AutoCAD into SketchUp then developing three-dimensional (3D) elements/features of the envisaged sustainable public space.

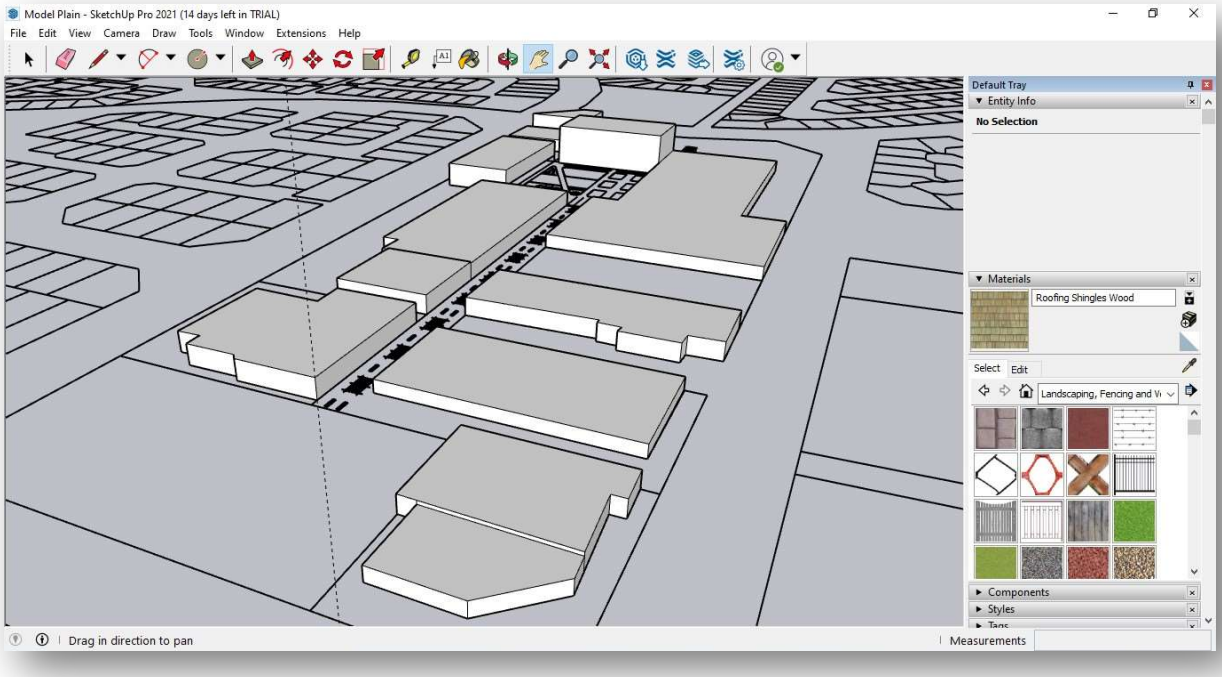

Figure 5.4: *A three-dimensional (3D) model of the built-up area of BBS Mall.*

5.3. Placemaking

The Project for Public Spaces developed widely accepted 11 Principles of Placemaking within the urban planning, architecture and urban design disciplines in the year 1999. These emanate from three key pillars intending to help communities integrate diverse opinions into a cohesive vision; translate that vision into a plan and program of uses; and ensure the sustainable implementation of the plan (Project for Public Spaces, 2007a).

The relevant principles adapted for this study are:

i. Creating a vision,
ii. Creating a place and not just a design,
iii. Learning by observation,
iv. Starting with the petunias i.e. Lighter, quicker, cheaper (LQC) interventions,
v. Form supports function.

The assessment of place-making in existing public spaces will be based on the themes and selected indicators in Table 5.1.

Table 5.1: *Indicators for assessing placemaking.*

Sociability	**Uses & Activities**
• Street Life • Social Networks • Diversity (Women, children & the elderly) • Interactive • Stewardship	• Local business • Land-Use • Indigenous • Fun/Active
Comfort And Image	**Access & Linkages**
• Safety • Clean and green • Walkability • Sittable • Building conditions • Historic and attractive	• Proximity • Readability • Parking Usage Patterns • Pedestrian Activity • Transit Usage & Mode Split

6. FINDINGS

6.1. Policy framework

The policy framework is divided into two groups according to the relevant themes of this study being energy sector policies and urban development policies. The custodians of the ones concerned with the energy sector are the Ministry of Mineral Resources, Green Technology and Energy Security (MMGE) through the Department of Energy. MMGE was previously known as Ministry of Minerals, Energy and Water Resources (MMWER). Those guiding urban development are under the Ministry of Lands, Water and Sanitation Services (MLWS) and the municipality being Gaborone City Council (GCC). MLWS was previously known as Ministry of Lands and Housing (MLH).

The main policy guiding Botswana's energy sector is the National Energy Policy of April 2021. The other supporting documents and legislation are depicted in Table 6.1 below:

Table 6.1: *Policies governing the energy sector.*

		Sub-Sector				
		Electricity	Solar	Biomass & Bio-fuels	Oil & Gas	Coal
Statutory Instrument	National Energy Policy (2021)	■	■	■	■	■
	National Energy Efficiency Strategy (2018)	■	■	■	■	■
	Renewable Energy Strategy for Botswana (Roadmap) 2018	■	■			
	Off-Grid Solar Action Plan (2018)	■	■			
	Rooftop Solar Guidelines (2020)	■	■			
	Building Regulations (2014)	■	■			
	Biomass Energy Strategy (2009)			■		
	Biofuels Guidelines			■		
	The Coal Roadmap	■				■
	Standards by Botswana Bureau of Standards (BOBS)	■	■	■	■	■

	Botswana Energy Regulatory Authority Act (2016)					
	Botswana Power Corporation Act					
	Electricity Supply Amendment Act					
	Petroleum Products Bill					
	Gas Bill					
	Forest Act (Chapter 38:03)					

6.1.1. National Energy Policy (2021)

Officially adopted in April 2021, the policy aims to pursue and execute a strategy with an approach of meeting the needs of consumers, government and service providers alike to ensure sustainability of energy supply. This therefore means guaranteeing efficiency, reliability and affordability while ensuring environmental protection.

The vision of the National Energy Policy is to create an energy system that would ensure secure and reliable supply of modern energy services for all the sectors of the economy and to significantly reduce energy-related atmospheric emissions by the year 2040 (Ministry of Mineral Resources, Green Technology and Energy Security, 2021). Of the twelve policy objectives, the ones directly relevant to this study are to:

- Diversify the national energy mix by promoting renewable energy sources, especially solar and clean coal technologies;
- Support the modernisation and expansion of energy infrastructure to meet the growing energy demand;
- To ensure equitable access to modern energy forms by the industry, rural communities and the disadvantaged groups;
- Minimize the impacts of energy supply and consumption on the environment through increase of renewable energy in the supply mix and improved efficiency in energy use;
- Mainstream gender, age and socio-economic status issues in energy development programs

The specific goals and objectives of the NEP that are relevant to this study are as shown in Table 6.2 below:

Table 6.2: *The goals and objectives of the national energy policy relevant to this study.*

POLICY STATEMENT	POLICY OBJECTIVE	HIGH-LEVEL STRATEGY
ELECTRICITY SUB-SECTOR		
P1 Electricity will be generated optimally from locally available energy resources to meet local demand and to ensure self-sufficiency.	**P1.2** To promote sustainable use of indigenous energy resources, especially solar for electricity generation.	**P1.2.1** Create opportunities for mini- and micro-generators to feed into the national grid and off-grid mini-grid networks. **P1.3.1** Guide the integrated energy resource planning through deliberate decisions that prioritize power generation from renewables and decentralised systems in way that will optimise the long-term cost of electricity supply.
P2 Transmission and distribution infrastructure will be enhanced to facilitate economic growth and universal access to electricity.	**P2.1** To ensure open access to modern energy services.	**P2.1.1** The country's transmission infrastructure and grid capacity will be improved to accommodate decentralised and intermittent generation.
P3 Electricity tariffs will be set in way that will balance the interests of the investors, consumers and the environment.	**P3.1** To ensure that electricity tariff policies provide a basis for sustainable power supplies over the long term.	**P3.1.1** The costs of electricity distribution to be optimised such that end-user electricity prices correctly reflect fixed and variable costs and convey relevant price signals to encourage efficiency.

	3.2 To make Botswana a preferred regional electricity supplier	**P3.2.1** Implement relevant grid technologies that improve the management of the distribution grid, reduce losses, enhance quality of supply, and increase the grid's capacity to accommodate small-scale grid connected decentralised generation, storage and demand side measures.
RENEWABLE ENERGY – SOLAR AND WIND		
P10 The government will support and facilitate the development of on-grid and off-grid solar in order to increase the contribution of solar energy in the energy supply mix.	**P10.1** Facilitate development and use of concentrated solar thermal power and photovoltaic electricity generation. **P10.3** Promote development and growth of solar energy-based industries.	**P10.1.3** Mainstream solar energy programmes into all levels of education systems. **P10.1.4** Promote the use of solar energy especially in households, hospitality and small businesses.
P13 Initiatives related to production and use of energy derived from biodegradable materials to offset the country's carbon footprint.	**P13.1** To increase the contribution of bioenergy in order to diversify the energy mix.	**P13.1.1** Facilitate construction of biogas plants for conversion of organic waste to produce gas as a thermal energy for households, commercial and industrial use.

	P13.3 Development and implementation of waste to energy technologies as a waste management solution.	**P13.1.2** Mainstream bio-energy into the school curriculum at primary, secondary and tertiary levels.
ENERGY CONSERVATION AND DEMAND SIDE MANAGEMENT		
14 Energy efficiency and conservation initiatives will be supported with a view to minimize energy wastage and to offset emissions from conventional power generation.	**P14.1** To promote efficient use and management of available energy resources for present and future generation.	**P14.1.2** Develop legislation that encourages the use of efficient energy equipment and appliances. **P14.1.3** Establish incentives to improve energy conservation and efficient use of energy across sub sectors. **P14.1.4** Mainstream energy efficiency, conservation and management programmes in all level of the education system.
ENERGY AND THE ENVIRONMENT		
P15 Energy extraction, production, transport and use will be done with minimal negative impacts on human health and on the environment.	**P15.1** To minimize environmental impacts from energy production and use.	**P15.1.1** Ensure adherence of energy products and technologies to environmental quality standards.

ENERGY AND GENDER		
P16 Gender mainstreaming in the energy sector will be promoted to ensure alignment of gender concerns with appropriate health, safety and environmental standards	**P16.2** To support the capacity development of women in the energy sector. **P16.3** To ensure participation of women in the formulation and implementation of energy interventions	*The objectives were not found relevant to this study.*

6.1.2. Rooftop Solar Guidelines (2020)

The Rooftop Solar Guidelines are applicable rules, regulations and standards guiding the development of solar energy technology in Botswana. These guidelines define the framework and administrative process for the implementation of small-scale grid-tied solar photovoltaic (PV) systems, either roof or ground mounted. The system-wide aggregate capacity of the Programme in the first 12 months is 10 MW (Ministry of Mineral Resources, Green Technology and Energy Security, 2020).

The goal of these Guidelines is to enable Botswana Power Corporation (BPC) electricity consumers to generate electricity for their own use while selling any excess to BPC up to the limit as defined by MMGE. They further seek to provide guidance to consumers on how they may use the Rooftop Solar (RTS) Programme in a compliant manner to generate electricity for their own use and sell any excess to BPC.

To be eligible for this Programme a consumer shall:

i. be a BPC consumer and have title to the Rooftop Solar System.
ii. site the system on the same property as the meter that will measure the consumption and export of the electricity;
iii. adhere to the limitations in capacity and sizing specifically, the following capacity limitations:
    a) Domestic – Up to 35 kW of generating capacity.
    b) Commercial & Industrial – Up to 1 MW of generating capacity.

Consumers are allowed to apply for multiple permits and/or licenses, as long as the total generating capacity of the RTS systems does not exceed 35 kW for each domestic consumer and 1 MW for each commercial & industrial consumer. For example, a commercial or industrial consumer, meeting the above criteria with the generating capacity not exceeding 1MW, each property could have the following RTS systems: 300 kW and 250 kW and 350 kW, totalling 900 kW.

6.1.3. Building Regulations (2014)

The regulations are meat to ensure energy efficiency and conservation in buildings as well as safety and the use of good quality products and technology (Ministry of Mineral Resources Green Technology and Energy Security, 2014). The following guidelines are relevant to this study:

i. Energy efficiency

Adequate provision shall be made for the conservation of energy in buildings by limiting heat gains and losses through the building envelope and thermal elements and other parts of building fabric. This can be achieved by considering the location, orientation, shading against direct sunlight, surface materials for roofs, walls and glazed areas as well as vegetation during site planning.

ii. Water efficiency

Adequate provision shall be made for the conservation of water in any building by usage of water efficient fittings and fixed appliances.

iii. Rain water harvesting and use of grey water

Adequate provisions shall be made for the capturing and storage of rain water or grey water to meet the water demand on the premises for construction, landscape irrigation, filling and topping up swimming pools as well as washing of vehicles and yard areas.

6.1.4. National Energy Efficiency Strategy (2018)

The National Energy Efficiency Strategy (NEES) is a necessary requirement for Botswana to achieve several of the priorities identified in the National Energy Policy. Its visions is to support the socio-economic development and social wellbeing of the people of Botswana by improving the efficiency of energy use, increasing energy security, promoting improved energy access

for the poor and enhancing long-term environmental sustainability (Ministry of Mineral Resources Green Technology and Energy Security, 2018).

The NEES recognises the triple bottom-line benefits energy efficiency however primarily being environmental and economic aspects. Environmentally, the NEES intends to reduce greenhouse gas (GHG) emissions while economically the motive relates to financial gains through cost-saving for example, a reduced need for the expansion of existing infrastructure. This therefore calls for urban design to promote a minimalist approach to infrastructure when creating urban spaces to minimise both costs of energy supply and greenhouse gas emissions.

The Government of Botswana has previously had measures in place to address energy efficiency. These are:

i. Building design guidelines

A technical booklet, (the Building Regulations discussed above) has been developed to provide minimum requirements for energy efficient design and construction of buildings and their systems.

ii. Compact Fluorescent Light bulb (CFL) retrofit

Under the BPC's energy efficiency in households project, one (1) million incandescent light bulbs were replaced with CFLs in households across the country. The programme resulted in a 35 MW decrease in demand. However, BPC has noticed that a significant percentage of these savings have been lost over time as households reverted back to incandescent bulbs as CFLs failed. Several policy changes are being considered to make the savings permanent, including removing Value Added Tax (VAT) on CFLs. The most likely action will be the banning of incandescent light bulbs according to the NEES.

iii. Energy efficiency awareness campaign

An awareness campaign was initiated, and has been sustained, by the Ministry and the utility. Although lacking the budget required for a high profile above the line national campaign, behavioural change has been achieved through constant advocacy efforts and low cost but

potentially impactful efforts, such as energy audits, meetings with building officials and prominent call to action messaging on BPC vehicles and outside offices.

The following energy efficiency opportunities have been identified by the NEES:

i. Public and commercial buildings sector

The NEES notes that lighting is one of the major uses of energy in both commercial and public buildings. However, like most sustainability interventions, efficient lighting usually comes as a retrofit in Botswana. Nonetheless, where efficiency measures do not exist, retrofitting has proven to be effective following the bold move by BPC to fit one million CFLs into homes. This initiative resulted in a 35 MW decrease in demand. Learning from this experience, the same initiative as extended to public buildings as a directive from the Office of the President as it was projected to save government approximately 20% of the total electricity bill which translates to 43GWh (or 150TJ) in the entire public sector (Ministry of Mineral Resources Green Technology and Energy Security, 2018).

Furthermore, it is noted that behavioural change is key to achieving efficiency targets and acts hand-in-hand with technical/physical interventions. Significant opportunities for energy saving exist in ensuring a total transition to using LPG, and further savings may be possible through training stove users in energy saving techniques. The overall potential for savings from a full switch to LPG would amount to about 70TJ by 2032 as forecasted by the NEES.

ii. Transport Sector

Consumption by sector shows the transport sector as the largest consumer of energy at 43% of the national total with mining as the largest consumer of electricity and households as the largest consumers of paraffin (Seanama Conservation Consultancy, 2012)

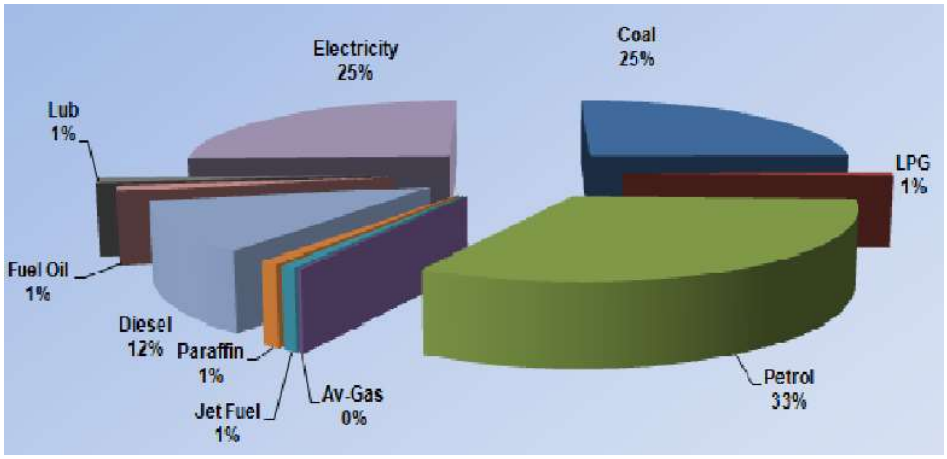

Figure 6.1: *Energy consumption by source, measured in tonnes of oil equivalent – TOE*

Source: (Seanama Conservation Consultancy, 2012)

City-wide public transport in Gaborone consists of mini-buses (combis), shared taxis (sedan) and special taxi/cabs (sedan). The shortcomings of public transport are that it is inefficient in terms of commuter times as traffic congestion is rife in the city. The only alternative to these is private cars whose use is very high in the city and the country at large which exacerbates traffic congestion. These run on petrol and diesel as the only fuels available for vehicles.

To address these urban transport problems that are negatively affecting energy usage, the NEES suggests behavioural change as one of the solutions. The keywords to the suggested behavioural change are to *"avoid, shift and improve."* This means avoiding trips/trip generation; shifting from inefficient modes of transport; and improving the existing public transport system. All these influence vehicle usage patterns and ultimately the amount of fuel consumed by the sector. The NEES states this can be achieved through urban planning interventions. The urban planning concept suited for this is Transit-Oriented Development (TOD).

A wide range of instruments may be applied in order to influence vehicle usage patterns. These include congestion charging, improved urban planning to reduce the need for journeys, and promoting the use of public transport alternatives a need for close collaboration with the Department of Transport in developing appropriate policy measures.

Based on the analysis of savings potentials and the barriers that hinder the implementation of energy efficiency interventions, the MMGE has identified a package of measures for each sector, as well as measures that are cross-cutting as depicted by Table 6.3 below.

Table 6.3: *Cross-cutting measures to achieve energy efficiency as identified by the NEES*

Sector	Measure
Public Buildings	• Continuation and scaling up of energy audits of public buildings. • Develop the public sector "Leading by Example" brand.
Public Services	• Developing an integrated approach to water and energy efficiency.
Residential	• Support research and design of cook stove technologies. Incentivise shift to more efficient cooking technologies. • Promote shift to LPG and regulation of LPG market.
Transport	• Support other ministries, departments and agencies in incorporating energy efficiency in town planning.

The NEES identifies the following as cross-cutting interventions to be undertaken in promoting energy efficiency:

i. <u>Tightening building standards and developing mechanisms for monitoring new buildings</u>

Significant steps have been taken to incorporate energy efficiency in the national building codes, specifically the Conservation of Energy in Buildings Technical Booklet disseminated in May 2016.

ii. <u>Raising public awareness of the opportunities and benefits of energy efficiency</u>

Improving energy efficiency is often as much about promoting behavioural change as it is about introducing new technologies. This indicates the need for concerted efforts to raise awareness among the general public, both of the potential benefits of saving energy as well as of the opportunities for doing so. A public awareness campaign is therefore recommended by the NEES. It intends on utilising the major media channels (television, radio, internet / social

networking, print media, posters/billboards, leaflets etc.), incorporating energy awareness into the school curriculum, and other approaches such as theatre and performance at community level.

The NEES notes that from experience, the impacts of public awareness campaigns typically begin to fade after about two to three years, indicating the need for campaigns to be repeated at regular intervals. In the medium or long term, the effectiveness of awareness campaigns may be enhanced if they are coupled with a help-desk or advisory service, from where target audiences can obtain additional information and advice.

iii. Transport sector

Transport accounts for almost 40% of total final energy consumption and is the fastest growing energy demand sector in Botswana. The challenge for improving energy efficiency within the transport sector is the complexity of factors and services to be taken into consideration in town planning, for example the provision of inclusive public transport services to less densely populated areas of town. Where possible, it was recommended that the introduction of traffic management systems and bus rapid transit networks should be encouraged (Ministry of Mineral Resources Green Technology and Energy Security, 2018).

6.2. Development Control Code of (2013)

The Development Control Code is a set of planning regulations meant to control the use of land and the activities that take place on it, which are mainly physical developments. It promotes land utilisation that is efficient and ensures physical developments are carried out in such a way that they take environmental and aesthetic issues into consideration. The motivation for controlling developments stems from several concerns being public health and safety, environmental and social issues, aesthetics and efficiency of urban systems (Ministry of Lands and Housing, 2013).

The code is therefore generally intended to achieve the following:

i) Classify, regulate and provide criteria/guidelines for the location of residential, commercial, civic and community, industrial, agricultural and other land uses and activities.

ii) Provide standards to which buildings and structures should conform.

iii) Provide for regulations and standards for orderly development of streetscapes and enhancement of the aesthetics of the built environment.

iv) Provide for regulations that regulate adequate public infrastructure and utilities facilities provision whilst ensuring accessibility for maintenance and expansion.

v) Provide for sufficient and effective regulations and standards for traffic circulation that provide adequate transportation – land-use linkages; the safe accommodation of pedestrian traffic movements and interlinks with public transport; and the proper locations and width of streets, road reserves and building line locations.

The DCC 2013 further provides guidelines for aesthetic improvement on landscaping, street trees, walls etc. It emphasises a combination of elements of both the natural and built environment.

Trees provide climate control through shading during summer months (thereby helping reduce the amount of electricity/energy used for cooling/air conditioning) and wind screening during winter. Trees and other plants can also buffer pedestrians from traffic. Walls, fences, trees, and other landscape materials also provide vital screening and buffering between land uses. Landscaped areas help to control surface water drainage and can improve water quality, as compared to paved or built surfaces (Ministry of Lands and Housing, 2013). The specific guidelines with regard to aesthetic enhancement are:

i. <u>Landscaping and landscape conservation</u>

Landscape conservation prevents the haphazard and unsystematic removal of significant trees and other vegetation, including vegetation associated with streams, wetlands, and other protected natural resource areas. Landscaping is required for all development sites that require Site Design Review. The use of mature, native vegetation within developments is a

preferred alternative to removal of vegetation and re-planting. Mature landscaping provides summer shade and wind breaks, controls erosion, and allows for water conservation due to larger plants having established root systems.

The relevant guidelines are:

- A minimum 10% of all development sites shall be soft landscaped.
- The following locations shall be provided with specific landscape treatment: main entrances to buildings; pedestrian and vehicular entrances and exits to a site; pedestrian activity nodes; outdoor amenity areas; intersections of streets; and roadways parking lot.
- Maintain unobstructed visibility to building entrances, key architectural features, signage and public spaces.
- Landscaping shall be used for protection from excessive summer sun and cold winter winds. This thus helps in reducing energy consumption for artificial cooling and heating respectively. Places, where people congregate shall be enhanced through landscaping and tree planting. This points to public spaces.
- Shrubs and trees shall be placed in such a manner that they do not create visual obstructions or provide hiding places for criminals.

ii. Streetscape

Streetscape shall also be enhanced through appropriate streetlights, traffic signals, vehicle and pedestrian signs, street furniture and utilities.

The relevant guidelines are:

- The incorporation of public art in urban design shall aim at achieving the proper balance of function, usability and aesthetic delight. These may include pocket parks, street furnishings, bridges, utility infrastructure, drainage accessories, and public transport shelters.

- Public art shall not be *reduced to a few objects placed in the middle of badly designed* open space. Rather it shall be integrated into the overall concept of an open space and form part of urban life. Examples are depicted by Table 6.4 below.
- The display of public art shall be required to be coordinated with the architecture and street furniture pieces adjoining them.
- Water features shall be designed where appropriate, including in areas such as terminal points to sight lines in plazas, parks, squares or corridors.

Table 6.4: *Types of public art*

DECORATIVE SIGNS	POSTERS /BANNERS	STREET FURNITURE	LIGHTING
• Clocks • Exhibitions • Community projects • Planters	• Floor works • Displays • Sculptures • Concourse gate	• Wall works or murals • Performances • Glasswork and brickwork	• New media • Railings • Decorative stone carvings

Source: (Ministry of Lands and Housing, 2013)

6.3. Site analysis

Site analysis was carried out through observation and mapping based on two main factors being the triple bottom-line of sustainable development (with specific focus on energy issues) and placemaking. The triple bottom-line assessed economic issues relating to cost-saving; environmental issues in relation to renewable energy transition, clean energy and energy efficiency; and social issues concerned with mobility/accessibility and sustainability awareness.

Placemaking in the study area was analysed based on aesthetics, functionality as well as land-use; public space; transit routes; pedestrian movement; parking; greenery and landscape contrast.

6.3.1. Land-use

There are three (3) land-uses in the mall being commercial (businesses); civic and community (social facilities); and open space (recreational and public areas). The mall is dominated by a

single active land-use being commercial as depicted by Figure 6.2 since the other two are ancillary. This homogenous land-use type of development means people stay away from jobs and services offered by the mall and therefore have to commute in order to access them.

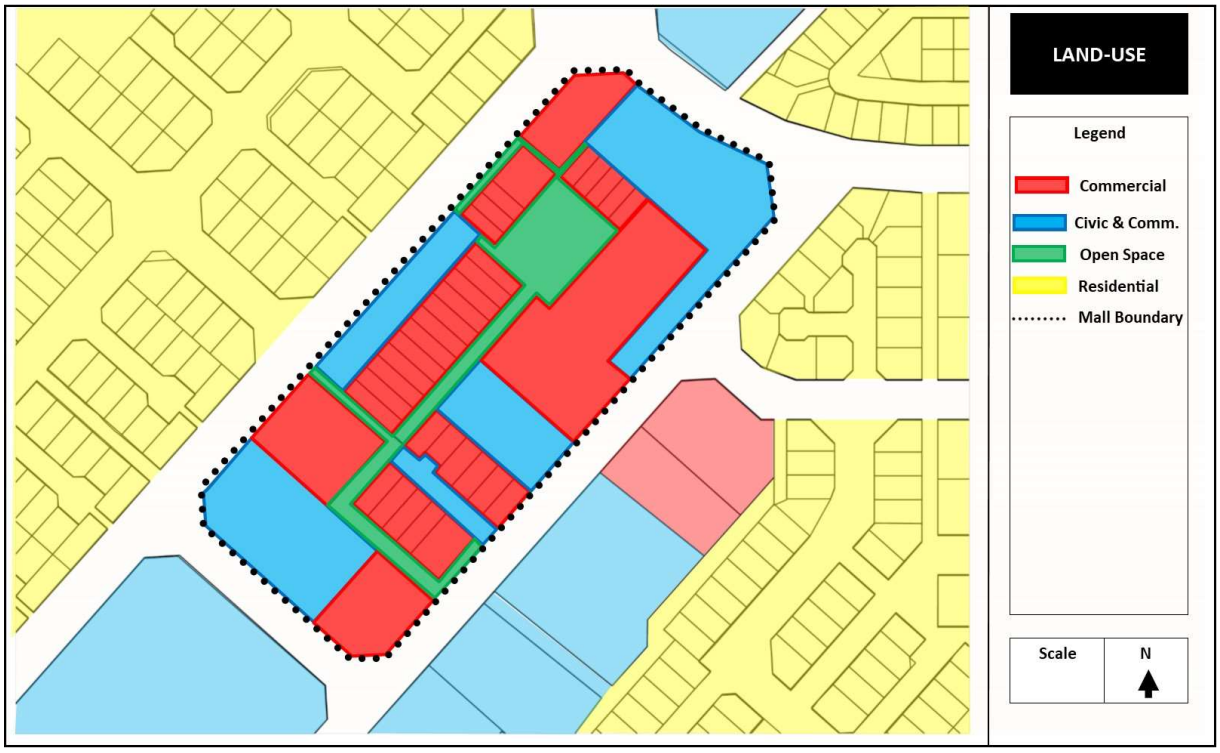

Figure 6.2: *Land-use map.*

6.3.2. Public space

Public space in the mall exists in three forms being a public square, a central promenade/pedestrian spine and parking lots (which are only an ancillary use) as shown by Figure 6.3.

6.3.3. Transit

Public transport in Gaborone is in the form of fourteen-seater (14) mini-buses commonly known as *"combi"* for singular and *"combis"* for plural. They operate on designated routes along primary and secondary roads within the city. There are currently four (4) routes passing along the main route depicted by Figure 6.4. These are Broadhurst Route 1, Block 8 Route 3, Block 10 Route 1 and Tlokweng Route 5. There is no presence of mass transit like trams, trains or Bus Rapid Transit (BRT).

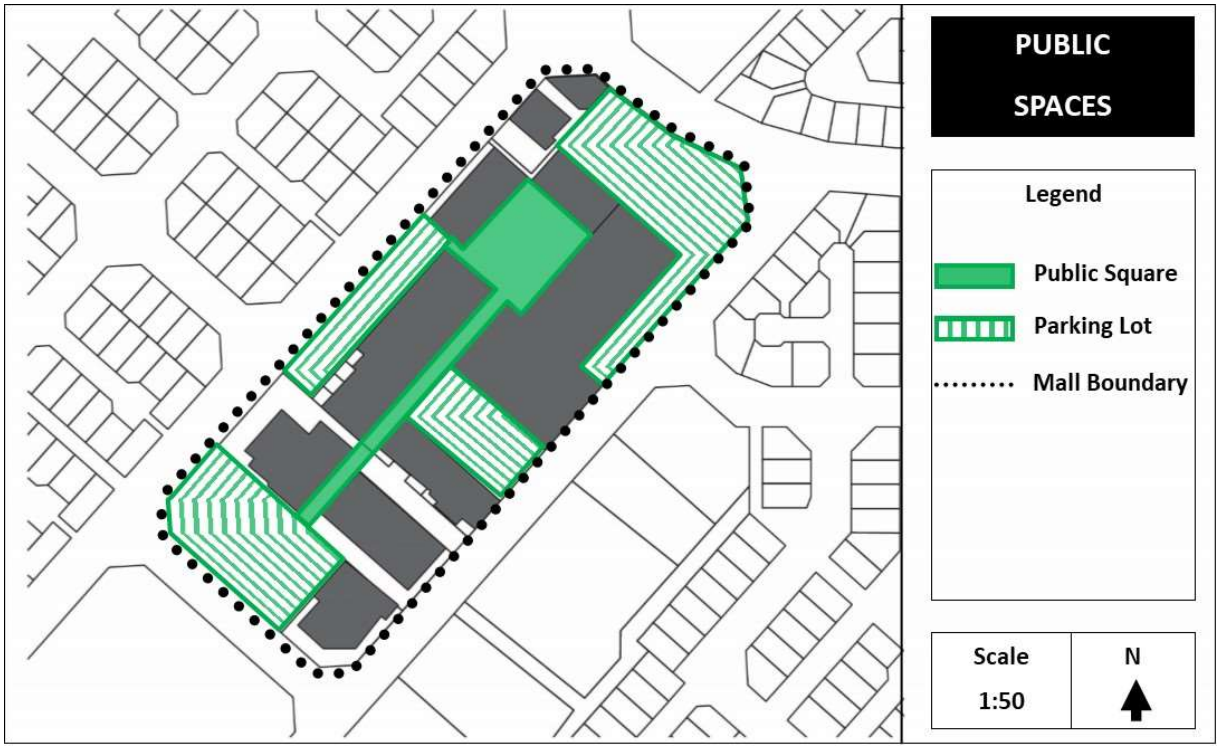

Figure 6.3: *Public space map*

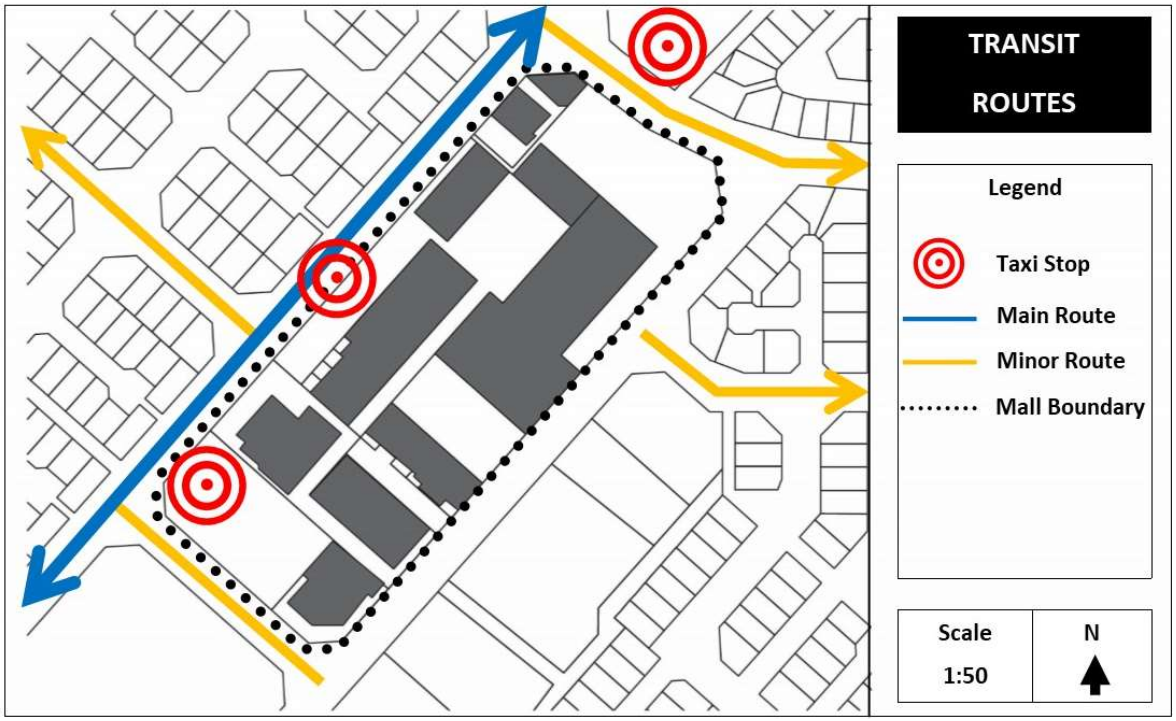

Figure 6.4: *Transit routes map.*

6.3.4. Pedestrian movement

Most of the major pedestrian routes are located around the mall along streets with the most important one that is car-free being in the middle in a north-east to south-west direction as shown by Figure 6.5. It is crucial to note that there exists a conflict between pedestrians and motor vehicular movement at several points along the routes. The conflict occurs due to lack of adequate crossings for both cyclists and pedestrians. Pedestrian crossings exist at road junctions however this is merely reduced to paint markings on the road with no measures to directly or indirectly reduce the speed of vehicles. In addition there is no consideration for disabled individuals using wheelchairs in terms of making the transition between the levels of the tarmac and sidewalk smooth as there is continuous kerbing/curbstones.

This acts as a discouraging factor for walking and cycling therefore promotes the use of private vehicles and the *combi*-based public transport system thereby increasing petroleum and diesel consumption and ultimately carbon emissions.

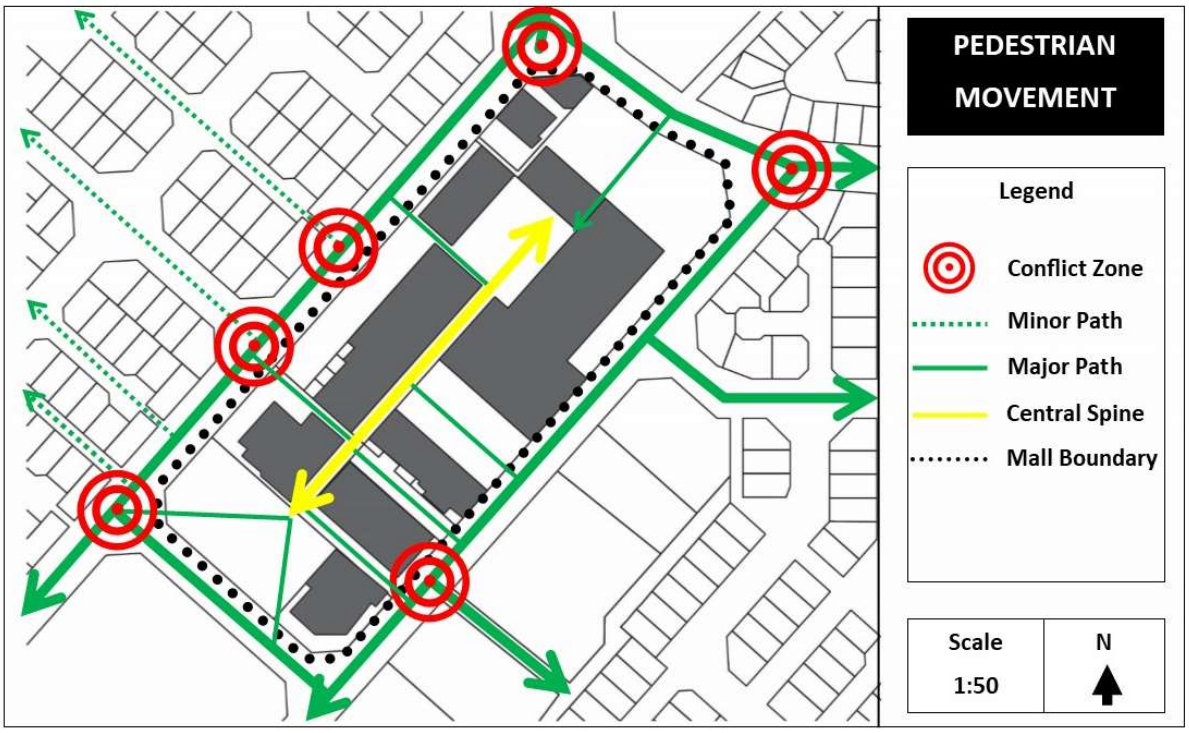

Figure 6.5: *Pedestrian movement map.*

6.3.5. Parking

As discussed above, the use of cars in high in the city and likewise BBS Mall is mostly accessed via motor vehicle-based public transport. This is evidenced by the significant amount of space occupied by surface parking as shown by Figure 6.6.

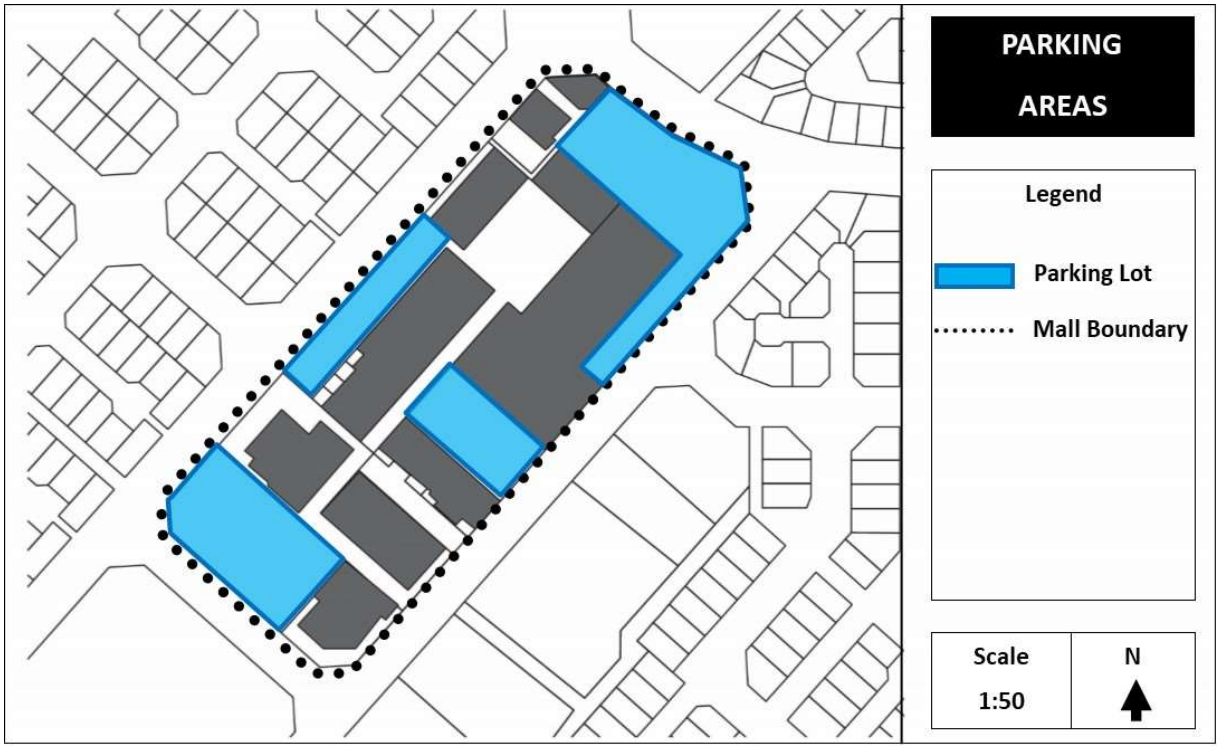

Figure 6.6: *Parking map.*

6.3.6. Greenery and landscape contrast

The mall is heavily built-up with little vegetative groundcover. There are no designated green spaces within its public realm. However there exists a few mature trees as depicted by Figure 6.7. Furthermore, when contrasted side-by-side, hard surfaces dominate the landscape by a great margin as opposed to soft surfaces (greenery) as shown by Figure 6.8.

Figure 6.7: *Public space map.*

Figure 6.8: *Landscape contrast map.*

6.3.7. Site Analysis Summary

The thematic maps discussed above were overlaid to give an overall picture of site conditions as in Figure 6.9.

Figure 6.9: *Site analysis overlay map.*

6.3.8. Site imagery

The current state of development at the mall is as depicted by the following: Figure 6.10 , Figure 6.11 and Figure 6.12.

Figure 6.10: *An aerial view of BBS mall and surrounding developments.*

Figure 6.11: *An aerial view of BBS mall showing the focus area bounded in a red line.*

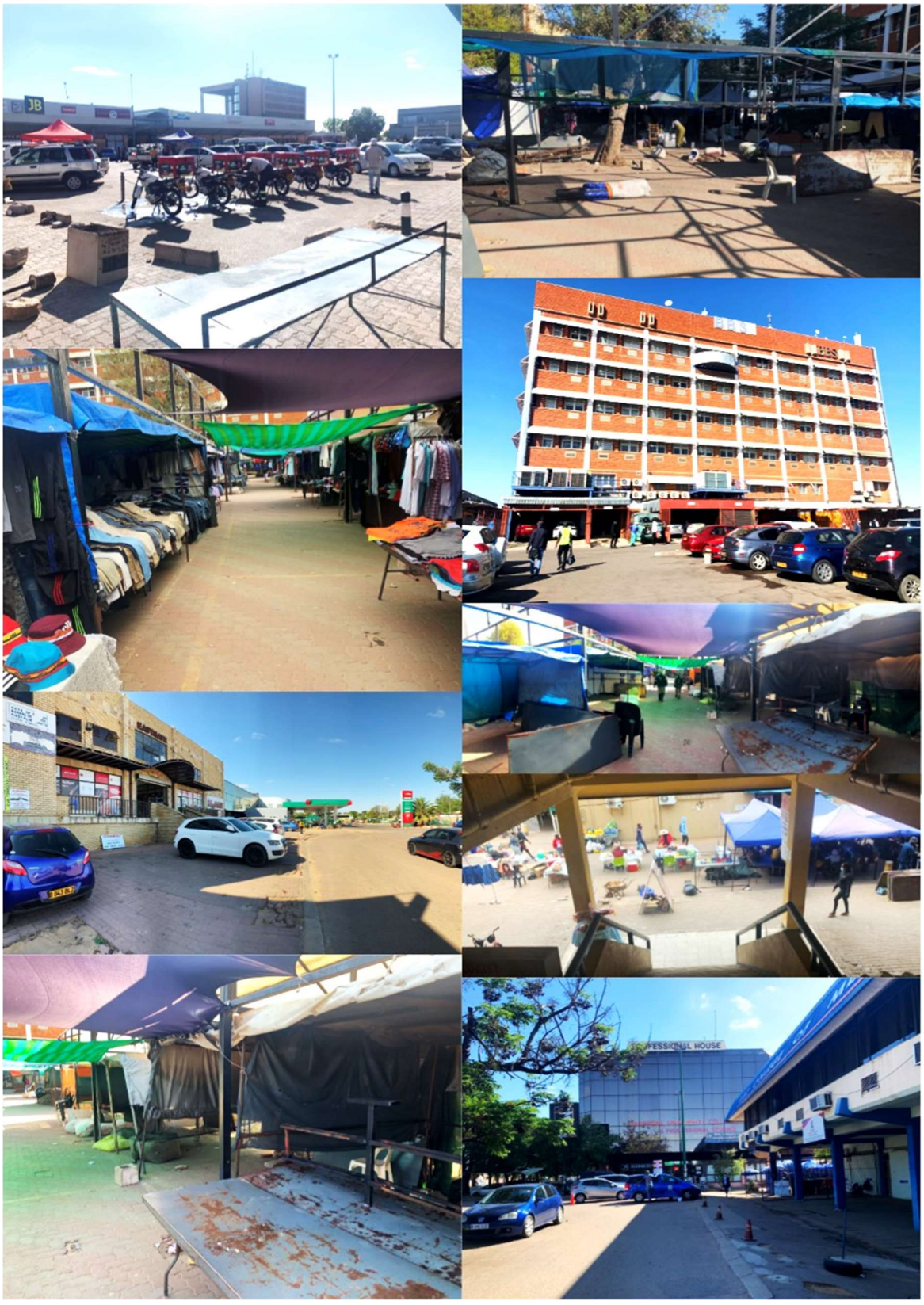

Figure 6.12: *Site conditions in different views/positions.*

Source: Study

6.3.9. Triple Bottom-line and placemaking assessment

The triple bottom-line and placemaking were assessed according to Tables 6.5 and 6.6.

Table 6.5: *Triple Bottom-line and placemaking assessment.*

THEME	STRATEGY	SCORE GUIDE	SCORE	TOTAL SCORE	MAX. SCORE
Economic	Cost-saving Mechanisms	0 – None 1 – Exist but not implemented 2 – In place but partially implemented 3 – Fully implemented	0	0	3
Environmental	Renewable Energy Transition & Clean Energy	0 – None 1 – Planned but failed 2 – Usage of clean energy 3 – Usage of renewable energy and/or clean energy	2	4	8
	Energy Efficiency Strategies	0 – None 1 – Planned but not implemented 2 – In place but partially implemented 3 – Fully implemented	0		
	Eco-friendly Materials	0 – None 1 – Planned but not adopted 2 – Adopted	2		
Social	Mobility/Accessibility	0 – Nil score not possible* 1 – Car-centric space 2 – Pedestrianisation partially implemented 3 – Fully pedestrianised	1	1	5
	Sustainability Awareness	0 – No sustainability information available 1 – Information exists but inaccessible 2 – Information is easily accessible	0		
Placemaking	Aesthetics	0 – Nil score not possible 1 – Design intent exists but not implemented 2 – Design intent partially implemented 3 – Design intent fully implemented	0	2	6
	Functionality	0 – Nil score not possible* 1 – Design intent exists but not implemented 2 – Design intent partially implemented 3 – Design intent fully implemented	2		
TOTAL				**7**	**22**

* means nil score is not possible for:

i. Mobility, since all public spaces have some form of accessibility.
ii. Functionality, since all public spaces have a particular way in which they operate.

Table 6.6: *The scale/gauge for the triple Bottom-line and placemaking assessment.*

0-4	5-8	9-14	15-18	19-22
Unsustainable	Fairly Sustainable	Average	Good Sustainability	Excellently Sustainable

The site had a total score of 7 out of 22 and therefore is rated *fairly sustainable*. This is three categories below the maximum score therefore it can be concluded that there is plenty of room for improvement to attain a satisfactory level of sustainability that is excellent or good at the least.

6.4. Public survey

The total number of informal traders in the mall varied on different days. This is did not engage trade or occupy their spots on a daily basis. On average, 100 traders were counted. A sample size of 10% which translates to 10 traders was interviewed using the questionnaire in Appendix A. The following findings were made from the public survey as shown by Figure 6.13:

i. 70% of the participants in the mini-survey stated that they felt the cost of electricity was too high and unaffordable while those who said it was either good; fair; or were unaware of the cost represented 10% each.
ii. 70% of the participants were aware of energy-related pollution specifically smoke emitted from vehicle exhausts. In this study this translates to carbon emissions due to the use of fossil fuels such as petrol and diesel.
iii. 100% of participants said they would embrace the introduction of less or non-polluting modes of transport.
iv. 50% of the participants were aware of the benefits of renewable energy specifically solar power. They stated advantages such as affordability (operational costs), simplicity and reliability during power cuts. The remaining 50% did not have knowledge of the benefits of solar power.
v. 100% of the participants said they would welcome the generation of renewable energy (solar power) on-site.

Figure 6.13: *Conducting site observations and public survey/interviews.*

6.4.1. Activities

The following are activities as depicted by Table 6.7 that participants said they would like to see introduced in order to improve the sustainability and vitality of public space in the mall.

Table 6.7: *Activities suggested by the public to improve the sustainability of the public realm.*

Local Business Or Land-Use (Economy)	• Investment opportunities • Cryptocurrency
Environment	• Increased frequency of cleaning • Improved waste management e.g. increasing the number of dustbins and addressing the problem of litter from food packaging.
Fun Or Social Activities (Social Life)	• Music and arts • Library • Recreational park • Games room • Cinema • Free internet • Television room • Resting place for eating • Introduction of public toilets • Improved lighting • Improved security

6.4.2. Public Realm Design

With regard to the general design and arrangement of activities and infrastructure within the public space(s) of the mall, the following concerns were raised and improvements were suggested as depicted by Table 6.8:

Table 6.8: *Suggestions of the public with regard to the overall design of the mall's public realm.*

Site Layout	• Adequate shading for pedestrians and informal traders. • Use of more durable informal trading stalls. • Improved parking layout so as to make it more pedestrian-friendly. • Increased parking as there is dire shortage.
Landscaping	• Increasing vegetative cover and planting more trees for shade. • Improved storm-water management as rain water forms pools/puddles which disrupts business. • Worn-out pavement and deteriorating manholes.
Building Appearance/Conditions	• The buildings need a facelift through repainting to improve neatness. • There is no uniformity in the aesthetics of the buildings.

7. DISCUSSION

7.1. Public survey

70% of the participants in the mini-survey stated that they felt the cost of electricity was too high. However, in contradiction, none of the participants was practicing any cost-saving actions in relation to electricity usage. This could be explained by the fact that generally the participants said they were unaware of energy cost-saving techniques or actions. This therefore calls for thorough and continuous public awareness-raising.

As majority (70%) of the participants were aware of energy-related pollution specifically smoke emitted from vehicle exhausts, it is appropriate that all of them said they would welcome less or non-polluting modes of transport. This therefore means there is an opportunity to improve mobility and make it sustainable by providing adequate and less energy-consuming pedestrian, cyclist and mass transit infrastructure as the public is open to it. Furthermore, they are knowledgeable to some extent of the dangers to the environment caused by the current high usage of motor-vehicles.

Another opportunity lies in advancing renewable energy transition as all participants stated they would embrace the generation and use of solar power within the mall. This is because half of them were aware of the benefits, stating that it is simple to use; cheap as the sources is being the sun cannot deplete and useful during power cuts which are fairly a common occurrence in the city and the country at large.

7.2. Economic perspective

The Rooftop Solar Guidelines empower consumers economically as they are allowed to apply for multiple permits and/or licences as long as the total generating capacity of the RTS systems does not exceed the set limits.

Through policy statement P1, the NEP intends to utilise locally available energy resources to meet local demand and to ensure self-sufficiency in electricity. Local energy resources considered to be in abundance in Botswana include:

7.2.1. Solar

According to (Mooiman & Edwin, 2016), the country has over 3 200 hours of sunshine per year and an average global irradiation of 21 MJ/m^2/day throughout the country, one of the highest levels of solar irradiation in the world. It is estimated that using less than 1% of the country's total land area, Botswana could meet its current electricity consumption. Global irradiation is highest in the west (as shown by Figure 7.1 below), averaging 2 350 kWh/m^2/year near Kang village and around Gemsbok National Park in the Kalahari Desert.

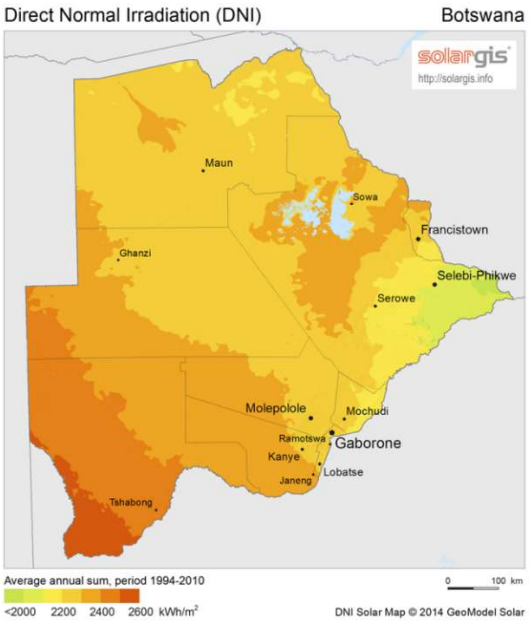

Figure 7.1: *Direct Normal Irradiation in Botswana.*

Source: (Mooiman & Edwin, 2016)

On a national scale, it is imperative to utilise local resources as the country imports part of its electricity supply from long-term bi-lateral contracts and from the Southern African Power Pool (SAPP) Energy Market to meet the shortfall mostly during peak hours (Botswana Power Corporation, 2019). These imports come from South Africa and Mozambique. The same applies for oil/petroleum and petroleum products which are entirely imported from or via neighbouring countries as well.

It must be noted that electricity from the national grid is highly subsidised as the selling price to consumers by BPC has been disproportionately decreasing between 2007 and 2015 to a point where the selling price per unit went from being almost equal to being almost half of the unit cost of production as shown by Figure 7.2. However, the NEP through P3.1.1 and P3.1.4 intends to strike a balance between the cost of production and tariffs so as to minimise expenses and financial losses in supplying electricity.

P3.1.1 says that the costs of electricity distribution are to be optimised such that end-user electricity prices correctly reflect fixed and variable costs and convey relevant price signals to encourage efficiency. P3.1.4 advocates for the adaptation of cost reflective electricity tariffs that promote efficient use of energy.

Figure 7.2: *The unit selling price versus the unit cost of production of electricity between 2007 and 2015.*

Source: (Mooiman & Matlotse, 2016)

Through high-level strategies P1.2.1 and P1.3.1, the NEP intends to optimise the long-term investment spending and reduce the costs of power supply incurred by BPC by introducing mini- and micro-generators that will feed into national grid. This will contribute to economic savings in two ways, firstly by eliminating the need for grid expansion since they will be decentralised and secondly, they will be generating power from renewable sources such as solar and biomass.

7.3. Environmental perspective

The main objectives of the NEP cater for environmental considerations by aiming to diversify the national energy mix by promoting renewable and clean energy technologies, improving energy efficiency and modernising infrastructure to satisfy the demand for energy.

Under the theme Energy and the Environment, the NEP intends ensure that energy products are of acceptable standards so as to prevent environmental damage through P15.1.1. This is done through guidelines and standards in each sub-sector including building regulations.

Renewable energy is addressed by P10.1.4 and P13.1.1 which aim to mainstream the use of renewable energy sources being solar and bio-gas for domestic and commercial use. Rooftop Solar Guidelines were developed in 2020 to facilitate this.

The Development Control Code of 2013 encourages the planting of street trees and conservation existing of mature ones to help in absorbing the carbon released through emissions from energy consumption.

7.4. Social perspective

With regards to addressing social issues, the NEP intends to ensure equity in accessibility of modern forms of energy with one of the targets including disadvantaged groups. It also tackles issues such as gender, age and socio-economic status in rolling out energy strategies. High-level strategies P10.1.3, P13.1.2 P14.1.4 intend to promote sustainability awareness by mainstreaming solar energy, bio-energy, energy efficiency, conservation and management programmes in all levels of the education system. This however has not been achieved and is yet to be initiated.

7.5. Placemaking

The Rooftop Solar Guidelines do not limit the small-scale generation of electricity for domestic, commercial and industrial use to rooftops. The solar photovoltaic (PV) systems can also be ground-mounted. This provides flexibility in design as commercial and industrial precincts

vary vastly in their layouts and spatial arrangement. In some instances, there may not be sufficient roof surface area but ample space on the ground as well as on vertical walls.

7.6. Issues and opportunities emanating from the findings and discussion and synthesis the public space energy strategies framework

The following thematic issues were identified from the findings and discussion and will therefore inform the synthesis of the framework:

i. Renewable Energy Transition (On-Site Renewable Energy Generation)
ii. Green Buildings & Energy Efficiency
iii. Micro-Climate Regulation
iv. Sustainability Awareness/Education
v. Safety, Wellness & Sociability
vi. Land-Use
vii. Mobility & Public Transit
viii. Innovation & Infrastructure
ix. Landscaping

7.6.1. Renewable energy transition (on-site renewable energy generation)

The quest to honour the Paris Agreement and keep the global temperature rise less than 2 degrees Celsius calls for a robust paradigm shift from non-renewable sources of energy, (that is fossil fuels) to energy efficiency and renewable energy particularly solar since it is infinite. According to IRENA (2018), renewable energy has the potential to provide two thirds of the total global energy supply by 2050. This transition will happen mainly in electricity supply primarily through crucial sectors being buildings (through rooftop solar PV installations as depicted by Figure 7.3), industry and transport including a steady decarbonisation of the electricity generation sector as a whole.

At its meeting in Johannesburg in 2002, the World Summit on Sustainable Development dedicated itself to encourage the uptake of renewable energy as a way of promoting sustainable consumption (Allah & Khalil, 2018). The following actions were agreed:

i. Trying to ensure economic growth does not cause environmental pollution.
ii. Improving resource efficiency services.
iii. Enabling consumers to receive more information on products and services.

Solar energy in particular, which is abundantly available in Botswana and has several environmental benefits such as evading resource extraction, pollution through carbon emissions and other harmful by-products has been chosen as the most suitable option for this study. According to Allah & Khalil (2018), a 1kW PV system producing 150kWh each month prevents 75kg of fossil fuel from being mined. It avoids 15kg of CO_2 from entering the atmosphere and keeps 473 litres of water from being consumed. One gallon (3.7854 litres) of gasoline produced and used in an internal combustion engine releases roughly 12kg of CO_2, a GHS that contributes to global warming.

Figure 7.3: *Rooftop solar PV installations.*

Source: *Google Images, 2021*

7.6.2. Green buildings & energy efficiency

Enhancements in energy efficiency have the ability to avail the necessary energy for human activities. They can also contribute to poverty alleviation, sustainability efforts as well as environmental protection (Eco Renewable Energy, 2021).

Allah & Khalil (2018) state that buildings account for approximately 40% of the total annual energy consumption in the world. Most of this energy is for interior comfort such as lighting,

heating and cooling etc. One smart way of minimising this massive energy consumption is through building design that takes into account sustainability issues. These can be addressed through building form, height and façade treatment. Passive interventions such as natural ventilation and passive solar gain can drastically decrease basic energy consumption in this regard.

Urban forms that are considered energy efficient are those where buildings absorb more of the sun's energy (heat and light) in winter to provide warmth and less of it in summer to maintain a cool environment (avoid unnecessary heating). This therefore calls for urban planning and urban design that takes into account local radiation as dictated by latitude in order to achieve good thermal comfort. This design principle/strategy is called Solar Orientation or Passive Solar Gain. Generally, the simplest designs are the most effective as opposed to extravagant ones. Simple urban forms and buildings allow the designer to pay more attention to and adequately address orientation (siting), form (shape and size) and layout/plan (arrangement of spaces). It must be noted however that solar orientation can still underperform when those tasked with specifying materials do not take into consideration their absorptance properties as mentioned above (Allah & Khalil, 2018).

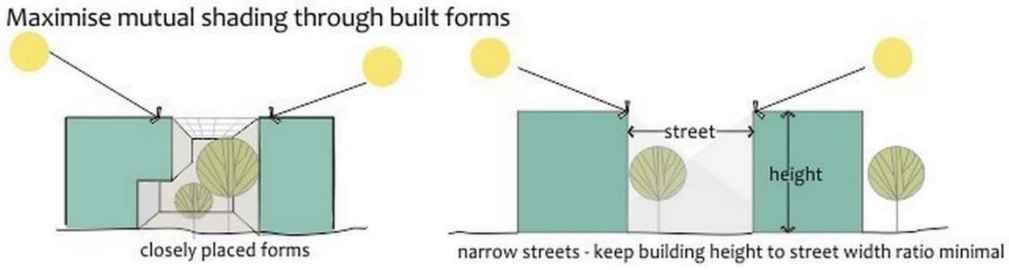

Figure 7.4: *Variation of urban forms.*

Source: *Google Images, 2021*

7.6.3. Micro-climate regulation

Surfaces such as parking lots, streets/roads and building roofs tend to absorb sunlight which they consequently emit/release to heat their surroundings. This phenomenon is called the Urban Heat Island Effect. Many cities suffer from this problem because they are heavily built-up as compared to rural areas or the countryside where there is significantly more open space

and greenery. Trees regulate (lower) the outdoor temperature of public spaces and ultimately reduce the use of artificial air conditioning in the surrounding buildings (Eco Renewable Energy, 2021).

Figure 7.5: The urban heat island effect.

Source: *Google Images, 2021*

7.6.4. Sustainability awareness/education

Public spaces such as parks designed around an ecological and renewable energy theme have emerged as a new way of raising awareness on sustainability issues, clean energy and the renewable energy transition movement (Eco Renewable Energy, 2021).

Figure 7.6: *Education through ecological and renewable parks.*

Source: *Google Images, 2021*

7.6.5. Safety, wellness & sociability

In addition to the monetary and environmental benefits, green innovations provide health benefits to people such as improved mental health. Renewable parks do this through

landscape elements/features such as smart energy outdoor furniture. For example, with smart energy benches, people can sit, relax and charge their electronic devices such as mobile phones and tablets while connected to free wi-fi hotpots (Eco Renewable Energy, 2021). As a result, this helps them cope with busy schedules which ultimately reduces stress and anxiety and thereby increasing the mind's ability to focus. This can then boost productivity at school and in the workplace.

Figure 7.7: *An individual relaxing and charging their phone on a smart energy bench in public.*

Source: Google Images, 2021

Being surrounded by vegetation and trees is therapeutic. The more green innovations that combine quality landscaping and renewable energy are installed in public spaces to promote sustainable energy use in cities, the more there will be trickle-down social benefits such as improved public health for people who live near these places through providing places that have a calming effect on their state of mind as well as promoting physical activity (Eco Renewable Energy, 2021).

Figure 7.8: *Social interaction in an urban green space.*

Source: *Google Images, 2021*

7.6.6. Land-use

Land-use has a great influence on daily energy use patterns particularly transport which affects the accessibility of public spaces. According to Allah & Khalil (2018), this can be achieved through the compact city theory which refers to urban growth characterised by high-density, mixed-use development where housing, workplaces and recreational places including green urban spaces are located in close proximity to one another. From an energy perspective, the primary justification for the compact city theory is that it is less energy intensive which enhances efforts to deal with the negative impacts of climate change while other sustainability benefits include improved public transport affordability and efficiency, social mixing and a higher quality of life in general. This approach has energy-saving benefits because it reduces distances per trip in order to access services therefore fuel consumption is also reduced.

For the above to be achieved, the following conditions are favourable for a significant reduction in energy use per capita:

- High population density at both city and neighbourhood level
- Locating workplaces and businesses around or in close proximity to green public spaces
- Low parking spaces at workplaces and businesses to discourage the use of cars.

Figure 7.9: *A mixed land-use map in a precinct where different uses are in close proximity.*

Source: *Google Images, 2021*

Different densities ranging from 37 to 250 dwelling units per hectare are attainable depending on discount rates and fuel prices (Allah & Khalil, 2018). The DCC 2013 does not specify densities for compact, mixed-use development however it does state a range of 6 to 15 dwelling units per hectare for areas that are dominated by stand-alone residential lots, called *Residential Single-Family Regulatory Zones (R1 and R2)*. It can then be assumed that for compact areas being *Residential Suburban Land Use (RSU) and Residential Urban Land Use (RU),* the minimum density shall be 16 dwelling units. For the *Mixed-use Regulatory Zones (MXD)* the level of densification will depend on the percentages of mixing.

Figure 7.10: *A mixed-use development where services are easily accessible.*

Source: *Google Images, 2021*

7.6.7. Mobility & public transit

As discussed above, the mixing of land uses, densification and compact development can contribute positively to the fight against climate change through increased use of public transit, walking and cycling to work and for accessing recreational services as depicted by Figure 14 below. This is because the emission of greenhouse gases from the exhausts of motor vehicles is reduced due to a reduction in the use of private cars as public transit use increases. Basically, high density and compact development correlates with lower fuel (petroleum and petroleum products) consumption due to a decrease in the total number of trips by private car. Furthermore, there is also a decrease in distances per trip.

It must be noted however that the profitability and efficiency of a good public transport system is highly dependent on adequate high density and compact development. It is recommended that 17 to 75 dwelling units per net hectare need to be achieved in order to sustain an efficient transit system (Allah & Khalil, 2018).

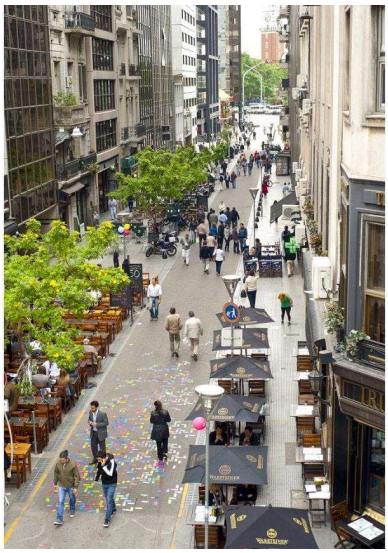

***Figure 7.11**: A former car-centric street converted into a vibrant pedestrian street.*

***Source:** Google Images, 2021*

7.6.8. Innovation & infrastructure

Modern innovations in sustainability have become a way of turning the public realm into green spaces (Eco Renewable Energy, 2021). As a result, green public spaces are a unique solution for introducing renewable energy in public spaces such as parks, walking trails, gardens and civic/public squares. Examples are as follows:

i. Energy-Generating Outdoor Furniture — These include everyday objects such as bicycles and benches that serve a totally different purpose within the landscape. Stationary bicycles are installed in some of the city's outdoor gyms where their sole purpose is recreational. Benches offer a place to sit which does not relate to energy at all. Through game-changing innovation stationary bicycles can convert human movement (kinetic energy) into electricity (electric energy) while benches fitted with solar panels can generate electricity as well.

Figure 7.12: *A smart energy bench.*

Source: *Google Images, 2021*

ii. Smart Energy Floors — These are Smart Flooring Systems and plug-ins used in outdoor events and exhibitions. They also convert movement into electricity when people walk and dance over them. Others are designed to act as solar panels.

7.6.9. Landscaping

The DCC 2013 provides guidelines for aesthetic improvement on landscaping, street trees, walls etc. The streetscape can also be enhanced through appropriate energy-related infrastructure such as streetlights, traffic signals, vehicle and pedestrian signs, street furniture et cetera. The traditional design of this infrastructure has little value to the aesthetics/beauty of the surrounding therefore should be designed such that they appear as public art with an energy-related purpose. For example, creative and captivating lighting can enhance the character of spaces, walls, artwork and other features as illustrated by Figure 17 below (Direct Trade Supplies Blog, 2015).

The incorporation of energy-inspired public art in urban design aims at achieving the proper balance of function, usability and aesthetic delight. Public art shall not be *reduced to a few objects placed in the middle of badly designed* open space; rather it shall be integrated into the overall concept of an open space and form part of urban life.

Trees provide climate control through shading during summer months and wind screening during winter. Trees and other plants can also buffer pedestrians from traffic. Walls, fences, trees, and other landscape materials also provide vital screening and buffering between land uses. Landscaped areas help to control surface water drainage and can improve water quality, as compared to paved or built surfaces.

Figure 7.13: *Creative lighting enhancing aesthetic appeal of a public space at night.*

Source: *Google Images, 2021*

8. CONCLUSION

The third objective of the study was to develop a framework that will guide built environment professionals in formulating energy strategies towards mainstreaming sustainability in the design and planning of public spaces while the fourth objective was to propose a design intervention for a sustainable public space in the city, using the proposed framework.

8.1. The public space energy strategies framework

The following strategies form the foundation of the framework as per the triple bottom-line and placemaking.

8.1.1. Economic theme

The strategies are:

i. Energy Conservation
ii. Energy Trade
iii. Energy Efficiency

8.1.2. Environmental theme

The strategies are:

i. Renewable Energy Transition
ii. Energy Efficiency
iii. Non-Motorised Transport
iv. Green Buildings
v. Water-Sensitive Urban Design (WSUD)
vi. Micro-Climate Regulation

8.1.3. Social theme

The strategies are:

i. Safety, Wellness and Sociability
ii. Walkability
iii. Sustainability Awareness/Education

8.1.4. Placemaking

The strategies are:

i. Innovation
ii. Land-Use
iii. Landscaping & Public Art

The output framework is presented as Table 8.1

Table 8.1: *The public space energy strategies framework.*

THEME	STRATEGY	ACTION	NOTES
ECONOMIC	Energy Conservation	Reduce private car usage.	▪ Public transport accessibility translates to a reduction in fuel consumption and ultimately savings on fuel costs.
	Energy Trade	Explore the possibility of feeding into the grid for sale.	▪ When there is surplus energy produced from renewable sources.
	Energy Efficiency	Specify low wattage appliances and infrastructure for lighting, heating etc.	▪ Lighting using light-emitting diode (LED) and compact fluorescent light (CFL) bulbs. ▪ LED and CFL bulbs require less energy than traditional incandescent light bulbs to produce the same amount of light resulting in lower electricity bills.
ENVIRONMENTAL	Renewable Energy Transition	On-site and/or off-site generation of renewable energy.	▪ Solar PV and bio-gas as the most suitable options. Incorporate infrastructure into buildings and spaces around them. ▪ For lighting, cooking, heating etc.
	Energy Efficiency	Specify low wattage appliances and infrastructure for lighting, heating, cooking etc.	▪ Outdoor lighting using light-emitting diode (LED) and compact fluorescent light (CFL) bulbs.

			▪ LED and CFL bulbs require less energy than traditional incandescent light bulbs to produce the same amount of light therefore less energy generated and less pollution.
	Non-Motorised Transport	Reduce car dependency.	▪ Reduces fuel consumption therefore reduces carbon emissions from motor-vehicles as well.
	Green Buildings	Natural ventilation.	▪ Utilising natural cooling and air flow minimises the use of artificial air conditioning therefore less power consumption.
		Solar orientation-based building design for passive solar gain.	▪ It provides interior space heating and natural lighting.
		Water Efficiency	▪ Green roofs, rain gardens, storage tanks (rooftop, ground, underground).
	Water-Sensitive Urban Design (WSUD)	Rainwater harvesting.	▪ Green roofs, rain gardens, storage tanks (rooftop, ground, underground).
		Storm-water management.	▪ Permeable paving, bioswales, rain gardens, tree planters
	Micro-Climate Regulation	Provide both natural and purposeful cooling and shading.	▪ Relates to urban heat island effect ▪ Soft landscaping, street trees, green walls, awnings etc. ▪ Water features/installations

SOCIAL	Safety, Wellness and Sociability	Active User Interaction with Energy	▪ Provide public and/or commercial power outlets for direct consumption of energy for personal and recreational use. ▪ Public mobile phone charging ports allows users to relax using electronics.
		Passive User Interaction with Energy	▪ Provide infrastructure for users to consume electricity indirectly for educational and entertainment purposes ("edutainment") relating to sustainability e.g. Digital information screens.
	Walkability	Provide cycle-ways and pedestrian paths.	▪ Reduces private car dependency. ▪ Improves public health. ▪ Gives users *freedom of choice.* ▪ Convenient connection to other precincts/activity hubs and green spaces. ▪ Walkways lined with trees offer protection from harsh weather and promote activities that foster social cohesion.
	Sustainability Awareness/Education	Sustainability/Energy Information Centre	▪ Office providing information on issues of energy conservation, energy efficiency and overall sustainability. ▪ Information-sharing should be incorporated into the landscape through notice boards and public art.

PLACEMAKING	Innovation	Incorporating the generation of renewable energy into landscape features through new and unconventional ways.	▪ Smart energy benches ▪ Stationary bicycles ▪ Smart Flooring Systems
	Land-Use	Densification and compact land use.	▪ Promotes mixed-use development. ▪ Enhances pedestrianisation/walkability. ▪ Prioritise underground or stacked parking i.e. avoid surface parking or limit size as it encourages the Urban Heat Island Effect.
	Landscaping & Public Art	Installing both stationary and interactive public art.	▪ Engage the senses through light, temperature, sound etc. ▪ Artistic and creative design of energy infrastructure e.g., streetlights, powerline poles, transformers, sub-stations, meter boxes etc
		Accent lighting.	▪ Dramatic and eye-catching lighting to enhance the character of spaces, walls, artwork and other features. Power supply should be from renewable sources.

8.2. Design intervention

The framework and methodology were applied to re-design the BBS Mall public realm to address the fourth objective.

8.2.1. Vision

The vision is:

> *Located at the heart of BBS Mall, Kagiso Square and Promenade will form an iconic hub for sustainable urbanism. Lush green spaces, renewable energy generated on-site and plentiful fun activities will be the pride of this delightful space.*
>
> *It will become an exciting destination to do business while mixing it with leisure. Walking and cycling will become a pleasant experience with safety and comfort guaranteed.*

The name *"Kagiso"* has been chosen as it is the original name of the mall however with time, it got to be informally and popularly known as BBS derived from Botswana Savings Bank which is one of the oldest and tallest buildings in the mall.

Kagiso is a Setswana word meaning "peace." In addition, it was revived so as to give the place a sense of local context and preserve history. This will also give the place a unique identity and character.

8.2.2. Design strategy and concept

The concept sketch and site plan for the development of the square are shown by Figure 8.1 and 8.2 while the final design and three-dimensional (3D) model are depicted by Figure 8.3 to 8.6. Furthermore, the proposed design was tested against the proposed framework as depicted by Table 8.2.

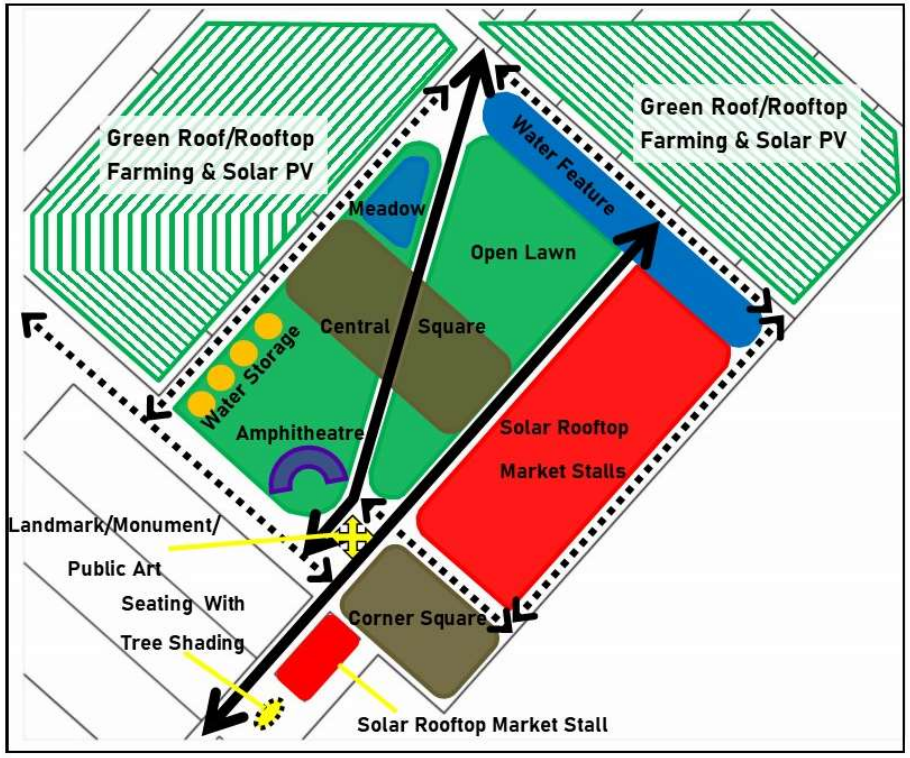

Figure 8.2: *Concept sketch for the site plan of the public square.*

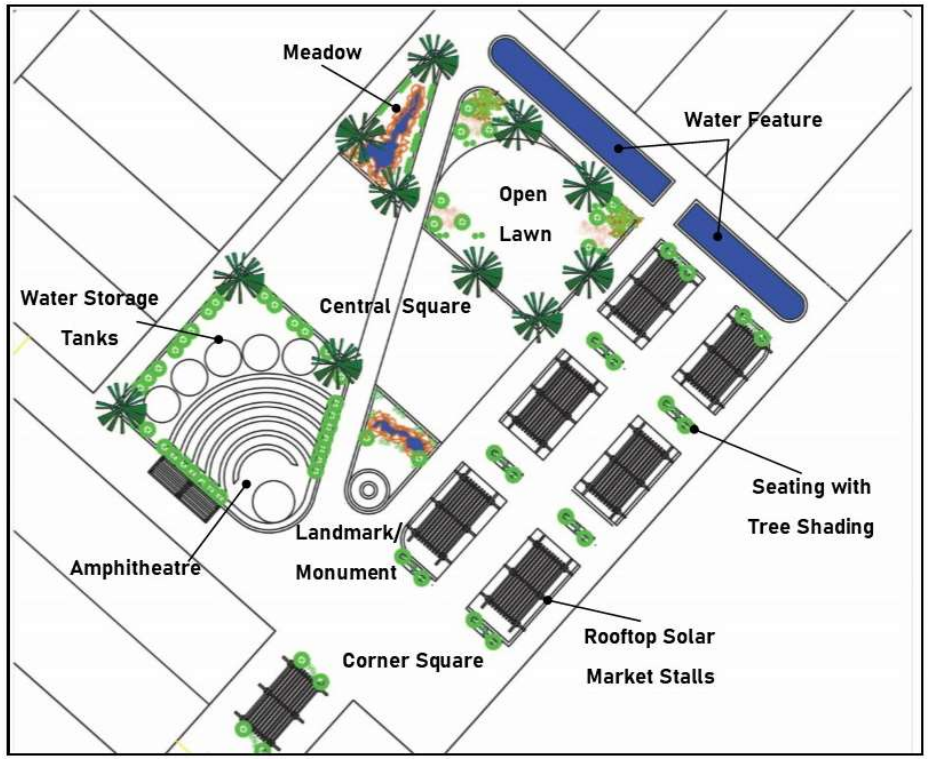

Figure 8.1: *Site plan of the public square.*

Figure 8.3: *Aerial view of the public square.*

***Figure 8.4**: The square from different views/angles.*

Figure 8.5: *The square and promenade extents.*

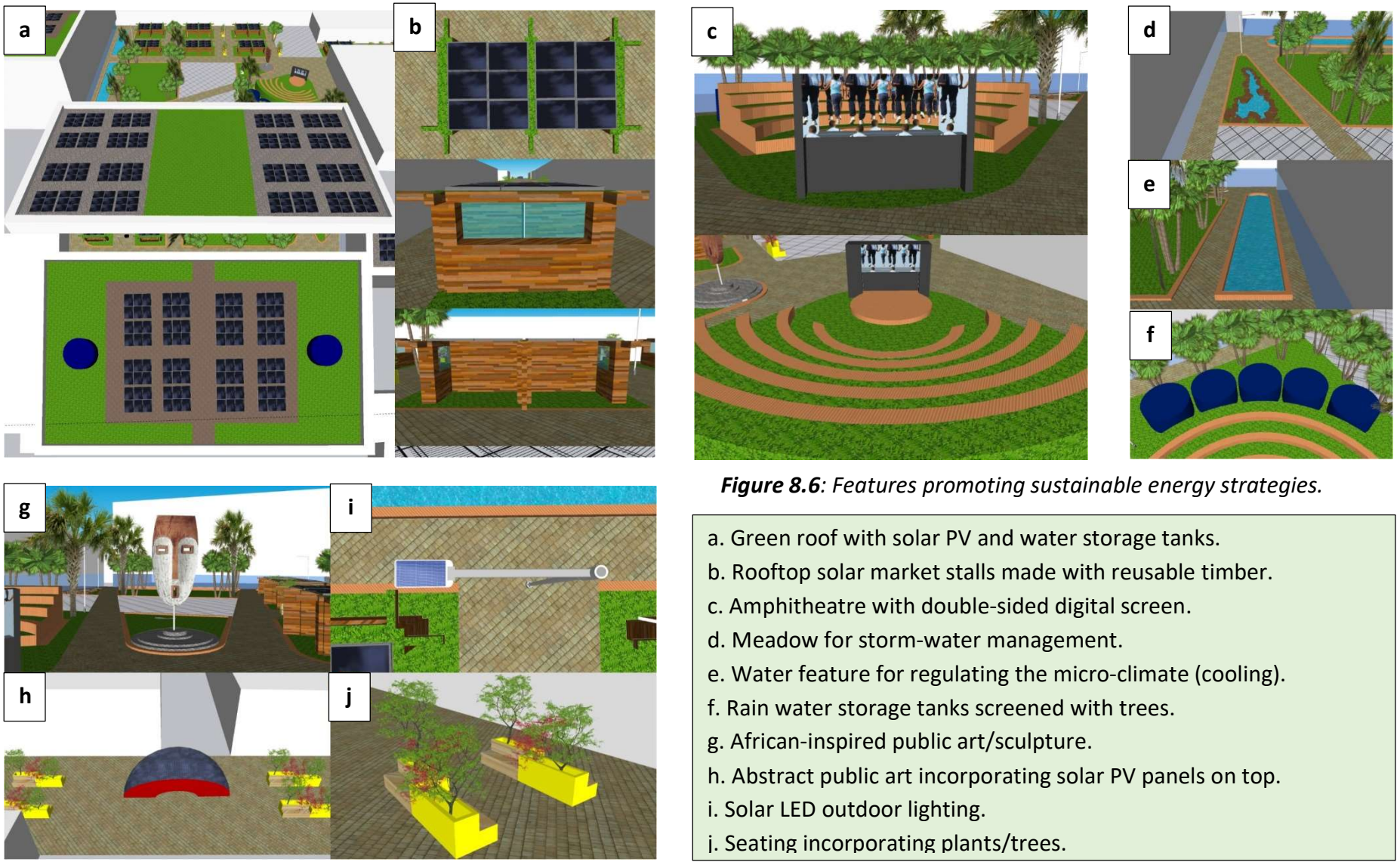

***Figure 8.6**: Features promoting sustainable energy strategies.*

a. Green roof with solar PV and water storage tanks.
b. Rooftop solar market stalls made with reusable timber.
c. Amphitheatre with double-sided digital screen.
d. Meadow for storm-water management.
e. Water feature for regulating the micro-climate (cooling).
f. Rain water storage tanks screened with trees.
g. African-inspired public art/sculpture.
h. Abstract public art incorporating solar PV panels on top.
i. Solar LED outdoor lighting.
j. Seating incorporating plants/trees.

***Table 8.**2: Assessment of the proposed design intervention against the proposed public space energy strategies framework.*

THEME	STRATEGY	ACTION	INTERVENTION
ECONOMIC	Energy Conservation	Reduce private car usage.	▪ Safe, 3 meter wide pedestrian walkways and central promenade.
	Energy Trade	Explore the possibility of feeding into the grid for sale.	▪ Rooftop Solar Programme for commercial and industrial entities.
	Energy Efficiency	Specify low wattage appliances and infrastructure for lighting, heating etc.	▪ Solar light-emitting diode (LED) for outdoor lighting.
ENVIRONMENTAL	Renewable Energy Transition	On-site and/or off-site generation of renewable energy.	▪ Rooftop solar PV on buildings and market stalls as well as on public art.
	Energy Efficiency	Specify low wattage appliances and infrastructure for lighting, heating, cooking etc.	▪ Solar light-emitting diode (LED) for outdoor lighting.
	Non-Motorised Transport	Reduce car dependency.	▪ Safe, 3 meter wide pedestrian walkways and central promenade.
	Green Buildings	Natural ventilation.	▪ No heavy metals on facades.
		Solar orientation-based building design for passive solar gain.	▪ *All land parcels have already been developed.*

		Water Efficiency	▪ Green roofs, rain gardens, storage tanks (on rooftops and behind amphitheatre).
	Water-Sensitive Urban Design (WSUD)	Rainwater harvesting.	▪ Green roofs, rain gardens, storage tanks (on rooftops and behind amphitheatre).
		Storm-water management.	▪ Meadow captures and filters water. ▪ Permeable paving and tree planters provided. ▪ Vegetated roofs capture some rainwater.
	Micro-Climate Regulation	Provide both natural and purposeful cooling and shading.	▪ Soft landscaping through open lawns, mature trees and green roofs. ▪ Water feature and meadow provide cooling to the surrounding.
SOCIAL	Safety, Wellness and Sociability	Active User Interaction with Energy	▪ Commercial power outlets for direct consumption of energy for personal and recreational use in market stalls. ▪ Public mobile phone charging ports in market stalls allow users to relax while using electronics.
		Passive User Interaction with Energy	▪ Double-sided digital screen by the amphitheatre allows users to consume electricity indirectly for educational and entertainment purposes.
	Walkability	Provide cycle-ways and pedestrian paths.	▪ Safe, 3 meter wide pedestrian walkways and central promenade improves accessibility with minimal fuel consumption.

	Sustainability Awareness/Education	Sustainability/Energy Information Centre	▪ One stall acts a dedicated office providing information on issues of energy conservation, energy efficiency and overall sustainability. ▪ Double-sided digital information screen displays energy efficiency and conservation as well as sustainability information for public consumption.
PLACEMAKING	Innovation	Incorporating the generation of renewable energy into landscape features through new and unconventional ways.	▪ Incorporating solar PV into the informal sector (market stalls) and public art.
	Land-Use	Densification and compact land use.	▪ Recommended in surrounding privately-owned buildings to support and enhance the vitality of the square to make it a great place.
	Landscaping & Public Art	Installing both stationary and interactive public art.	▪ Abstract sculpture along promenade with solar PV panels on top. ▪ African-inspired sculpture at the square for identity and character.
		Accent lighting.	▪ Recommendation for LED outdoor lighting.

9. SUMMARY AND RECOMMENDATIONS

The objective of the study was to develop an urban design framework that will guide built environment professionals in formulating energy strategies towards mainstreaming sustainability issues in the design and planning of public spaces.

In summary, the renewable energy transition will be realised through recognising the vital role played by small scale generation. Recognition of energy efficiency as the third fuel is imperative. Efficiency, particularly in buildings will help minimise energy consumption and promote conservation.

The outdoors, that is public spaces such as streets and open spaces play an equally important role in minimising energy consumption via the regulation of the micro-climate through landscaping and streetscape treatment.

Awareness about sustainability issues by the public is a necessary support to ensure the success and longevity of technical efforts/interventions. Energy strategies have an impact on the safety, wellness and sociability of public spaces as places where people congregate to socialise with one another and interact with their environment.

Land-use patterns influence how, where and why energy is consumed, that is whether it is commercial, industrial, residential or recreational places.

The transport sector is a major consumer of fossil fuel-based energy particularly petrol and petroleum products which contributes to high carbon emissions. Urban mobility therefore ought to occur in non-polluting ways.

In order to make places more interesting, productive and attractive, there ought to be more innovations in terms of energy infrastructure and strategies. Landscaping or landscape design can beautify the landscape by incorporating energy infrastructure into public art. It can also encourage non-motorised mobility, land-use mixing, micro-climate regulation and sociability.

It is recommended that future studies consider the financing/cost of implementing energy strategies aimed at achieving sustainability in public spaces. Furthermore, waste management issues such as reduction, re-use, recycling and sorting at source should be reflected on.

10. REFERENCES

Abd Elrahman, A. S., & Asaad, M. (2020). Urban design & urban planning: A critical analysis to the theoretical relationship gap. *Ain Shams Engineering Journal*, *xxxx*. https://doi.org/10.1016/j.asej.2020.04.020

Alexandrakis, J. (2021). Cycling towards sustainability: The transformative potential of urban design thinking in a sustainable living lab. *Transportation Research Interdisciplinary Perspectives*, *9*(November 2020), 100269. https://doi.org/10.1016/j.trip.2020.100269

Allah, H., & Khalil, E. E. (2018). Energy Efficiency Strategies in Urban Planning of Cites. *Energy Efficiency Strategies in Urban Planning of Cites*. https://doi.org/10.2514/6.2009-4622

Botswana Power Corporation. (2019). *Botswana Power Corporation Annual Report 2019*.

Calleri, C., Rossi, L., Astolfi, A., Armando, A., Shtrepi, L., & Bronuzzi, F. (2015). Drawing the city with the ears. Urban spaces comprehension and design through auditory perception. *Energy Procedia*, *78*, 19–24. https://doi.org/10.1016/j.egypro.2015.11.104

Dias, N., Curwell, S., & Bichard, E. (2014). The Current Approach of Urban Design, its Implications for Sustainable Urban Development. *Procedia Economics and Finance*, *18*(September), 497–504. https://doi.org/10.1016/s2212-5671(14)00968-x

Direct Trade Supplies Blog. (2015). *The Difference Between Ambient, Task & Accent Lighting*. Direct Trade Supplies Blog. https://www.directtradesupplies.co.uk/blog/difference-ambient-task-accent-lighting/

Eco Renewable Energy. (2021). *Why Green Energy Innovations in Parks and Open Spaces Matter*. Eco Renewable Energy. https://www.ecorenewableenergy.com.au/news/green-energy-innovations/

GET Invest. (2020). *Botswana Renewable Energy Potential*. Retrieved August 28, 2021, from GET Invest: https://www.get-invest.eu/market-information/botswana/renewable-

energy-potential/

IRENA. (2018). Power System Flexibility for the Energy Transition. In *Part 1: Overview for policy makers* (Issue November).

John, F. (2010). Place and place-making in cities: A global perspective. *Planning Theory and Practice*, *11*(2), 149–165. https://doi.org/10.1080/14649351003759573

Klarin, T. (2018). The Concept of Sustainable Development: From its Beginning to the Contemporary Issues. *Zagreb International Review of Economics and Business*, *21*(1), 67–94. https://doi.org/10.2478/zireb-2018-0005

La Malva, F., Lo Verso, V. R. M., & Astolfi, A. (2015). Livingscape: A multi-sensory approach to improve the quality of urban spaces. *Energy Procedia*, *78*, 37–42. https://doi.org/10.1016/j.egypro.2015.11.111

Magombo, G., & Fabre, J. (2009). *Technical Report: National Energy Policy Strategy Implementation Plan.* Gaborone: USAID/Southern Africa.

Maipose, G. S. (2008). *Institutional Dynamics of Sustained Rapid Economic Growth with Limited Impact on Poverty Reduction.* Geneva.

Ministry of Lands and Housing. (2013). *Development Control Code of 2013*.

Ministry of Mineral Resources Green Technology and Energy Security. (2014). *Building Regulations 2014 - Draft*.

Ministry of Mineral Resources Green Technology and Energy Security. (2018). *National Energy Efficiency Strategy for Botswana*.

Ministry of Mineral Resources Green Technology and Energy Security. (2020). *Rooftop Solar Guidelines*. https://www.gov.bw/ministries/ministry-mineral-resources-green-technology-and-energy-security-mmge

Ministry of Mineral Resources Green Technology and Energy Security. (2021). *National*

Energy Policy (Issue April).

Mooiman, M. B., & Edwin, M. (2016). A Multidisciplinary Examination of Solar Power in Botswana. *A Multidisciplinary Examination of Solar Power in Botswana*, *December*. https://www.researchgate.net/publication/311993872_A_Multidisciplinary_Examination_of_Solar_Power_in_Botswana

Mooiman, M., & Matlotse, E. (2016). *A Multidisciplinary Examination of Solar Power in Botswana.* ResearchGate.

One World Nations Online. (2020). *Botswana*. Retrieved August 28, 2021, from One World Nations Online: https://www.nationsonline.org/oneworld/botswana.htm

Ozgun, K. (2020). Towards a sustainability assessment model for urban public space renewable energy infrastructure. *Energies*, *13*(13). https://doi.org/10.3390/en13133428

Project for Public Spaces. (2007a). *Eleven Principles for Creating Great Community Places*. https://www.pps.org/article/11steps

Project for Public Spaces. (2007b). *What is Placemaking?* https://www.pps.org/article/what-is-placemaking

Redclift, M. (1992). The meaning of sustainable development. *Geoforum*, *23*(3), 395–403. https://doi.org/10.1016/0016-7185(92)90050-E

Seanama Conservation Consultancy. (2012). *Energy Policy Brief: Reflecting on the Challenges of Attaining a Green Economy for Botswana.* Gaborone: Government of Botswana.

Seanama Conservation Consultancy. (2012). Energy Policy Brief: Reflecting on the Challenges of Attaining a Green Economy for Botswana. In Seanama Conservation Consultancy (Ed.), *United Nations Conference on Sustainable Development of June 2012*. Government of Botswana. http://sustainabledevelopment.un.org/content/documents/1009National Report (Energy) - Botswana.pdf

Storring, N., & Walker, M. (2016). *8 Placemaking Principles for Innovation Districts*. Project for Public Spaces. https://www.pps.org/article/eight-placemaking-principles-for-innovation-districts

United Cities and Local Governments. (2016). *UCLG Public Space Policy Framework*.

United Nations Department Of Global Communications. (2020). *Sustainable Development Goals: Guidelines for the Use of the SDG Logo*. https://www.un.org/sustainabledevelopment/news/communications-material/

United Nations Development Programme. (2019). *2019 Human Development Index Ranking*. Retrieved August 28, 2021, from United Nations Development Programme - Human Development Reports: http://hdr.undp.org/en/content/2019-human-development-index-ranking

United Nations. (2020). *The Sustainable Development Goals Report 2020*. https://doi.org/10.29171/azu_acku_pamphlet_k3240_s878_2016

World Bank. (2019). *Population, total - Botswana*. Retrieved July 28, 2021, from World Bank: https://data.worldbank.org/indicator/SP.POP.TOTL?end=2018&locations=BW&start=1960

World Bank. (2020, April 13). *Botswana*. Retrieved August 28, 2021, from World Bank: https://www.worldbank.org/en/country/botswana/overview

Yazdanie, M., & Orehounig, K. (2021). Advancing urban energy system planning and modeling approaches: Gaps and solutions in perspective. *Renewable and Sustainable Energy Reviews*, *137*(December 2020), 110607. https://doi.org/10.1016/j.rser.2020.110607

APPENDICES

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APPENDIX A

PUBLIC SURVEY QUESTIONNAIRE

Date: __/__/2021 **at** Kagiso Mall (commonly known as BBS Mall), Gaborone, Botswana

MAINSTREAMING SUSTAINABILITY IN PUBLIC SPACE:
FORMULATING ENERGY STRATEGIES THROUGH URBAN DESIGN IN GABORONE, BOTSWANA

BACKGROUND

As cities embrace climate change adaptation and mitigation, it has become critical to address energy issues in public spaces in the quest to achieve sustainable urban development. Through urban design interventions, this study intends to develop a design framework to rethink energy strategies in the public realm, that address environmental issues relating to renewable energy transition; economic issues relating to cost saving; social issues relating to a vibrant lifestyle; and placemaking issues relating to functionality and aesthetics.

RESPONDENT PROFILE/BIO

Gender: Male ☐ Female ☐

Age: 18 or below ☐ 19-25 ☐ 26-30 ☐ 31-35 ☐ 36 or Above ☐

User Category: Informal Trader ☐ Visitor ☐ Formal Employee In/Around Area ☐

QUESTIONS AND RESPONSES

1. How often do you come here?
   i. ☐ Everyday
   ii. ☐ 3-6 days a week
   iii. ☐ Less than 3 days a week/When there is a need.

2. How do you usually come here?
   i. Private vehicle ☐ ii. Public transport ☐ iii. Walking or cycling ☐

3. Are you satisfied with the mode of transport you usually use? Yes ☐ No ☐ Please elaborate._____
   _____

4. Are you aware that the use of fossil fuel-based vehicles (particularly private cars) contributes to climate change through carbon emissions? Yes ☐ No ☐

5. Would you use less- or non-polluting modes of transport more if convenience is guaranteed? Yes ☐ No ☐

6. Are you aware of the benefits of renewable energy such as solar? Yes☐ No☐ If so, kindly state some _____

7. Do you practice energy conservation and/or efficiency including any sustainability measures in this place? Yes ☐ No ☐

8. Which other measures in question 6 would you like to see implemented if you are aware of any? _____
_____

9. How do you feel about the cost/affordability and accessibility of the following sources of energy?
    a. Electricity: Good ☐ Fair ☐ Bad ☐
    b. LPG: Good ☐ Fair ☐ Bad ☐

10. Do you think energy consumption is done in an orderly and safe manner in this place?
    a. Electricity: Yes ☐ No ☐
    b. LPG: Yes ☐ No ☐

11. Would you welcome renewable energy such as solar power if it was generated on-site?
    Yes☐ No☐

12. Which activities relating to the following topics do you or would you like to see bearing in mind sustainable energy use and climate change adaptation and mitigation.
    a. Local business/Land-uses _____
    b. Fun/Social Activities _____
    c. Environmental Protection _____

13. *Urban Design can briefly be defined as a thought process of arranging spaces and infrastructure in the built environment to create functional places for human activity.* What would you like to see concerning the following elements of the design of this place?
    a. Site Layout _____
    b. Landscaping _____
    c. Building Appearance _____

14. Are you satisfied with the level of general maintenance of the place (including infrastructure such as streetlights et cetera)? Yes ☐ No ☐
    If no, please elaborate why and what can/should be done. _____
    _____

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APPENDIX B

EXPERT INTERVIEW FOR AN URBAN PLANNER

Date: __/ __/2021 **at** Gaborone, Botswana

MAINSTREAMING SUSTAINABILITY IN PUBLIC SPACE:
FORMULATING ENERGY STRATEGIES THROUGH URBAN DESIGN IN GABORONE, BOTSWANA

BACKGROUND

As cities embrace climate change adaptation and mitigation, it has become critical to address energy issues in public spaces in the quest to achieve sustainable urban development. Through urban design interventions, this study intends to develop a design framework to rethink energy strategies in the public realm, that address environmental issues relating to renewable energy transition; economic issues relating to cost saving; social issues relating to a vibrant lifestyle; and placemaking issues relating to functionality and aesthetics.

RESPONDENT PROFILE/BIO

Full Name: _____
Position: _____
Organisation: _____
Department: _____

QUESTIONS

1. What kind of public spaces does the city have?
2. Which policies does the city follow in public space design and development?
3. As an Urban Planner, how do you think land-use planning can influence sustainability (energy, climate action, responsible consumption)?
4. How does the city promote the renewable energy transition movement?
5. How does the city regulate the micro-climate when designing public spaces?
6. Are there any ways in which the city raises public awareness on issues of sustainability (energy, climate action, responsible consumption)? If so, please state.
7. How do you think energy (including climate action and responsible consumption) can contribute to sustainable development with regard to the following thematic areas:
    a. Economic
    b. Environmental
    c. Social
    d. Placemaking
8. How does the design of public spaces achieve placemaking in the following thematic areas:
    a. Comfort and Image
    b. Access and Linkages

c. Uses and Activities
d. Sociability:

9. What challenges are facing sustainability efforts (energy, climate action, responsible consumption) in Gaborone
10. What are your recommendations with regard to achieving sustainability (energy, climate action, responsible consumption) in Gaborone?

NOTES