FINANCING SUSTAINABLE CITIES IN SOUTH AFRICA

by

Gregory Justin Ducie

Submitted in fulfilment of the requirements for the

Degree of Doctor of Philosophy: Business Management

in

The Faculty of Business and Economic Sciences

at

Nelson Mandela University

Promoter: Prof: Miemie Struwig
Co-promoter: Dr Sibongile Muthwa

2017

DECLARATION

NAME: Gregory Justin Ducie

STUDENT NUMBER: 212444697

QUALIFICATION: Doctor of Philosophy: Business Management

TITLE OF PROJECT: FINANCING SUSTAINABLECITIES IN SOUTH AFRICA

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

……..
Gregory Justin Ducie

DATE: 4 August 2017

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to the following people for their contributions to making this study possible:

- Professor Miemie Struwig for her:
  - unwavering assistance, when at times, this was not deserved
  - guidance on particular issues, that if not provided, would have resulted in a lesser outcome
  - passion for providing opportunity and experience, that many a supervisor would find hard to match and, finally,
  - “I’m not in your head” mantra which enabled me to express my thoughts more convincingly.
- Dr Sibongile Muthwa for her advice and assistance.
- Dr Marcelle Harran for her assistance with the language edit and Redene Steenberg for the technical edit.
- The participants who provided me with valuable inputs towards my model.
- The Nelson Mandela University for allowing me time-off to attend to my PhD study.
- The Research Development at Nelson Mandela University for financial assistance to finalise my thesis.
- My family who facilitate my passions and encourage my imaginings.

ABSTRACT

Although directives exist with respect to promoting sustainable development, financial strategies to cater for collective sustainable development, along with an increasing population, need to be formulated relevant to metropolitan and urban areas. This study determined the infrastructure investment basis of a sustainable city to investigate various funding mechanisms resulting in the design of a model for the financing of sustainable cities.

For the study, first the various infrastructure investment alternatives were established from the literature, and thirteen themes and their relevant interventions were identified. Tangible and intangible methods of assessment were then identified as ways to calculate the acceptability of an intervention. A case study based on a hypothetical city was developed to determine the infrastructure investment base. Initially, only one intervention of a theme was populated and then confirmed by city development experts. Thereafter, all the themes were populated, and the acceptability of the interventions were determined. This provided an overview of the investment base of a sustainable city.

The investment base facilitated deriving applicable tools and instruments to finance it. As a result, possible finance alternatives were derived for each of the identified themes. Although most of the financing of sustainable cities revolved around public sector finance, the private sector also played an important role for the financing of sustainable cities.

Based on the investment base for sustainable cities and the resultant financing thereof, a model for the financing of sustainable cities was developed. The model consisted of four components. Firstly, the model included an application of financing tools and instruments relevant to the identified themes of sustainable city development. Secondly, the model included the application of financing tools and instruments with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention and an enabling intervention. Thirdly, the model included financing tools and instrument types in terms of incentive, opportunity, punitive and mandatory interventions. Fourthly, the model included the application of financing tools and instruments with respect to scale in terms of a city-wide application, sector-wide

application, urban application or suburban application. In addition, the model included the application of financing tools and instruments and their relation to addressing poverty within the city context.

Although the public sector will always remain the key initiator behind infrastructure development, various mechanisms of financing, along with applicable financing partners and the basis of investment, are required to address future sustainable cities. This study may potentially form the basis of that platform.

TABLE OF CONTENTS

CHAPTER TWO

RESEARCH DESIGN AND METHODOLOGY

CHAPTER THREE

NATURE OF SUSTAINABLE CITY DEVELOPMENT

CHAPTER FOUR

A HYPOTHETICAL SUSTAINABLE CITY

CHAPTER SIX

MECHANISMS OF FUNDING OF SUSTAINABLE CITY DEVELOPMENT

CHAPTER SEVEN

A MODEL FOR THE FINANCING OF SUSTAINABLE CITIES

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

The United Nations General Assembly has provided the necessary directive for sustainable development (United Nations General Assembly, 2012). The United Nations General Assembly's (2012) resolution stipulates a common vision for the future wherein economic, social and environmental aspects are mainstreamed at all levels to achieve sustainable development. This resolution recognises that the need to achieve sustainable development is obtained by promoting sustained, inclusive and equitable economic growth, raising basic standards of living, promoting the integrated and sustainable management of natural resources and ecosystems as well as fostering equitable social development (United Nations General Assembly, 2012). These factors are inherently associated with population growth along with the subsequent accommodation of that growth within urban centres.

Although directives exist with respect to promoting sustainable development, financial strategies to cater for collective sustainable development, along with an increasing population, need to be formulated relevant to metropolitan and urban areas. As urban economic output and energy needs increase, urban areas will increasingly need to invest in infrastructure to ensure sustainable and eco-friendly solutions (Siemens White Paper on Sustainable Cities, 2010). Furthermore, the Organisation for Economic Co-operation and Development (OECD) estimates that 3.5% of the global GDP is required to be invested in basic infrastructure to cater for future population growth whilst simultaneously bearing the cost of minimising impacts on the environment (Chalons-Browne, 2011). Key to the required investment in infrastructure is who will assume the costs and direction thereof?

This study, initially, sought to quantify the basis of infrastructure investment with respect to the development of a sustainable city. Thereafter, a determination on the various financing methods of funding sustainable cities was undertaken resulting in the design of a model to finance sustainable cities. Such a model would provide guidance to the public and private sector for the development of future sustainable communities / cities.

The following sections first provide a brief literature review. Thereafter, the study's research design and methodology are outlined, and the main contributions of the study are provided.

1.2 BACKGROUND TO THE STUDY

The world's population has grown from 1.6 billion in 1900 to around 6.1 billion in the 2000s, with the vast majority of this growth being in the developing world (Cohen, 2006). Respective population sizes per developed and less-developed regions from 1950 to a projected 2030 are depicted in Table 1.1.

Table 1.1: Urban population size and distribution by major geographic area, 1950-2030

Region	1950	1975	2000	2030
Total population (millions)				
World	2519	4068	6071	8130
More-developed regions	813	1047	1194	1242
Less-developed regions	280	3021	4877	6888
Rural population (millions of inhabitants)				
World	1786	2552	3214	3185
More-developed regions	386	344	311	228
Less-developed regions	1400	2208	2902	2958
Urban population (millions of inhabitants)				
World	733	1516	2857	4945
More-developed regions	427	703	882	1015
Less-developed regions	306	813	1974	3930

Region	1950	1975	2000	2030
Percentage of population living in urban areas				
World	29.1	37.3	47.1	60.8
More-developed regions	58.3	67.2	73.9	81.7
Less-developed regions	17.9	26.9	40.5	57.1
Distribution of the world's urban population				
World	100	100	100	100
More-developed regions	58.3	46.4	30.9	20.5
Less-developed regions	41.7	53.6	69.1	79.5

Source: Cohen (2006)

As depicted in Table 1.1, the projected annual population growth rate over thirty years (2000-2030) equates to 1.8%. This rate of growth signifies a doubling of the world's population in thirty-eight years (Cohen, 2006). The challenge in accommodating this increased population is how to do so in a sustainable manner.

1.3 PROBLEM DEFINITION

No single city development financing method can claim to ensure the sustainable development of cities (United Nations, 2013). Furthermore, as Gunningham (2014) states, a range of policies and interventions is required as part of a financing policy mix, however, this is dependent on a country's potential energy sources, technological capabilities, economic circumstances along with the political, economic and social constraints within which decisions need to be taken.

Although directives exist with respect to promoting sustainable city development, financial strategies to cater for collective sustainable development, along with an increasing population, need to be formulated relevant to metropolitan and urban areas. As urban economic output and energy needs increase, urban areas will increasingly need to invest in infrastructure to ensure sustainable and eco-friendly solutions (Siemens White Paper on Sustainable Cities, 2010). Key to the required investment in infrastructure is who will assume the costs and direction thereof?

Although the public sector will always remain the key initiator behind infrastructure development, various mechanisms of financing, along with applicable financing partners and the basis of investment, will be required to address future sustainable cities.

The question can be posed whether the basis of infrastructure investment with respect to the development of a sustainable city can be quantified to determine the financing thereof? This study will develop a model to demonstrate how to finance sustainable cities.

1.4 RESEARCH OBJECTIVES

For the study, the primary and secondary objectives need to be outlined.

1.4.1 Primary Research Objective

The primary research objective of this study was to determine the infrastructure investment basis of a sustainable city to investigate various funding mechanisms resulting in the design of a model for the financing of sustainable cities.

1.4.2 Secondary Research Objective

To give effect to the primary objective of this study, the following secondary research objectives were formulated.

- To define the nature of sustainable development within a sustainable city
- To determine the themes and associated interventions that should be addressed for a city to be defined as sustainable
- To define the acceptance of the themes and associated interventions of sustainable city development
- To formulate tools and instruments to determine the sustainability of the themes and associated interventions of sustainable city development
- To determine whether the themes and associated interventions are indeed acceptable thereby confirming their inclusion in sustainable city development
- To investigate tools and instruments to finance the investment of a sustainable city

- To match the tools and instruments with the themes and associated interventions of sustainable city development to propose potential funding mechanisms
- To develop a model to finance sustainable cities

1.4.3 Research Questions

This study intended to provide answers to the following research questions:

a) What is the nature of sustainable development within a sustainable city and what themes and associated interventions should be addressed for a city to be defined as sustainable?
b) How is the acceptance of the themes and associated interventions of sustainable city development defined?
c) How can it be determined whether the themes and associated interventions are indeed acceptable thereby confirming their inclusion in sustainable city development?
d) How is the acceptance of the themes and associated interventions of sustainable city development determined?
e) What tools and instruments can be utilised to finance the investment in a sustainable city?
f) What model can be developed to finance sustainable cities?

The relationship between the research objectives and the research questions is illustrated in Table 1.2.

Table 1.2: Relationship of study's research questions to research objectives

RESEARCH QUESTIONS	RESEARCH OBJECTIVES
What is the nature of sustainable development within a sustainable city and what themes and associated interventions should be addressed for a city to be defined as sustainable?	• To define the nature of sustainable development within a sustainable city • To determine the themes and associated interventions that should be addressed for a city to be defined as sustainable
How is the acceptance of the themes and associated interventions of sustainable city development defined?	• To define the acceptance of the themes and associated interventions of sustainable city development

RESEARCH QUESTIONS	RESEARCH OBJECTIVES
How can it be determined whether the themes and associated interventions are indeed acceptable thereby confirming their inclusion in sustainable city development?	• To formulate tools and instruments to determine the sustainability of the themes and associated interventions of sustainable city development
How is the acceptance of the themes and associated interventions of sustainable city development determined?	• To present the acceptance for the themes and associated interventions of sustainable city development utilising tools and instruments • To determine whether the themes and associated interventions are indeed acceptable thereby validating their inclusion in sustainable city development
What tools and instruments can be utilised to finance the investment in a sustainable city?	• To investigate tools and instruments to finance investment of sustainable city • To match the tools and instruments with the themes and associated interventions of sustainable city development to propose potential funding mechanisms
What model can be developed to finance sustainable cities?	• To develop a model to finance sustainable cities

Source: Author's own compilation

1.5 A BRIEF LITERATURE OVERVIEW

In the following sections, the concepts used in the study are first clarified. Thereafter, financing methods for sustainable city development are discussed followed by a brief overview of a model to finance sustainable cities and previous studies with respect to green economy and city finances.

1.5.1 Clarification of Concepts

Given the four factors of the future sustainable development of cities, determining an adequate basis of investment for future development, converging the multiple visions of sustainable development along with coupling financing mechanisms to fund these multiple visions it is, for the purposes of this study, important to define the following:

- Measurement of urban sustainability
- Investment in natural capital
- Social equity
- Community driven, managed and owned infrastructure
- Shortfalls in municipal budgeting and financing

(i) The measurement of urban sustainability

Although Swilling (2005) has identified issues that need to be addressed to ensure that future development occurs in a sustainable manner thereby integrating equity and urban economic growth, a mechanism of measurement is required to ensure the appropriate attainment of those issues. For example, Ratas and Maeltesemess (2013) detail criteria used in the European Green Capital Award which seeks to recognise cities' efforts in valuing environmental protection activities along with their efforts in creating a harmonious urban environment. A typical example of the criteria utilised is reflected in Table 1.3.

Table 1.3: Environmental indicators of three European Green Cities award winners (2010)

European Green Capital	Reduction in CO^2 emissions per person, % 1990-2005	Length of cycle paths		% of population who live <300m from public transport stop	% of population affected by noise level during day	Waste generation: kg/person/ year	Water consumption: l/person/day	Population density	Public green areas	
		Km	Km/km²					People/km²	m²/ person	% of population who live <300m from open green area
Stockholm	-26	760	3.64	90	35	409	200	4141	86	90
Hamburg	-25	1700	2.25	99	18	479	110	2331	39	89
Copenhagen	-26	349	3.95	98	36	469	117	5708	28	79

Source: Ratas and Maeltesemees (2013)

As illustrated in Table 1.3, various indicators exist with respect to determining the 'green' status of a city. One can apply the same rationale to this study where the factors that ensure sustainability through integrating equity and urban economic growth are benchmarked to ensure measurability of sustainability along with the funding mechanisms to achieve that sustainability. For the purposes of this study, the measurement of urban sustainability entailed the sustainability components as detailed in Table 1.4.

Table 1.4: Measurement of urban sustainability for the purposes of this study

SUSTAINABILITY FACTOR	MEASUREMENT
Reducing the total consumption of water along with the dependence on large-scale water capture systems	% of total water consumption produced by large-scale water capture systems
Encouraging a community-based sanitation system for all income groups where sewerage is treated and re-used	% of sewerage that is treated and re-used
Promoting densification, mixed land use and mixed income residential areas	% of city footprint over 30 dwelling units per hectare
Reducing the use of private vehicles whilst simultaneously increasing the use of public transport	The footprint of public transport across the city
Reducing the use of fossil fuel-based energy leading to a transition of energy provision that utilises a combination of solar, wind, micro-hydro and hydrogen power coupled with increased efficiencies	% of energy produced by renewable sources
Increasing food supplies from urban farms along with building local food retail markets	% of local food production
Promoting the separation at source of solid waste coupled with collection and recycling systems	% of waste recycled
Ensuring that building materials and design are based on the assessment of the environmental and social impact	% of building materials used with minimum environmental impact

SUSTAINABILITY FACTOR	MEASUREMENT
Reducing air pollution and CO^2 emissions from vehicles, utilities and homes	% of emissions per person
Ensuring a public health system that focuses on the provision of basic services	Extent of basic health care provision
Increasing biodiversity and recreational space	% footprint of the city dedicated to biodiversity and recreational space
Enhancing child-centred development and learning	Number of facilities dedicated to child-centred learning and development

Source: Author's own compilation

As detailed in Table 1.4, for the purposes of this study, the twelve factors sought to benchmark urban sustainability, which would thus inform the appropriate funding mechanisms.

(ii) Investment in natural capital

Many of the components that would form the basis of measuring sustainability in this study reflected a reliance on natural capital. The value of natural capital is, however, difficult to define. As Constantinescu (2013) states, two common errors occur with respect to the value of natural capital. The first error relates to the attempt to define natural capital in monetary terms only thereby ignoring the value of natural capital in making sustainability simpler. The second error relates to assessing natural capital in terms of goods and services provided by nature whose market value can be easily determined at the exclusion of those goods and services whose value cannot be easily determined.

Luzadis, Alkire, Mater, Romm, Stewart, Will and Vaagen (2001) present four strategies with respect to natural capital investment, namely, innovations in private investment, jurisdictional boundaries, government funding and community-based ecosystem management. These four strategies serve as a basis of staying true to environmental and community values. Innovations in private investment (Luzadis *et al*., 2001) include:

- Third-party certification of sustainability measures: Includes independent third-party certification to become a viable market-based financial tool to fund ecosystem management
- Carbon sequestration leverage packages: Involves the accumulation of carbon in terrestrial forms thereby limiting greenhouse gas build up
- Resource banks: Refers to trading natural asset value for use thereby attempting to ensure the balance between the need for natural assets and monetary value
- Partnership financing: Involves major corporation financing of sustainability practices and certification
- Technology and new markets leveraging: Involves the identification and implementation of new technologies and markets to match buyers with resources generated from sustainable ecosystem management

Innovations in jurisdictional boundaries include the creation of mechanisms that allow for the use and need of ecosystem services regardless of jurisdictional boundaries. This is achieved through fiscal / ecological zoning where natural areas are specifically zoned to attract commercial activity that generates revenue for the locality.

Innovations in the government funding of ecosystem management relates to altering the perspective where ecosystem finance is viewed as an investment issue as opposed to an administrative or budgetary problem.

Innovative community-based ecosystem management relates to the fundamental concept that communities are central to solving the ecosystem investment problem as they are best placed to capture and reinvest in the resulting benefits to sustain ecological improvements.

(iii) Social equity

Eventual financing mechanisms of sustainable cities should seek to ensure that social equity convergence is core to the financing strategy. Equity does not refer to equality but rather refers to instances in which a community is treated fairly but not necessarily the same thereby ensuring that all benefit from the prosperity of a sustainable city (UN-Habitat, 2014b). Urban equity within the context of development means that public goods and services should be available to everyone thereby resulting in an

environment where the goods and services are distributed to all according to needs (UN-Habitat, 2014b). Furthermore, the *S*tate of African Cities, Re-imagining Sustainable Urban Transitions, the UN-Habitat (2014b) Report states that, where possible, measures are put in place for a fair and more efficient use of resources, skills and opportunities to promote equal outcomes for all. This complies with the intended core of this study where proposed financing mechanisms were sought to fund the sustainable interventions whilst integrating equity and urban economic growth.

As Phimphanthavong (2014) identifies, sustainable development is a combination of economic growth, social development and environmental protection under the premise that economic growth is distributed to the entire population through the reduction of poverty and the minimisation of inequality whilst maintaining natural resources. Sustainable development further involves all sectors including education and health improvement, sanitation system extension, poverty reduction and the promotion of natural resource protection. The primary principle of sustainable city development is that all these factors interact in decision-making (Phimphanthavong, 2014). A financing strategy for sustainable city development, therefore, needs to be developed and exist within a cross-section of sustainability interventions that contribute to overall city sustainability.

(iv) Community-driven, managed and owned infrastructure

Coupled with social equity, key to a financing strategy to fund sustainable city development is that of community participation within city development. True community participation seeks to provide equal opportunities amongst the community to share ideas and needs with the objective being to ensure increased capacity and awareness of the local population that could be utilised for the future development of their communities (Phimphanthavong, 2014). As such, various mechanisms of financing sustainable city development that were proposed in the study, should seek social equity and community involvement. The primary objective of appropriate community involvement is to increase capacity and awareness of the local population in the future development of their communities. This is achieved where a community has a direct stake in future sustainable development, which harnesses a will to participate and contribute to the future development of their communities.

Behavioural barriers, however, need to be overcome in developing sustainable cities. A fundamental shift in how we perceive opportunity, and not the problem, of ensuring sustainable city development and what must be done to capitalise on that opportunity (Hanna, 2014) must form the basis of community engagement.

More specifically, stakeholder connectivity in infrastructure capacity management within a community is made up of two key constructs, namely, collaborative relationships and knowledge sharing along with the impact on organisational or municipal performance (Too, 2011). Appreciating the value of stakeholder connectivity in adding value to infrastructure capacity management can lead to the development of new solutions by exploiting existing opportunities (Too, 2011). This is key to any financing strategy for sustainable city development. Approaching the financing of sustainable city development through traditional private sector project financing methods where developers remain incentivised to increase their return on investment results in the marginalisation of the community (Baker, 2014). The project financing of sustainable development needs to include the meaningful participation of all affected parties thereby preserving the ecological heritage of communities in which development takes place (Baker, 2014).

(v) Shortfalls in municipal budgeting and financing

In order to green the economy, public budgets alone will not be able to provide the necessary financial resources. Additional resources need to be mobilised, in particular, respect to green investments in developing countries and emerging markets (Lindenberg, 2014). As such, governments may make use of public instruments to leverage capital for sustainable city development. According to Lindenberg (2014), additional financial resources can be grouped into three categories which seek to leverage capital for sustainable investment. These financial resources include:

- Instruments that primarily provide funding to projects
- Instruments that transfer knowledge or risk
- Instruments that raise additional private funds

These additional financial resources have different advantages and weaknesses and are dependent on country circumstances. As such, a mix of approaches need to be

applied within varying countries, however, the potential for mainstreaming green finance and utilising the additional financial resources on a larger scale is relatively limited (Lindenberg, 2014). According to Lindenberg (2014), knowledge on the effectiveness along with the implications of green finance is incomplete. As such Lindenberg (2014) proposes the following policy recommendations:

- Greater knowledge is required with respect to green finance with respect to current financing arrangements
- Governments should bear in mind that green investments do not always require financing but rather a conducive environment
- Whatever form of green financing is utilised, it must be simple to understand
- Governments should utilise all of the various instruments to leverage private capital owing to the usefulness for different purposes, project phases and situations

1.5.2 Financing Methods for Sustainable City Development

Financing methods include instruments such as crowd funding, alternative forms of property rating based on renewable energy technologies, trading schemes, capital subsidies for sustainable city development, public-private partnerships and government funding leverage to encourage private sector financing amongst other financing strategies. Key to the development of a financing model is the context of the South African city, and what components create the structure of a sustainable city. In addition, the outsourcing of future city infrastructure and services is likely to increase in the future (Lossa, Spagnolo & Vellez, 2013). The outsourcing of city infrastructure and services is coupled with alternative funding strategies as the size of the state in the economy reduces.

Future city development, given increased population growth and the associated need to eradicate poverty, is an inevitable occurrence within the South African context. However, as Swilling (2005) states, the challenge exists in reconciling development within a limit to growth mentality ensuring that developing countries do not replicate unsustainable systems as within the developed world. As cities continue to grow increased demands on water, energy, food, land and building material provision will continue unabated producing unprecedented quantities of waste. In addition, cities

previously constructed in South Africa were built on the assumption that there was cheap coal-based energy, unlimited supplies of water, low fuel costs, unlimited provision to cater for the disposal of waste and unlimited supplies of land (Swilling, 2005). These assumptions cannot apply to modern day South Africa. As such, Swilling (2005) states that the following issues need to be addressed to ensure that future development occurs in a sustainable manner thereby integrating equity and urban economic growth:

- Reducing the total consumption of water along with the dependence on large-scale water capture systems
- Encouraging a community-based sanitation system for all income groups where sewerage is treated and re-used
- Promoting densification, mixed land use and mixed income residential areas
- Reducing the use of private vehicles whilst simultaneously increasing the use of public transport
- Reducing the use of fossil fuel-based energy leading to a transition of energy provision that utilises a combination of solar, wind, micro-hydro and hydrogen power coupled with increased efficiencies
- Increasing food supplies from urban farms along with building local food retail markets
- Promoting the separation at source of solid waste coupled with collection and recycling systems
- Ensuring that building materials and design are based on the assessment of the environmental and social impact
- Reducing air pollution and CO^2 emissions from vehicles, utilities and homes
- Ensuring a public health system that focuses on the provision of basic services
- Increasing biodiversity and recreational space
- Enhancing child-centred development and learning

As urban sprawl continues, governments are in dire need of intervention strategies to foster urban development by means of eco-efficient strategies and social inclusiveness (Bammeke, 2013). As such, multiple pathways are required in making cities more sustainable through large-scale investment programmes to bottom-up interventions such as shifts in behaviour (Williams, 2010).

Although mechanisms exist to ensure an adequate basis of investment, key to future sustainable development is the recognition that multiple visions of sustainable city development, from the built and the natural environment through to the concept of social equity, converge. This has implications for the financing thereof. As identified by Swilling (2005), an alternative approach to local economic development in developing country cities is required to target sectors for investment where the potential for poverty reduction is the greatest. Typical current local economic development interventions within South Africa are arguably focused within the sectors of tourism and urban agriculture. For these sectors, little to no opportunities are sought from the re-engineering of water, sanitation, land, energy and food systems. Nor are preventable leakages from the local economy sought with respect to purchasing less water from outside the local economy and utilising less disposable income of households on energy, for example (Swilling, 2005). However, the eventual financing mechanisms of sustainable cities should seek to ensure that social equity convergence is core to the financing strategy.

Given the extent of the sustainable interventions required within the development of a city, a combination of financing mechanisms are required to fund future sustainable city development rather than predominantly rely on inter-governmental fiscal transfers. In addition, an over-reliance on inter-governmental fiscal funding does not necessarily conform to the principle of sustainable finance. As such, varying mechanisms of financing a sustainable city, based on sector specific characteristics along with social parameters, should ideally be applied.

Crowd sourcing, for example, could potentially be used as a mechanism to address an issue within the future development of a sustainable city. As Sundic and Leitner (2013) find, crowd sourcing has proven to be an innovative strategy and, furthermore, a business model in establishing innovation platforms not to mention the versatility thereof. These innovative platforms can potentially be used through bottom-up interventions that result in shifts in behaviour along with an opportunity for alternative funding mechanisms. The same could be said of alternative forms of property rating based on renewable energy technologies, trading schemes, capital subsidies for sustainable city development, public-private partnerships and government funding leverage.

Practices such as property taxes, borrowings to finance capital expenditure, crowd funding, public private partnerships, renewable technologies and social re-engineering, should, therefore, be structured in such a way to ensure that future development occurs in a sustainable manner thereby integrating equity and urban economic growth (Swilling, 2005).

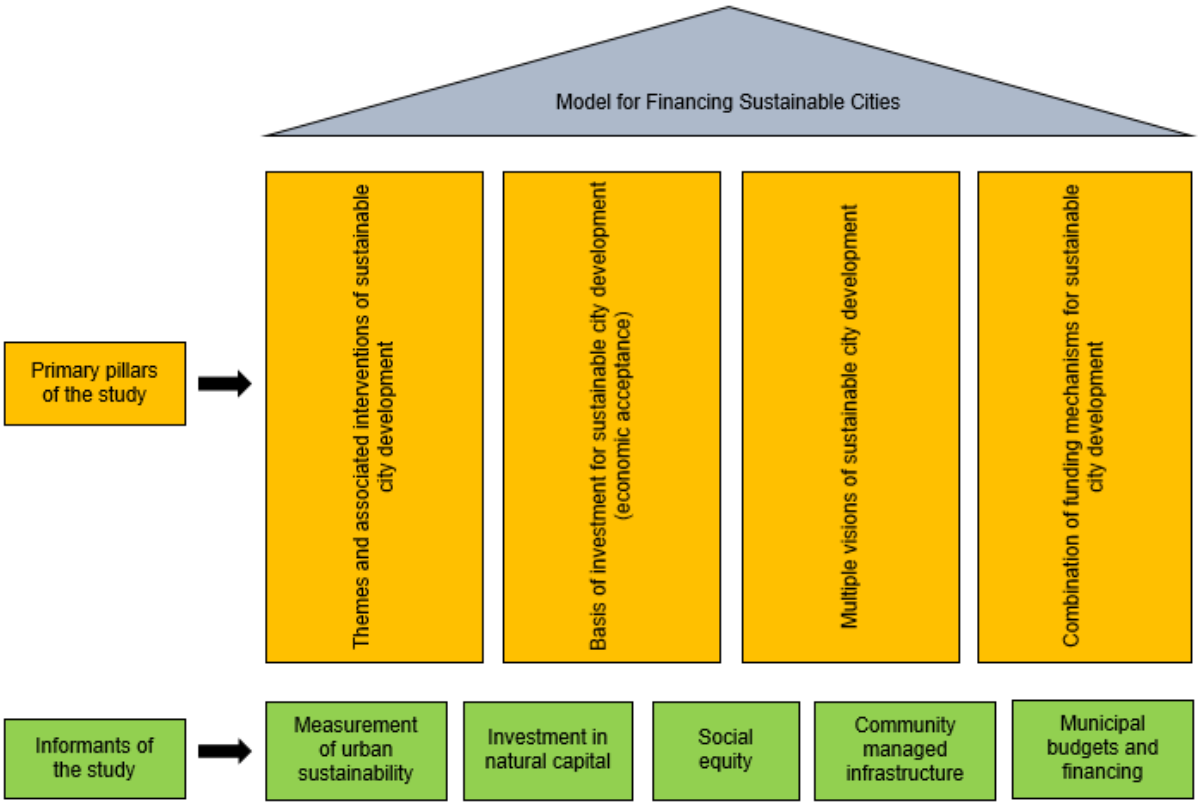
1.5.3 Brief Overview of a Model to Finance Sustainable Cities

Section 1.2 detailed the literature overview and associated background to this study which was diagrammatically represented in Figure 1.1. As such, this study has four primary pillars that would inform an eventual model for financing sustainable cities, namely, the themes and associated interventions of sustainable city development, the economic acceptance of sustainable city development and the multiple visions of sustainable city development along with the mechanism of funding for sustainable city development.

The primary informants to the four pillars included the concepts of measuring urban sustainability, investment in natural capital, social equity, community-managed infrastructure along with municipal budgets and financing.

Figure 1.1 outlines the four pillars which would inform the eventual model for the financing of sustainable cities.

Figure 1.1: Diagrammatical representation of the study



Source: Author's own compilation

The pillars, as depicted in Figure 1.1, would assist in devising a model for financing sustainable cities.

1.5.4 Previous Studies with Respect to the Green Economy and City Finances

Sustainable development became the primary goal the international community since the UN Conference on Environment and Development in 1992 (Agenda 21, United Nations Sustainable Development, 1992). The term green economy was first tabled in 1989 in a report for United Kingdom government by environmental economists (United Nations, 2012). The report sought to determine whether there was consensus on the term 'sustainable development' along with the implications of sustainable development for the measurement of economic progress (United Nations, 2012). Subsequent sequels to the report in 1991 and 1994 built on the concept that economics could come to the aid of environmental policy.

In 2008, the ‘green economy’ term was revived in the context of policy response to the multiple global crises (United Nations, 2012). The United Nations Environment Programme championed the concept of green stimulus packages where large-scale investment could initiate a green economy (United Nations, 2012). Respective governments followed suit in attempting to implement green stimulus packages as part of economic recovery efforts.

In Africa, and more specifically South Africa, numerous research themes have been developed with respect to the green economy. Table 1.5 reflects previous studies with respect to green economy and city finances.

Table 1.5: Studies with respect to green economy and city finances

APPLICABILITY	THEME	SOURCE	FOCUS
International	Macomber (2011) states that three trends will dictate urban development, investment, and entrepreneurship in the next two decades. These include: Urbanisation: • A growing shortage of resources that can be regarded as public goods, and • No government will have the funds or access to capital that will be required to deliver infrastructure necessary for the development of new cities along with the renovation of old ones. As such, Macomber (2011) advocates that the private sector needs to be involved in financing and investing in new cities.	Macomber (2011)	Access to capital

APPLICABILITY	THEME	SOURCE	FOCUS
Africa	Swilling (2013) states that the global economic crisis will only cease once finance capital has been disciplined and once green technology driven by finance capital is heightened. The challenge is that despite the potential in green technology, there is a lack of high risk investments that need to go beyond niche markets (Swilling, 2013).	Swilling (2013)	Private sector investments lacking
Africa	The UN-Habitat (2014b) Report states that increased temperatures and shifting rainfall patterns will compromise, amongst others, food security, water availability, vital infrastructure and biological diversity. As urbanisation continues, Southern African countries need to focus their social and environmental vulnerabilities to climate change in urban areas (UN Habitat, 2014b). As such, further consistent and long-term budget allocations are required for city scale environmental plans and projects.	UN-Habitat (2014b)	Long-term budgets required for city-scale environmental projects
South Africa	Five priority areas have been identified by the Department of Environmental Affairs and Tourism (2008) to achieve sustainable development. These include: • Enhancing systems for integrated planning and implementation • Sustaining our ecosystems and using natural resources efficiently • Ensuring economic development via investing in sustainable infrastructure	Department of Environmental Affairs and Tourism (2008)	Investment in sustainable infrastructure

APPLICABILITY	THEME	SOURCE	FOCUS
	• Creating sustainable human settlements • Responding appropriately to emerging human development, economic and environmental challenges		
South Africa	According to the UNEP (2013), priority areas for green policy-making could include: • Restricting government spending in sectors that deplete natural capital • Promoting investment in sectors that stimulate a green economy • Installing a regulatory framework that harnesses investment into environmentally and socially-valuable activities	UNEP (2013)	Investment that stimulates the green economy
Provincial Context, South Africa	The Gauteng Department of Economic Development (2010) advocates the need to introduce a green low carbon economy. It further advocates the need to realign economies on long-term sustainability thereby resulting in a shift of capital focussed investment to strategic investments in knowledge capital and innovation systems.	Gauteng Department of Economic Development (2010)	Strategic investments in innovation systems
South African Cities	The South African Cities Network (2013), states, as applicable to South African cities, states that the performance of a city is a measure of their contribution to sustainable development. The Report further elaborates that owing to a city's financial capital along with its focus on infrastructure and services, great potential exists with respect to mobilising the green economy. As	South African Cities Network (2013)	Innovative financing mechanisms

APPLICABILITY	THEME	SOURCE	FOCUS
	such, a pre-requisite for a green economy is smart public policy along with innovative financing mechanisms. The South African Cities Network (2013) proposes three categories to promote and encourage a green economy, namely: • Category 1: Promote a change in behaviour of city inhabitants that results in cost savings and environmental benefit. • Category 2: Re-align existing budgets to ensure impact and efficiency as opposed to simple expenditure. • Category 3: Provide additional upfront expenditure in order to realise a subsequent financial benefit, risk reduction or economic growth benefit.		

Source: Author's own compilation

As depicted in Table 1.5, key themes with respect to research surrounding the green economy and city finances include:

- Private sector and alternative forms of funding would be required in the future with respect to the financing of sustainable cities
- Natural resources need to be utilised efficiently
- Frameworks are required that harness the potential for investment into environmentally-friendly activities.

1.6 A PROPOSED FRAMEWORK FOR THE STUDY

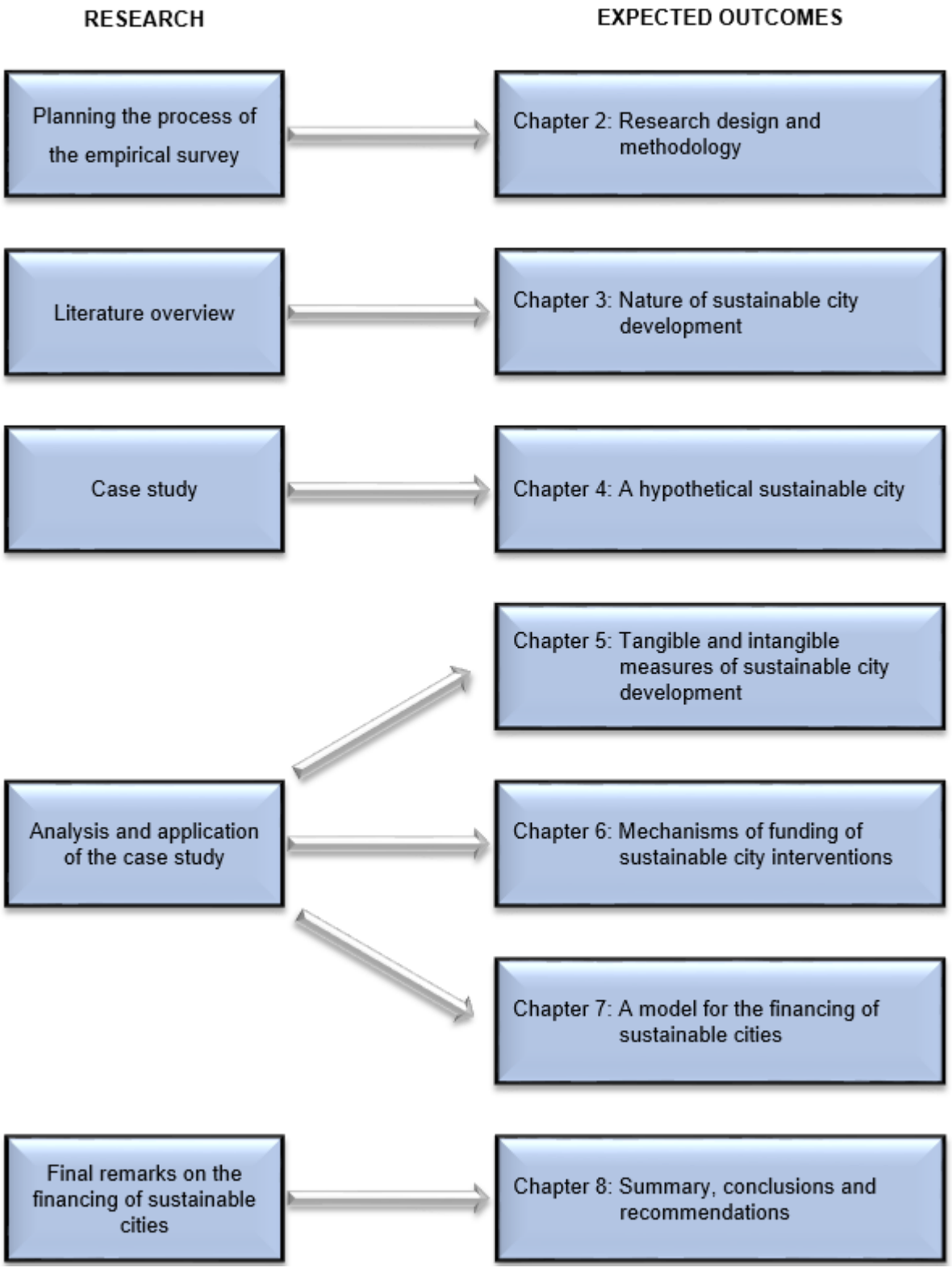
To address the problem of the study, the components that contribute to a sustainable city would first be determined followed by the relevant acceptance in investing in such components. From thereon, mechanisms of funding were formulated based on the

informants along with the investment criteria. This process formed the basis of a proposed framework for the study.

This process required detailing the exact interventions required for developing a sustainable city.

The process followed in this study is diagrammatically portrayed in Figure 1.2.

Figure 1.2: Proposed framework for the study



Source: Author's own compilation

Figure 1.2 demonstrates how a model for financing a sustainable city may be derived. In order to populate the research, information would need to be sourced from the local and international government as well as non-governmental institutions. The outcome would demonstrate the approaches available in financing sustainable cities in South Africa.

1.7 RESEARCH PROCESS

The research process followed entailed both secondary and primary research.

1.7.1 Secondary Research

A comprehensive literature search was conducted to identify as many factors as possible that could influence the outcome of the study. International and national data searches were conducted by the Library of Nelson Mandela University, which included Sabinet databases, ISAP (National library of South Africa), SAe Publications, EBSCO (MasterFile premier, Business Source premier, Academic Source premier), FS Articles First, Kovsidex, SA Cat and FS Worldcat, ScienceDirect, UPECAT, Google searches, Dialog and Dissertation Abstracts database.

Data was also accessed from other international and national libraries by means of the inter-library loan facilities at Nelson Mandela Metropolitan University. As far as can be ascertained, no similar research study has been previously undertaken in South Africa.

1.7.2 Primary Research

There are two research paradigms that can be adopted in research, namely, the positivistic and the phenomenological research paradigms. The positivistic paradigm refers to quantitative, objectivist, scientific, experimentalist or traditional research. The phenomenological paradigm refers to qualitative, subjectivist, humanistic or interpretive research (Cooper & Schindler, 2008). For Collis and Hussey (2003), the data produced by a positivistic paradigm can be quantitative, and the data produced by the phenomenological paradigm can be qualitative.

For the purpose of this study, the phenomenological paradigm (qualitative research) was adopted as secondary data would be used to populate a framework.

A hypothetical case would also be used to determine the tangible and intangible acceptability of an identified intervention of sustainable city development which, in turn, would be confirmed through identified city development experts.

As a qualitative approach was selected for this study, qualitative research was the focus. Qualitative research is an anti-positivist approach, where the research object, the human experience, cannot be separated from the individual who is experiencing the phenomenon. Therefore, for qualitative research studies, human behavioural experience and not the behaviour of the individual is the focus (Welman, Kruger & Mitchell, 2010). Zikmund, Babin, Carr and Griffen (2010) describe qualitative research as research that focuses on discovering meanings and new insights into phenomena without relying on numerical data. Qualitative research is also subjective in nature as it involves examining and reflecting views of humans in the understanding of the social and human activities investigated (Collis & Hussey, 2003).

In determining the tangible and intangible acceptability of the identified interventions of sustainable city development, an initial application was made against one of the identified interventions. The application and resultant outcome of the tangible and intangible determinants of the case study were then confirmed via the testing of the process through identified city development experts. The outcomes of the testing exercise in applying the tangible and intangible measures specific to the identified intervention were then considered and applied across all identified interventions of sustainable city development as further elaborated upon in Chapter 5.

1.7.3 Study Research Process

The research process to be undertaken in this study included seven steps, namely:

a) Step 1: Define the nature of sustainable development within a sustainable city. This was undertaken by means of a literature review.
b) Step 2: Determine the themes and associated interventions that should be addressed for a city to be defined as sustainable. This was undertaken by means of a literature review.
c) Step 3: Define the acceptance of the themes and associated interventions of sustainable city development. This was undertaken by means of a literature review.

d) Step 4: Develop a hypothetical case of a sustainable city. Using a hypothetical city size both tangible and intangible perspectives of the acceptance of projects were determined. A hypothetical case was assessed based on the application of tangible and intangible perspectives against one intervention of sustainable city development. The applied tangible and intangible measures were then appraised by means of interviews with sector specific specialists.
e) Step 5: Complete the hypothetical case by populating all interventions resulting in an investment scenario. This was undertaken by means of an interpretive study.
f) Step 6: Utilise investment scenarios to determine the financing thereof. This was undertaken by means of an interpretive study.
g) Step 7: Develop a model for the financing of sustainable cities.

The research design of this study is discussed comprehensively in Chapter 2.

1.8 SCOPE OF THE STUDY

This study applies to urban development within the South African context given increasing urbanisation pressures within the country along with increasing constraints on government funding. Cities are focal points in the quest for sustainability but are, however, vulnerable to a lack of resources (UNEP, 2012).

1.9 CONTRIBUTION OF THE STUDY

South African cities are predominantly maintained and developed in the form of conventional infrastructure and the associated conventional funding thereof. This includes national government grants and the local tax base. The promotion of sustainable practices in urban development is not necessarily coupled with alternative or sustainable forms of financing. Nor is a collective foundation of investment fostered and pursued. This study seeks to present an approach to sustainable development that is underpinned by three key elements, namely, defining the delivery mechanisms of sustainable development, providing a basis of investment for future development as a precursor for future sustainable development and, ultimately, financing that sustainable development from initiation through to development and maintenance. As such, this study sought to present an inclusive approach to sustainable city development that not only focused on the delivery of a service but also the acceptance of initiating that service along with the subsequent financing and development thereof.

As a result, this could assist local government, private developers, communities and investors in the formulation of instruments and financing mechanisms to fund sustainable city development. An alternative perspective on sustainable financing was thus provided.

1.10 STRUCTURE OF THE RESEARCH

The structure of the research is provided in Table 1.6.

Table 1.6: Structure of research

STUDY CHAPTERS
Chapter 1: Introduction to the study
Chapter 2: Research design and methodology
Chapter 3: Nature of sustainable city development
Chapter 4: A hypothetical sustainable city
Chapter 5: Tangible and intangible measures of sustainable city development
Chapter 6: Mechanisms of funding of sustainable city interventions
Chapter 7: A model for the financing of sustainable cities
Chapter 8: Summary, conclusions and recommendations

1.11 SUMMARY

Chapter 1 introduced the research to be undertaken and provided the background to the research. Although directives exist with respect to promoting sustainable development, financial strategies to cater for collective sustainable development, along with an increasing population, needed to be formulated. This chapter introduces the research problem, proposes how the research problem is to be analysed as well as the research questions. A brief literature review provided the definitions of key terms and concepts. It further outlined financing methods for sustainable city development and briefly introduced a model to finance sustainable cities.

The research process was briefly described, the study report outlined, and the key terminology defined. The chapter also provided a proposed framework for the research

process and included details of each of the eight chapters that comprise the research. Chapter two presents the research methodology to be utilised in this study.

CHAPTER TWO

RESEARCH DESIGN AND METHODOLOGY

2.1 INTRODUCTION

The primary research objective of this study is to investigate various funding mechanisms for sustainable city development thereby resulting in the design of a model for the financing of sustainable cities.

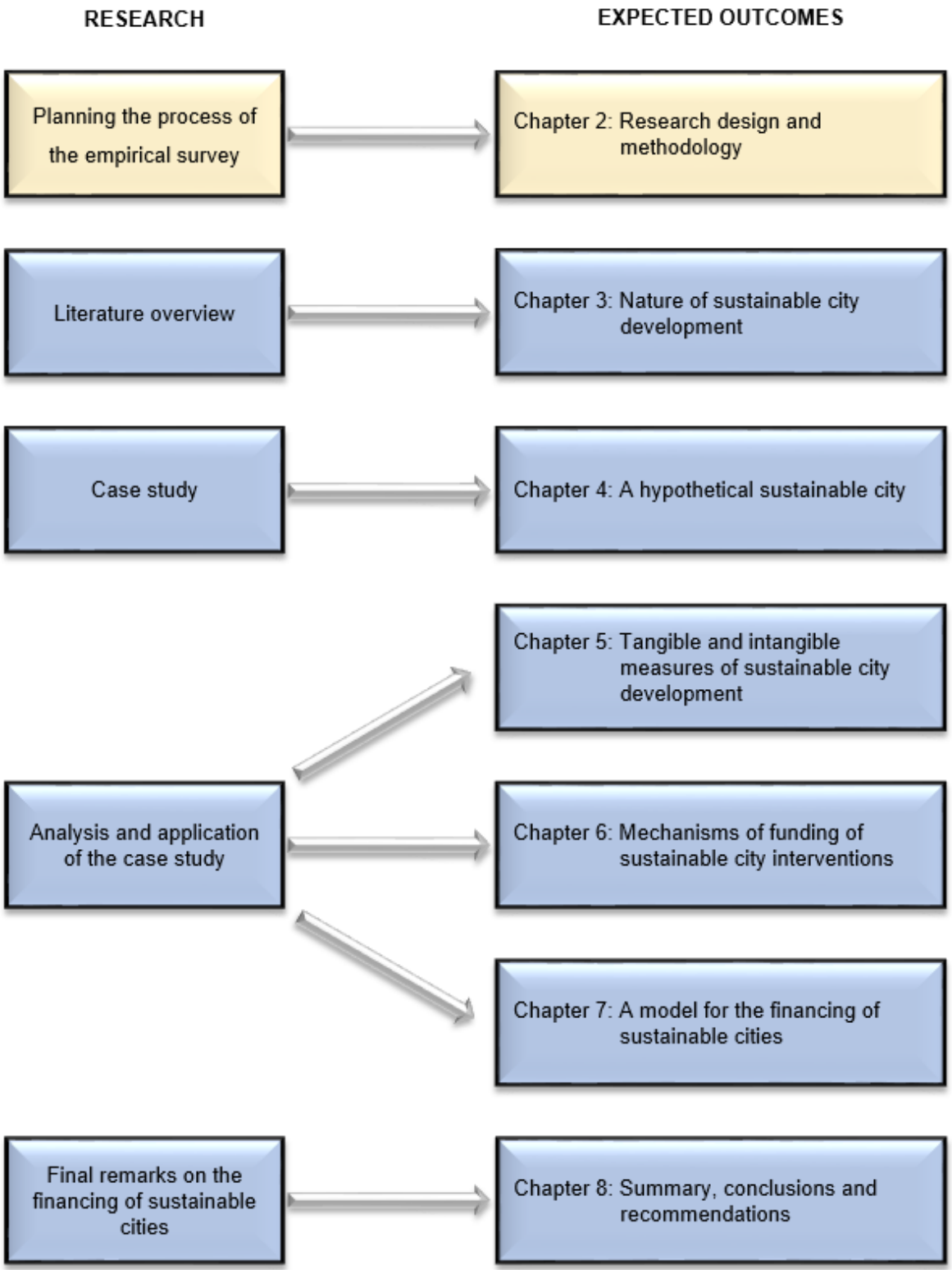
To develop such a model, the basis of a sustainable city first needs to be defined in the form of various themes and associated interventions. These themes and associated interventions of sustainable city development would ultimately inform the funding mechanisms required for sustainable city development. The acceptance of these sector specific themes and associated interventions, however, must first be determined through the application of tools and instruments that measure sustainability to ultimately validate their inclusion into the definition of sustainable city development. Alternative financing tools and instruments, each corresponding to the various themes and associated interventions of sustainable city development, were also developed concluding in a financing model to fund sustainable city development.

This chapter identifies and describes in detail the processes followed during the research process. The nature of research and the various research classifications are first described, the different research paradigms are discussed, and the specific paradigm chosen is motivated. The data collection and subsequent analysis are also addressed.

2.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 2.1.

Figure 2.1: Study framework



Source: Author's own compilation

As depicted in Figure 2.1, this study is comprised of eight chapters, and Chapter 2 relates to planning the process of the empirical survey.

2.3 NATURE OF RESEARCH

Research is the implementation of appropriate steps to produce original knowledge that will satisfy the users of the research. The implementation of the research steps needs to be performed rigorously, implying that it should be done in a systematic manner, and that the results of the research answer the research questions (Oates, 2006). Collis and Hussey (2003) summarise research as a process that enquires and investigates in a systematic and methodical manner with the ultimate aim to increase knowledge.

Zikmund *et al*. (2010) describe the research design as a step-by-step master plan detailing the methods and procedures to be followed when collecting and analysing data to ensure that the primary objective will be attained.

2.4 RESEARCH PARADIGMS

There are two research paradigms that can be adopted in research, namely, the positivistic and the phenomenological research paradigms. The positivistic paradigm refers to quantitative, objectivist, scientific, experimentalist or traditional research. The phenomenological paradigm refers to qualitative, subjectivist, humanistic or interpretive research (Cooper & Schindler, 2008). Collis and Hussey (2003) describe the data produced by a positivistic paradigm as quantitative, and the data produced by the phenomenological paradigm as qualitative.

For the purpose of this study, the positivistic paradigm was followed and adopted as secondary data was used to populate a model where:

- The acceptance of sector specific themes and associated interventions of sustainable city development were determined through the application of tools and instruments that measure sustainability
- A basket of financing tools and instruments, each corresponding to the various themes and associated interventions of sustainable city development, were developed
- A financing model was developed to fund sustainable city development.

2.5 SECONDARY AND PRIMARY RESEARCH

Secondary research was undertaken by means of literature review whereas primary research follows a qualitative approach as detailed in Sections 2.5.1 and 2.5.2.

2.5.1 Secondary Research

A comprehensive literature search was conducted to identify as many factors as possible that could influence the outcome of the study. International and national data searches were done by the Library of the Nelson Mandela Metropolitan University and to date included Sabinet databases, ISAP (National library of South Africa), SAe Publications, EBSCO: MasterFile premier, Business Source premier, Academic Source premier, FS Articles First, Kovsidex, SA Cat and FS Worldcat, ScienceDirect, UPECAT, Google searches, Dialog, Dissertation and Abstract databases.

Data was accessed from other international and national libraries by means of the inter-library loan facilities at the Nelson Mandela Metropolitan University. As far as could be ascertained, no similar research study had been undertaken in South Africa previously.

2.5.2 Primary Research

There are two types of research that are classified according to the processes that are followed during the research, namely, quantitative and qualitative research. A qualitative approach was followed in this study utilising a case study.

According to Cresswell (2014), a qualitative approach relies on the researcher as the instrument for data collection, is both inductive and deductive, is based on participant meanings and includes researcher reflexivity. Furthermore, the process of interpreting findings involves stating lessons learnt, comparing the findings with past literature, posing questions and / or advancing an agenda for reform (Cresswell, 2014).

Yin (2011) states that utilising an individual case study within a research process not only presents the outcomes of a particular situation, but also contributes to the intention to inform other situations within a research process.

2.6 CASE STUDY AS A RESEARCH DESIGN

In this section, the case study as a research design is discussed including the definition of a case study and the basis for selecting a case study research design.

2.6.1 Definition of a Case Study

Yin (2009) defined a case study research design as an in-depth practical investigation of a current event in the actual context. In case studies, investigators adopt the research design to understand a real-life phenomenon under important natural conditions that are relevant to the occurrence under investigation (Yin & Davis, 2007).

For the purpose of this study a descriptive case study type was used at it describes an intervention or phenomenon and the real-life context in which it occurred (Yin 2009).

2.6.2 Basis for Selecting a Case Study Research Design

Yin (2009) listed five bases for selecting a case study research design as appropriate, and emphasises that a case study should be equated to an experiment. The first rationale for a case study research design is that it includes the *critical case,* in testing one's theory. The critical case, for example, is where the theory has specified a clear set of propositions and also where the conditions within the propositions are considered as true. According to this rationale, a case study can confirm, challenge or extend the theory, as long as the case meets all of the conditions for testing the theory. A second rationale for a case study design is when the case study represents an *extreme case* or a *unique case.* The unique or extreme case is, as Yin (2009) observes, a common focus in clinical studies. The third rationale for a case study research design is the *representative* or *typical case.* This is usually called an exemplifying case, as the case study mainly represents a typical project among many different projects, such as a service firm believed to be typical of many other service firms in the same industry, for example. In this kind of case, the objective is to capture the circumstances and conditions of an everyday or commonplace situation (Yin 2009). A fourth rationale for a case study research design is the *revelatory case.* The basis for the revelatory case exists when a researcher has an opportunity to observe and analyse a phenomenon previously inaccessible to scientific investigation. The

longitudinal case is the fifth rationale for a case study. Yin (2009) suggests that a case may be chosen because it affords the opportunity for studying the same case at two or more junctures.

Stake (2005) states that a case study should be selected based on the analysis of what can be learnt, are easy to complete and has willing informants. As a result, the problem to be researched in this study required the use of a case study.

2.7 STEPS IN THE RESEARCH PROCESS

The research process to be undertaken in this study included seven steps and is detailed as follows.

(i) Step 1: Define the nature of sustainable development within a sustainable city

To execute this step, a literature review was undertaken. The literary review distinguished the nature of sustainable city development within the context of the social, economic and environmental pillars of sustainability (World Summit, 2005).

(ii) Step 2: Determine the themes and associated interventions that should be addressed for a city to be defined as sustainable

To execute this step, a literature review was undertaken. The literature review was to distinguish the themes and associated interventions, and these were determined by addressing the following questions:

- What are the locational parameters of sustainable city development
- How the total consumption of water along with the dependence on large-scale water capture systems can be reduced
- How a community-based sanitation system for all income groups where sewerage is treated and re-used can be encouraged
- How densification, mixed land use and mixed income residential areas can be promoted
- How the use of private vehicles whilst simultaneously increasing the use of public transport can be reduced

- How the use of fossil fuel-based energy leading to a transition of energy provision that utilises a combination of solar, wind, micro-hydro and hydrogen power coupled with increased efficiencies can be reduced
- How food supplies from urban farms along with building local food retail markets can be increased
- How the separation at source of solid waste coupled with collection and recycling systems can be encouraged
- How to ensure that building materials and design are based on the assessment of the environmental and social impact
- How to reduce air pollution and CO^2 emissions from vehicles, utilities and homes
- How to instil a public health system that focuses on the provision of basic services
- How to increase biodiversity and recreational space
- How to enhance child-centred development and learning

Addressing these questions would assist in determining the themes and associated interventions necessary for a city to be sustainable.

(iii) Step 3: Define the acceptance of the themes and associated interventions of sustainable city development

The acceptance of the themes and associated interventions of sustainable city development were determined through an assessment on whether or not the future of the various components could be guaranteed with sufficiently high probability. This was undertaken by means of a literature review. Both a tangible and intangible perspective of the acceptance of the interventions in the investment decision were undertaken.

(iv) Step 4: Develop a hypothetical case of a sustainable city

A hypothetical sustainable city with set population parameters and growth trajectories was developed. Within the hypothetical city, the structuring elements of the city were described inclusive of these themes and associated interventions of sustainable city development. These themes were used as a basis for investment decisions such as the acceptability of interventions.

One intervention was utilised as a case study in determining the acceptability of stated tangible and intangible measures, the outcomes of which were appraised by means of interviews with sector specific specialists.

(v) Step 5: Complete the hypothetical case by populating all interventions resulting in an investment scenario

This was undertaken by means of an interpretive study. The acceptance of the themes and associated interventions of sustainable city development was determined through an assessment of scenario values against current sector specific values in the development of a city considering long-term sustainability objectives.

(vi) Step 6: Utilise the investment scenarios to determine the financing thereof

A financing 'basket of tools and instruments' was presented relevant to all themes and associated interventions of sustainable city development. This was undertaken by means of an interpretive study.

(vii) Step 7: Develop a model for the financing of sustainable cities

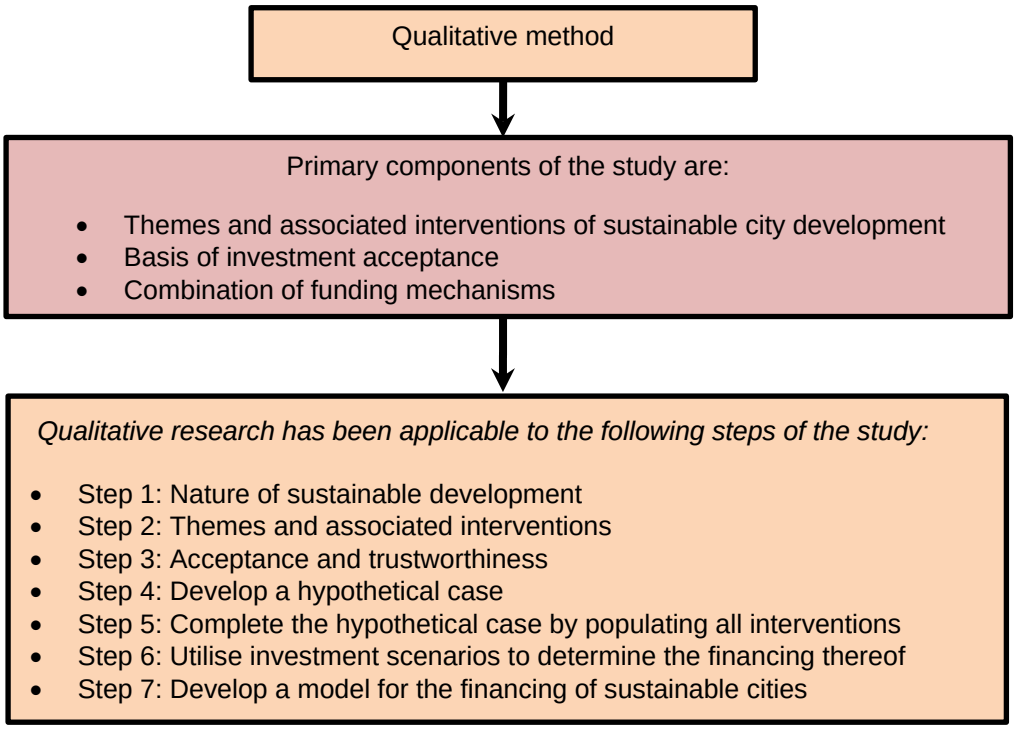
Based on the influencing factors, the tangible and intangible criteria along with the scale of intervention and the implications for funding instruments and tools, financing directives and alternatives per theme were applied resulting in a model for the financing of sustainable cities within the context of four applications. The first application related to how financing tools and instruments were applied across the varying stated themes and associated interventions of sustainable city development. The second application related to how financing tools and instruments were applied with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention or and enabling intervention. The third application related to how financing tools and instruments were applied with respect to application type in terms of either incentive, opportunity, punitive or mandatory interventions. The last application related to how financing tools and instruments were applied with respect to scale in terms of city-wide, sector-wide, urban or suburban application.

In addition to the four applications, an evaluation of how the application of financing tools and instruments related to the addressing of poverty within the city context would occur. In addition to these steps identified, the following were also undertaken in support of the research process:

- Ensuring the trustworthiness of the research: An audit trail complemented the research process
- Ensuring the reliability of the research: A review of the method of coding and the subsequent analysis of the data was performed by an external party to verify the appropriateness of the classifications
- Ensuring the ethical practice of the research: Ethical considerations are also of great concern for all researchers. As all the data used was secondary in nature and most were freely-available in the public domain, no ethical clearance needed to be obtained.

The qualitative research method relevant to each of the study's steps is further illustrated in Figure 2.2.

Figure 2.2: Qualitative research methodology



Source: Author's compilation

2.8 RESEARCH DESIGN OF THE STUDY

A hypothetical case for one intervention of sustainable city development was determined based on literature review and interpretive studies. The hypothetical case of the singular intervention was appraised by city development experts to verify the approach. The following sections describe this process.

2.8.1 Study Sample

The appraisal of tangible and intangibles measures, relevant to the singular intervention of sustainable city development as a basis of determining acceptability, occurred via the means of reviewer input. City development expert reviewers were used as independent reviewers to evaluate the tangible and intangible measures. The independent reviewers interviewed in this study included professionals within the realm of city planning and development, and ten reviewers were identified to provide insights into the hypothetical case. It should be noted that if saturation were achieved, less than ten reviews might be used.

2.8.2 Schedule to Collect Data

Appendix A depicts the interview schedule that was used in this study. Within the interview schedule, an introduction and background was presented to the interviewees to provide the study's context. The framework of the study was also presented along with how sustainability interventions, tangible measures and intangible measures would be utilised. In addition, the results of the case study were presented to the interviewees. The participants were then asked questions based on the hypothetical case. The questions posed revolved around comments on the hypothetical case and the measures used in it.

2.8.3 Data Collection

Data was collected by means of personal one-on-one interviews, which were personally conducted by the researcher along with the subsequent note-taking and recordings of the interview discussions. A week before the interviews, the participants were presented with a PowerPoint presentation showing the background, objectives, results of the study and also the questions to be answered. This enabled the participants to prepare themselves for the interview.

2.8.4 Data Analysis

Feedback received from participants was collectively collated into a table. Recorded responses included all responses and were not linked to a particular participant. The issues that were raised were addressed within the respective chapters of the study, which assisted in the population and analysis of the stated themes and associated interventions of sustainable city development.

2.8.5 Research Rigor and Ethics

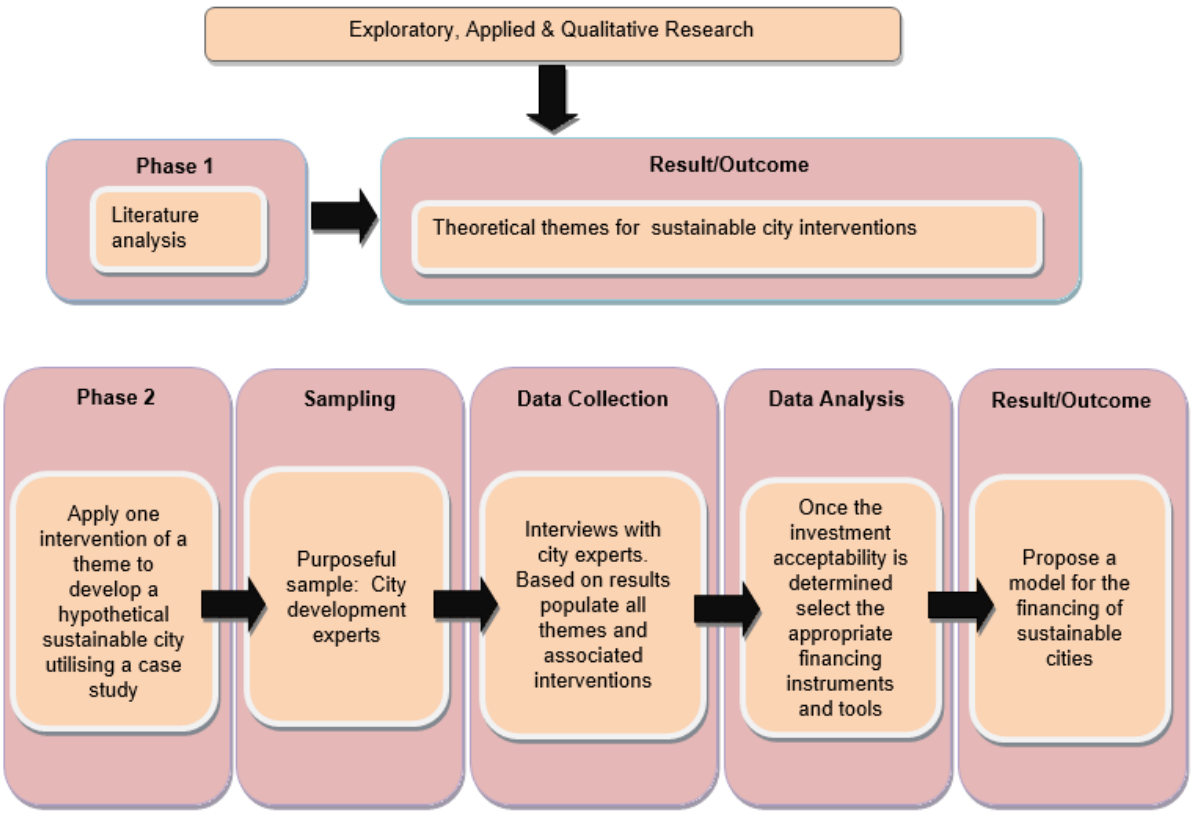
When data is collected through qualitative research methods, the question of quality and reliability is extremely important, as reliability is synonymous with consistency. Bryman and Bell (2007) as well as Easterby-Smith, Thorpe and Lowe (2006) propose that it is necessary to specify terms and ways of establishing and assessing the trustworthiness and reliability of qualitative research that provide an alternative to reliability and validity in quantitative research approaches. The two primary criteria for assessing a qualitative study are *trustworthiness* and *authenticity.*

Trustworthiness in qualitative studies comprises four criteria or tests, each of which has an equivalent criterion in quantitative research (Bryman & Bell, 2007).

- Credibility, which parallels internal validity
- Transferability, which parallels external validity
- Data dependability, which parallels reliability
- Confirmability, which parallels objectivity

Figure 2.3 depicts the graphic representation of the steps followed in the qualitative research design process.

Figure 2.3: Qualitative research design process



Source: Author's own compilation

As depicted in Figure 2.3, the qualitative research design process of the study encompassed a literature analysis coupled with the relevant case study approach in determining the ultimate proposed model for the financing of sustainable cities.

2.9 SUMMARY

In Chapter 2, the research process and methodology of the study was outlined. A qualitative research design was followed based on a case study approach. The hypothetical case was developed and experts were interviewed to confirm the parameters used in the hypothetical case. In Chapter 3, the nature of sustainable city development is discussed in which the themes and associated interventions of sustainable city development are defined.

CHAPTER THREE

THE NATURE OF A SUSTAINABLE CITY DEVELOPMENT

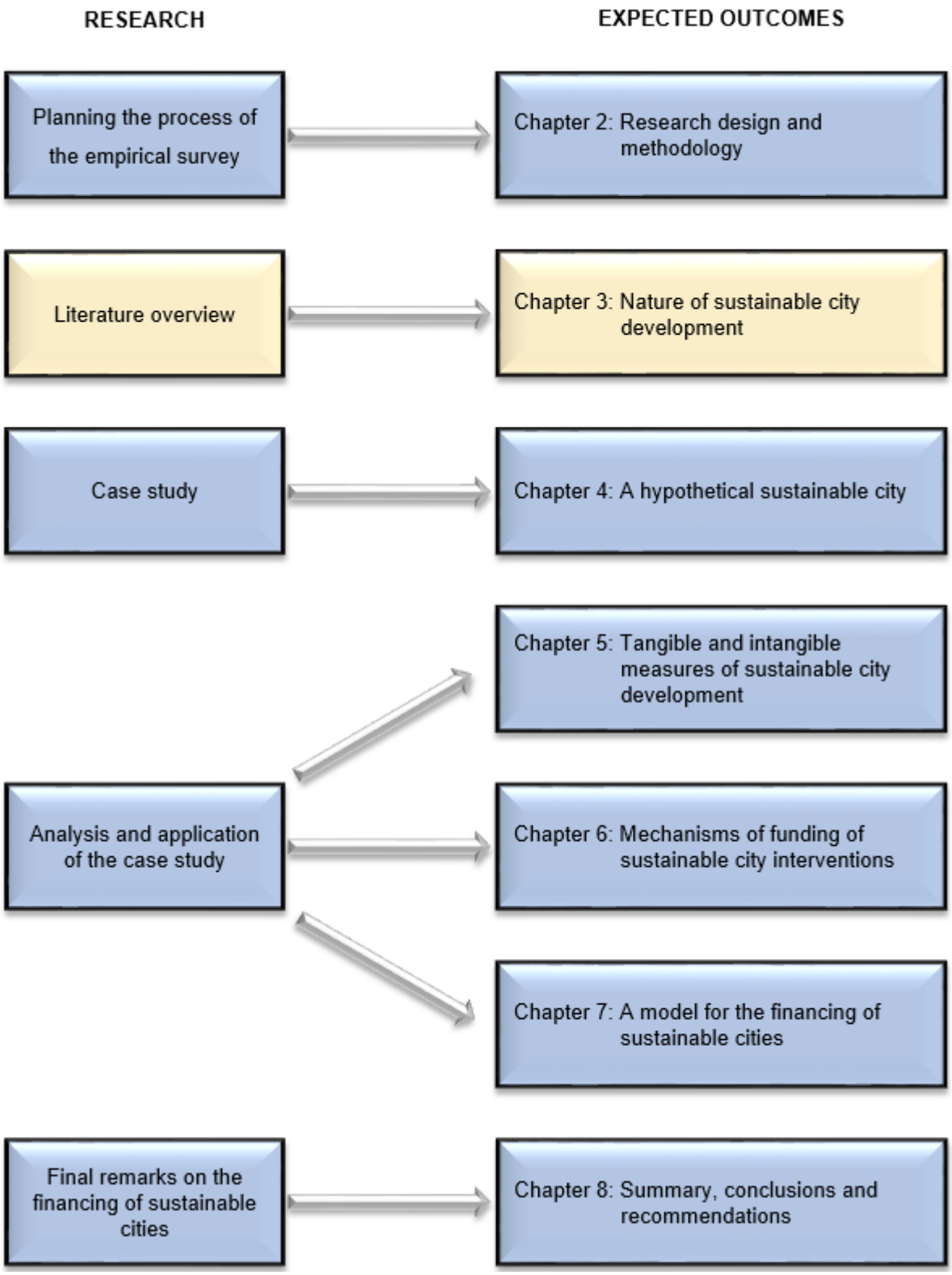
3.1 INTRODUCTION

In Chapter 2, the research methodology to be followed in this study was outlined. As the primary objective of this study is to investigate various funding mechanisms for sustainable city development so that a model for the financing of sustainable cities can be designed, it is important, firstly, to define the nature of sustainable development within a city. Once the nature of sustainable development within a city is defined, the themes and associated interventions that need to be addressed to define a city as sustainable need to be defined and elaborated upon. As such, this chapter defines the nature of sustainable development relevant to the city context along with detailing the themes and associated interventions of sustainable city development.

3.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 3.1.

Figure 3.1: Study framework



Source: Author's own compilation

As depicted in Figure 3.1, this study is comprised of eight chapters, andChapter 3 relates to the literature overview in relation to the nature of sustainable city development.

3.3 THE NATURE OF SUSTAINABLE CITY DEVELOPMENT

Although there are varying definitions to define a sustainable city, most definitions include a number of principles. Table 3.1 illustrates, according to varying sources, the varying principles of sustainable city development.

Table 3.1: Varying principles of city sustainability

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY
Deb (2010)	Sustainability is dependent on parameters which change roles as per regional parameters. Within these variable parameters are functions which support growth and functions, which follow the dynamics of growth, perception, aspirations and socio-cultural changes.
Stilwell (2000)	Although sustainable cities may be pursued through focussing on the economic, social and ecological dimensions of sustainability along with pursuing options for the restructuring of urban and regional development, impediments to change will continue to exist. Stilwell (2000) states that the primary impediments to change revolve around the reluctance of societies to trade-off income levels against environmental quality which is fundamentally based on the institutions of capitalism which have a vested interest in profits at the expense of social and environmental concerns
Portney (2001)	Cities that require sustainability interventions the most, with respect to pollution control, for example, are the least likely to initiate such programmes. As a city's manufacturing base declines, sustainability initiatives become increasingly more feasible. As the populations of cities age, sustainability programmes are more easily adopted.
Swilling (2005)	The sustainability challenge exists in reconciling development within a limit to growth mentality ensuring that developing countries do not replicate unsustainable systems as within the developed world.

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY
Allen (2009)	Allen (2009) suggests that although sustainable city development has in the past been described as the intersection between social, environmental and economic goals, the resultant balancing act between the three components has negated any real change in the form of sustainable development owing to a lack of understanding in the inherent trade-offs found in the simultaneous pursuit of the social, environmental and economic goals.
Choon, Siwar, Pereira, Jemain, Hashim and Hadi (2011)	Considering the inter-relation of city systems, Choon *et al.* (2011) advocate that a sustainable city should be measured in terms of the fulfilment of human and environmental well-being as the socio-economic condition of a city is closely-related to its inhabitants whilst a city's quality of life affects its socio-economic level.
United Nations (2013)	Achieving the sustainability of cities further requires the integration of the social development, economic development, environmental management and urban governance.

Source: Author's own compilation

A further elaboration on the varying principles of a sustainable city as depicted in Table 3.1 is provided by the authors.

Deb (2010) states that global parameters for sustainable human settlements are impossible given the different characteristics of various societies within various settlements. As such, sustainability is dependent on parameters which change roles as per regional parameters. Within these variable parameters are functions which support growth and functions, which follow the dynamics of growth, perception, aspirations and socio-cultural changes. These relate to issues of city policy, management, operation, regulation, performance, finance and education (Deb 2010).

As Stilwell (2000) argues, identifying what a sustainable city entails is troublesome. As such, Stilwell (2000) seeks to explore the concept of sustainable cities by:

- Scrutinising the economic, social and ecological dimensions of sustainability
- Highlighting options for the restructuring of urban and regional development
- Analysing impediments to change

In scrutinising the economic, social and ecological dimensions of sustainability, Stilwell (2000) expresses the following with respect to the dimensions of sustainability:

- Economic sustainability: Goods and services are produced through resources that can be indefinitely reproduced
- Social sustainability: Equitable social structures and relationships are maintained through changes driven in part by structural economic conditions
- Ecological sustainability: Includes the maintenance of biodiversity, ecological integrity and intergenerational equity

For Stilwell (2000), options for the restructuring and urban and regional development include:

- Space: Equitable patterns of urban development are required to ensure economic, social and ecological equity
- Transport: Urban transport systems need to favour public transport as opposed to private vehicle usage
- Land-use planning: Land-use planning should seek to discourage urban sprawl
- Housing: Housing forms should encourage minimal demand on scarce energy resources
- Infrastructure: Access to infrastructure, be it in the form of educational, water, sanitation and other community purposes, should be provided on a scale appropriate to local needs
- Redistribution of work: Work opportunities should be distributed across areas of varying income levels
- Redistribution of income: Respective economies should be restructured to aim for economic equality amongst communities

Although sustainable cities may be pursued through focussing on the economic, social and ecological dimensions of sustainability along with pursuing options for the restructuring of urban and regional development, impediments to change will continue to exist. Stilwell (2000) states that the primary impediments to change revolve around the reluctance of societies to trade-off income levels against environmental quality which is fundamentally based on the institutions of capitalism, which have a vested interest in profits at the expense of social and environmental concerns. As such, the

commodification of society and nature, results in the antithesis of sustainability principles (Stilwell, 2000).

Portney (2001) assesses the sustainability of cities through the respective policies, programmes and activities of cities. For Portney (2001), the respective categories and sub-categories of these policies, programmes and activities include:

- Measuring the sustainability of a city with respect to benchmarks, goals and timelines for improvements also known as a sustainability indicator programme
- Adopting smart growth policies or programmes inclusive of:
  - Eco-industrial park development
  - Cluster or targeted economic development
  - Eco-village project or programme
  - Brownfield redevelopment
- Implementing land-use planning programmes, policies and zoning inclusive of:
  - Operation of public transit (buses and / or trains)
  - Limits on downtown parking spaces
  - Car pool lanes
  - Alternatively-fuelled city vehicle programmes
  - Bicycle ridership programmes
- Pollution prevention and reduction efforts inclusive of:
  - Household solid waste recycling
  - Industrial recycling
  - Hazardous waste recycling
  - Air pollution reduction programmes
  - Recycled product purchasing by city government
  - Superfund site remediation
  - Asbestos abatement programmes
  - Lead paint abatement programmes
- Energy and resource conservation / efficiency initiatives inclusive of:
  - Green building programmes
  - Renewable energy use by city government
  - Energy conservation efforts
  - Alternative energy offered to consumers

  - Water conservation programmes
- Improved organisation / administration / management / coordination / governance of the city inclusive of:
  - Single government / non-profit agency responsible for implementing sustainability
  - Integration into a city-wide comprehensive plan
  - Involvement of city / country / metropolitan council
  - Involvement of mayor or chief executive officer
  - Involvement of the business community
  - General public involvement in sustainable cities initiative

In assessing the sustainability of cities through the various categories as listed above, Portney (2001) concludes that future sustainable cities are largely influenced by the following:

- Cities that require sustainability interventions the most, with respect to pollution control, for example, are the least likely to initiate such programmes
- As a city's manufacturing base declines, sustainability initiatives become increasingly more feasible
- As the populations of cities age sustainability programmes are more easily adopted

Future city development, given increased population growth and the associated need to eradicate poverty, is an inevitable occurrence within the South African context. However, as Swilling (2005) argues, the challenge exists in reconciling development within a limit to growth mentality ensuring that developing countries do not replicate unsustainable systems as within the developed world. As cities continue to grow, increased demands on water, energy, food, land and building material provision will continue unabated producing unprecedented quantities of waste. In addition, cities previously constructed in South Africa were built on the assumption that there was cheap coal-based energy, unlimited supplies of water, low fuel costs, unlimited provision to cater for the disposal of waste and unlimited supplies of land (Swilling, 2005). These assumptions cannot apply to modern day South Africa. As such Swilling (2005) states that the following issues need to be addressed to ensure that future

development occurs in a sustainable manner, thereby integrating equity and urban economic growth. The issues that need to be addressed include:

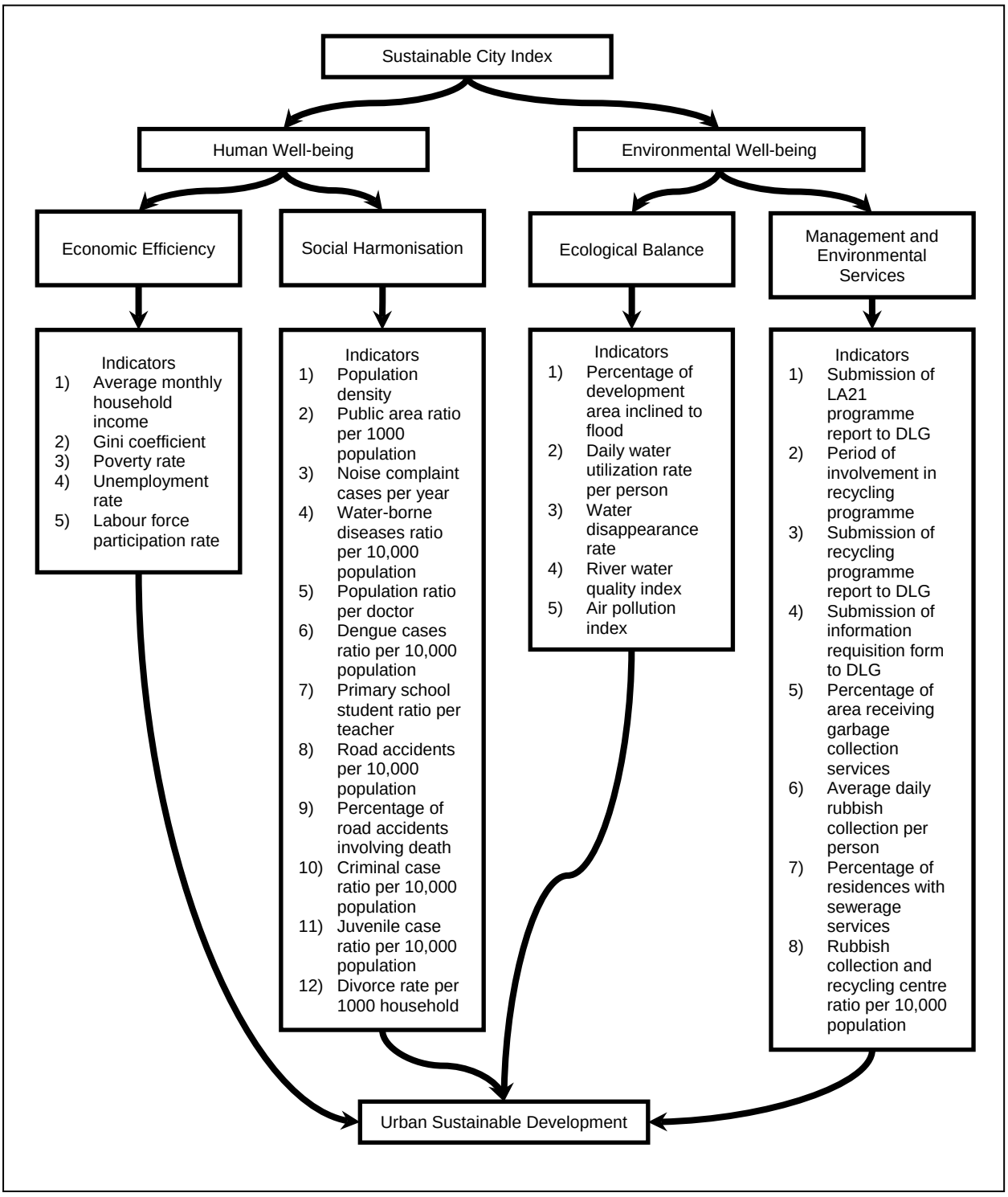
- Reducing the total consumption of water along with the dependence on large-scale water capture systems
- Encouraging a community based sanitation system for all income groups where sewerage is treated and re-used
- Promoting densification, mixed land use and mixed income residential areas
- Reducing the use of private vehicles whilst simultaneously increasing the use of public transport
- Reducing the use of fossil fuel-based energy leading to a transition of energy provision that utilises a combination of solar, wind, micro-hydro and hydrogen power coupled with increased efficiencies
- Increasing food supplies from urban farms along with building local food retail markets
- Promoting the separation at source of solid waste coupled with collection and recycling systems
- Ensuring that building materials and design are based on the assessment of the environmental and social impact
- Reducing air pollution and CO^2 emissions from vehicles, utilities and homes
- Ensuring a public health system that focuses on the provision of basic services
- Increasing biodiversity and recreational space
- Enhancing child-centred development and learning

Allen (2009) suggests that although sustainable city development has in the past been described as the intersection between social, environmental and economic goals, the resultant balancing act between the three components has negated any real change in the form of sustainable development owing to a lack of understanding in the inherent trade-offs found in the simultaneous pursuit of the social, environmental and economic goals. Allen (2009) further states that cities are inherently unsustainable as economic activities within a city inevitably depend on environmental resources from outside the city. As such, although one should still apply the principles of social, environmental and economic goals in defining sustainable city development, the built environment needs to be recognised as the central component in defining city sustainability along

with the political / institutional decision-making mechanisms which could seek to promote the cooperation of various sustainability agents (Allen, 2009).

Choon *et al.* (2011) sought to define a sustainable city, within the Malaysian context, in the form of a sustainable city index. Considering the inter-relation of city systems, Choon *et al*. (2011) advocate that a sustainable city should be measured in terms of the fulfilment of human and environmental well-being as the socio-economic condition of a city is closely-related to its inhabitants whilst a city's quality of life affects its socio-economic level. Furthermore, the environmental status of a city is always related to its ecological support and environmental management. The focus of human and environmental well-being in defining city sustainability is illustrated by Figure 3.2.

Figure 3.2: Framework of a sustainable city index



Source: Choon *et al.* (2011)

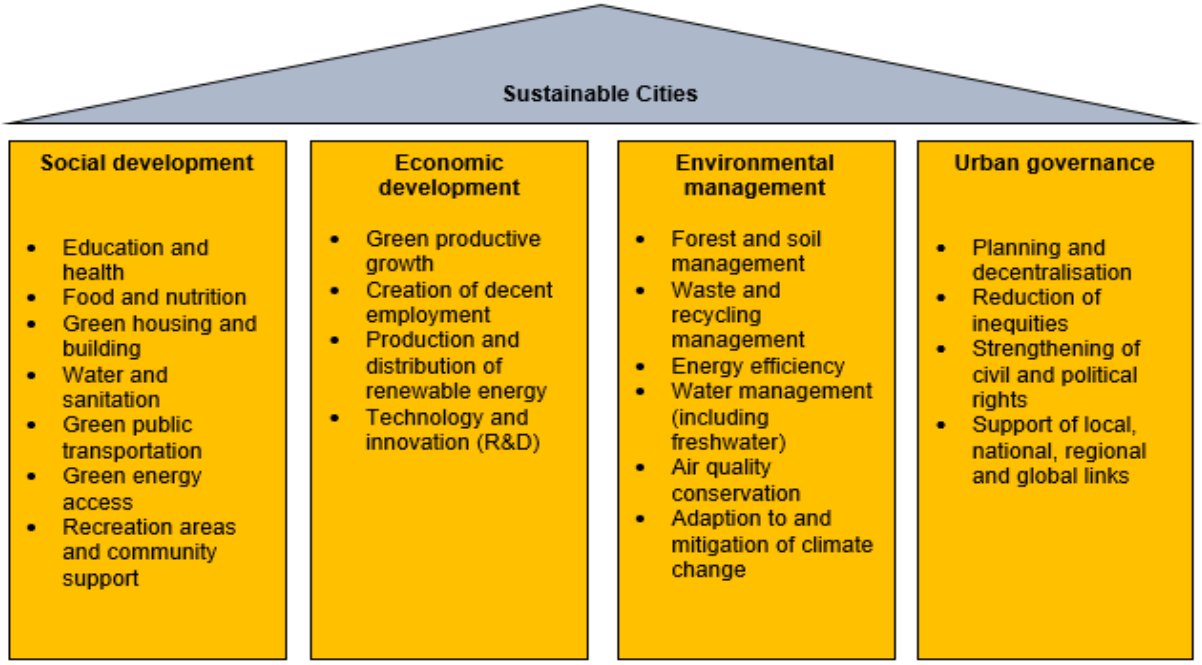
As illustrated in Figure 3.2, Choon *et al*., (2011) define city sustainability from the perspective of human and environmental well-being. Contained within the element of human well-being are aspects with regards to economic efficiency and social harmonisation, whilst within the environmental well-being component are aspects relating to ecological balance and management and environmental services.

According to the United Nations (2013), the development of sustainable cities requires investment in the following:

- Renewable energy sources
- Efficiency in the use of water and electricity
- Retrofitting of buildings along with an increase in green areas
- Reliable public transportation
- Improved waste and recycling systems

Achieving the sustainability of cities further requires the integration of the social development, economic development, environmental management and urban governance as depicted in Figure 3.3 (United Nations, 2013).

Figure 3.3: Pillars for achieving sustainability of cities



Source: United Nations (2013)

As illustrated in Figure 3.3, the four pillars which comprise sustainable cities are further broken down into various sub-components.

A summary of the varying principles of sustainable city development along with the associated sub-components of those respective principles are depicted in Table 3.2. As illustrated in Table 3.2, the dimensions of social, economic and environmental sustainability are inherently contained within each principle of city sustainability along with urban governance as a consolidating factor in striving for city sustainability. These are represented by the following coding:

- Social sustainability:
- Economic sustainability:
- Environmental sustainability:
- Urban governance:

Table 3.2: Summary of principles and sub-components of sustainable city development

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
Deb (2010)	Sustainability is dependent on parameters which change roles as per regional parameters. Within these variable parameters are functions which support growth and functions which follow the dynamics of growth, perception, aspirations and socio-cultural changes.	City policy
		Management
		Operation
		Regulation
		Performance
		Finance
		Education
Stilwell (2000)	Although sustainable cities may be pursued through focussing on the economic, social and ecological dimensions of sustainability along with pursuing options for the restructuring of urban and regional development, impediments to change will	Space
		Transport
		Land use planning

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
	continue to exist. Stilwell (2000) states that the primary impediments to change revolve around the reluctance of societies to trade-off income levels against environmental quality which is fundamentally based on the institutions of capitalism which have a vested interest in profits at the expense of social and environmental concerns	Housing
		Infrastructure
		Redistribution of work
		Redistribution of income
Portney (2001)	Cities that require sustainability interventions the most, with respect to pollution control, for example, are the least likely to initiate such programmes. As a city's manufacturing base declines, sustainability initiatives become increasingly more feasible. As the populations of cities age, sustainability programmes more are easily adopted.	Measuring the sustainability of a city with respect to benchmarks, goals and timelines for improvements also known as a sustainability indicator programme
		Adopting smart growth policies or programmes inclusive of: • Eco-industrial park development • Cluster or targeted economic development • Eco-village project or programme • Brownfield redevelopment
		Implementing land-use planning programmes, policies and zoning inclusive of: • Operation of public transit (buses and / or trains) • Limits on downtown parking spaces • Car pool lanes • Alternatively fuelled city vehicle programmes • Bicycle ridership programmes

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
		Pollution prevention and reduction efforts inclusive of: • Household solid waste recycling • Industrial recycling • Hazardous waste recycling • Air pollution reduction programmes • Recycled product purchasing by city government • Superfund site remediation • Asbestos abatement programmes • Lead paint abatement programmes
		Energy and resource conservation / efficiency initiatives inclusive of: • Green building programmes • Renewable energy use by city government • Energy conservation efforts • Alternative energy offered to consumers • Water conservation programmes
		Improved organisation / administration / management / coordination / governance of the city inclusive of: • Single government / non-profit agency responsible for implementing sustainability • Integration into a city-wide comprehensive plan • Involvement of city / country / metropolitan council • Involvement of mayor or chief executive officer

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
		• Involvement of the business community • General public involvement in sustainable cities initiative
Swilling (2005)	The sustainability challenge exists in reconciling development within a limit to growth mentality, ensuring that developing countries do not replicate unsustainable systems as within the developed world.	Reducing the total consumption of water along with the dependence on large-scale water capture systems.
		Encouraging a community-based sanitation system for all income groups where sewerage is treated and re-used
		Promoting densification, mixed land use and mixed income residential areas
		Reducing the use of private vehicles whilst simultaneously increasing the use of public transport
		Reducing the use of fossil fuel-based energy leading to a transition of energy provision that utilises a combination of solar, wind, micro-hydro and hydrogen power coupled with increased efficiencies
		Increasing food supplies from urban farms along with building local food retail markets
		Promoting the separation at source of solid waste coupled with collection and recycling systems
		Ensuring that building materials and design are based on the assessment of the environmental and social impact
		Reducing air pollution and CO^2 emissions from vehicles, utilities and homes

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
		Ensuring a public health system that focuses on the provision of basic services
		Increasing biodiversity and recreational space
		Enhancing child-centred development and learning
Allen (2009)	Allen (2009) suggests that although sustainable city development has in the past been described as the intersection between social, environmental and economic goals, the resultant balancing act between the three components has negated any real change in the form of sustainable development owing to a lack of understanding in the inherent trade-offs found in the simultaneous pursuit of the social, environmental and economic goals	Social dimension
		Economic dimension
		Environmental dimension
		Built environment dimension
		Political / institutional dimension
Choon *et al.* (2011)	Considering the inter-relation of city systems, Choon *et al.* (2011) advocate that a sustainable city should be measured in terms of the fulfilment of human and environmental well-being as the socio-economic condition of a city is closely-related to its inhabitants whilst a city's quality of life affects its socio-economic level	Economic efficiency: • Average monthly household income • Gini coefficient • Poverty rate • Unemployment rate • Labour force participation rate
		Social harmonisation: • Population density • Public area ratio per 1000 population • Noise complaint cases per year

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
		• Water-borne diseases ratio per 10,000 population • Population ratio per doctor • Dengue cases ratio per 10,000 population • Primary school student ratio per teacher • Road accidents per 10,000 population • Percentage of road accidents involving death • Criminal case ratio per 10,000 population • Juvenile case ratio per 10,000 population • Divorce rate per 1000 household
		Ecological balance: • Percentage of development area inclined to flood • Daily water utilization rate per person • Water disappearance rate • River water quality index • Air pollution index
		Management and environmental services: • Submission of LA21 programme report to DLG • Period of involvement in recycling programme • Submission of recycling programme report to DLG • Submission of information requisition form to DLG • Percentage of area receiving garbage collection services

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
		• Average daily rubbish collection per person • Percentage of residences with sewerage services • Rubbish collection and recycling centre ratio per 10,000 population
United Nations (2013)	Achieving the sustainability of cities further requires the integration of the social development, economic development, environmental management and urban governance.	Social development: • Education and health • Food and nutrition • Green housing and building • Water and sanitation • Green public transportation • Green energy access • Recreation areas and community support
		Economic development: • Green productive growth • Creation of decent employment • Production and distribution of renewable energy • Technology and innovation (R&D)
		Environmental management: • Forest and soil management • Waste and recycling management • Energy efficiency • Water management (including freshwater) • Air quality conservation • Adaption to and mitigation of climate change
		Urban governance:

SOURCE	PRINCIPLE OF CITY SUSTAINABILITY	SUB-COMPONENTS OF CITY SUSTAINABILITY
		• Planning and decentralisation • Reduction of inequities • Strengthening of civil and political rights • Support of local, national, regional and global links

Source: Author's own compilation

Based on the varying sub-components as depicted in Table 3.2, the following deductions can be made with respect city sustainability:

- Social, economic and environmental dimensions of sustainability are inherently contained within each principle of city sustainability as presented in Table 3.2 by the following colour coding:
  - Social sustainability:
  - Economic sustainability:
  - Environmental sustainability:
- Social, economic and environmental dimensions of sustainability, along with the components within those dimensions, are not exhaustive;
- City sustainability, in addition to the social, economic and environmental dimensions of sustainability, is dependent on:
  - Trade-offs between varying social, economic and environmental aspects of sustainability
  - Appropriate management / urban governance is the consolidating factor in striving for city sustainability as presented in Table 3.2 by the following colour coding:
  - Locational characteristics influence the nature of sustainability interventions
  - Growth needs to be reconciled within developmental limitations

The financing or investment in sustainability interventions within a city context, through the application of varying tools and instruments, need, as such, to occur within the realms of urban governance, inter-dimensional trade-offs, locational characteristics and developmental limitations.

As such, for the purposes of this study, the components of city sustainability entailed:

- Trade-offs between the social, environmental and economic dimensions of sustainability
- Efficient urban governance
- Recognising locational characteristics
- Growth reconciled within development limitations

These components related directly to the social, environmental and urban governance issues of city sustainability. The principle of economic sustainability was encapsulated in the approach of this study, which was primarily based on the following factors:

- That future development, within a South African context, occurred in a sustainable manner
- That a sound basis of investment existed for future development as a precursor for future sustainable development
- That financing future sustainable cities recognised the convergence the multiple visions of sustainable development, from the built and natural environment perspective through to the concept of social equity
- That a combination of financing mechanisms to fund future sustainable cities might be possible given the multiple visions of sustainable development from the built environment perspective through to the concept of social equity

Although future sustainable city development might be directed by ensuring trade-offs between the social, environmental and economic dimensions of sustainability, efficient urban governance, recognising locational characteristics and reconciling growth within developmental limitations, a foundation for viability was required to ensure an adequate basis of investment existed for future development as a precursor for future sustainable development. In summary, envisaged financial strategies for the various components of sustainable city development could only be implemented if the investment criteria proved to be acceptable. Broadly-speaking, the basis of investment is for a city to re-invent itself through six key strategy areas, as defined by the US Department of Housing and Development (2013). These include:

- Building the middle class
- Integrating newly-arriving communities and addressing racial disparities
- Leveraging public resources and assets for private investment
- Linking the city to the regional and national economy
- Building and sustaining leadership and partnerships
- Fostering state level policy reform

In summary, for the purposes of this study, the nature of a sustainable city was defined, as:

- Recognising trade-offs between the social, environmental and economic dimensions of sustainability
- Ensuring efficient urban governance
- Recognising locational characteristics

These elements of a sustainable city were underpinned by acceptability directives to ensure an adequate basis of investment existed for future development as a precursor for future sustainable development. Within the four components of a sustainable city were common themes from which an adequate basis of investment for future development could be determined. These included:

- Location
- Water
- Sanitation
- Compact cities
- Public transport
- Energy
- Urban agriculture
- Solid waste
- Green buildings
- Air pollution
- Public health
- Biodiversity
- Child-centred development

The discussion of the respective themes follows within the subsequent sub-sections.

3.4 LOCATION

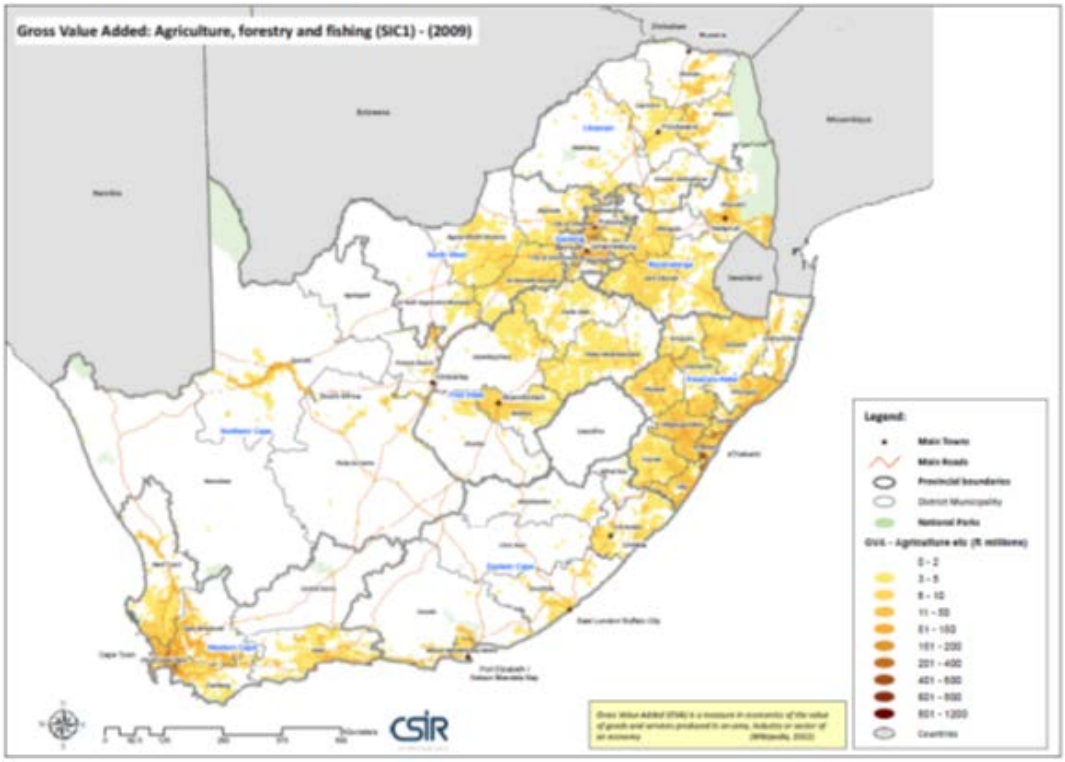
In the instance of linking the city to the regional and national economy, a link could be made between assessing future spatial development and the economy as undertaken by the CSIR through their Geospatial Analysis Platform (GAP) as reviewed in 2011. This basis of investment, therefore, influences future financing directives.

In summary, the GAP seeks to articulate a set of spatial priorities and criteria as one of the mechanisms to inform and co-ordinate planning and investment. This is done by demarcating South Africa into 25,000 mesozones, each approximately 50km² in size.

These mesozones contain information relating to levels of human activity and linkages to a strategic national road network where spatial interaction modelling is used to calculate a range of accessibility and proximity measures. The outcome is an enhanced understanding of human / economic geography and the associated interactions within the built and national environment along with profiling local development magnitudes such as needs, potentials, service and economic accessibility levels.

A typical example of the GAP application is depicted in Figure 3.4, which indicates the spatial distribution of economic activity, relevant to the agriculture, fishing and forestry sector, represented by Gross Value Addition (GVA).

Figure 3.4: Gross Value Addition- Agriculture, forestry and fishing, South Africa (2009)



Source: CSIR (2009)

As depicted by Figure 3.4, volumes of economic activity can be gauged relevant to certain sectors of GVA along with overall GVA. Furthermore, one is able to derive indicators such as demands on infrastructure and ecosystem services thereby providing a basis of investment which should influence future financing directives.

3.5 WATER

According to the OECD (2009), there are diseconomies of scale attached to large-scale municipal systems for supplying water owing to the high costs of water transport and network maintenance primarily. Reuse of water can, however, be organised at different scales. Furthermore, alternative water systems can reuse water for a variety of uses and can be based on decentralised infrastructures producing water where it is consumed.

OECD (2009) states that the current predominant mechanisms of water supply and sanitation is based on piped water supply and water-borne sewerage treatment

occurring within a centralised system, which is neither sustainable, economically feasible nor environmentally or socially desirable. An alternative approach to water supply seeks a scale change where water supply and sanitation at alternative scales can increase cost effectiveness of water services, increase revenues and introduce new models to meet capital needs.

Alternative mechanisms of supplying water include rainwater harvesting, the utilisation of grey water along with the utilisation of reclaimed water. An illustration on the distinction between centralised and non-centralised infrastructure with regard to the supply of water is depicted in Table 3.3.

Table 3.3: Distinction between centralised and decentralised infrastructure in the supply of water

	FRESHWATER ONLY	ALTERNATIVE SOURCES OF WATER
Central infrastructure	Single quality water is provided by central infrastructures. Waterborne sewerage is centrally-collected and treated in a plant usually located at the outskirts of the urban area	Treated or untreated rain and grey water is sent back to the city where it is used again. The system requires an additional network and energy is used to transport wastewater and reclaimed water.
Decentralised infrastructure	Relies on point of use resources (wells). Connections to central infrastructure may be needed to ensure reliable sourcing.	Water is produced and treated locally (on the point of use). Treated or untreated rain and grey water is used for (usually non-potable) uses.

Source: OECD (2009)

Centralised and decentralised systems of infrastructure not mutually exclusive. As such degrees of decentralisation should be encouraged whilst recognising that a combination of the two approaches is required.

In considering the cost effectiveness of alternative water systems, OECD (2009) states that there is no simple universal cost ranking which can be applied to both centralised

and decentralised systems. Rather contextual features such as favourable location and situation dictate the cost effectiveness of both centralised and decentralised systems. There will, however, be advantage in reducing centralised costs with respect to pipelines and pumping that transport water over large distances hence diseconomies of scale within urban areas.

Potential options with respect to financing decentralised water services include a land value increment specifically-related to the increase in land value owing to the provision of water services (OECD, 2009). This, however, would have more relevance in undeveloped areas as opposed to developed areas. The potential for investment in decentralised systems does, however, exist when schemes are encouraged for single family or multi-family complexes (OECD, 2009).

The applicability of a relevant scheme or system, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant scheme.

3.6 SANITATION

As with water capture systems, centralised and decentralised forms of sanitation systems should be promoted in recognising that a combination of the two approaches is required. Investing in decentralised community-based sanitation systems should necessarily be viewed as an intervention to serve poor or densely-populated communities, but also as a principle of intervention that can contribute to the sustainability of city infrastructure development.

A community-based sanitation system seeks a holistic approach in improving hygiene behaviour and sanitation infrastructure in a more integrated and sustainable manner (Community Based Sanitation, 2015). According to Community Based Sanitation (2015), a community-based sanitation approach seeks to address a gap between inappropriate on-site sanitation, typically associated with low-income communities, and the shortcomings of expensive conventional centralised sewerage collection and treatment systems. Furthermore, a community-based sanitation scheme seeks to ensure that communities assess their own informed demand and are encouraged to organise the operation and maintenance of the sanitation infrastructure.

Key to community-based sanitation schemes is the participation of target communities along with the involvement of the applicable municipality. Community Based Sanitation (2015) stipulate that there are two primary forms of community based sanitation schemes, namely:

- A provider managed community-based sanitation scheme where initial investment costs for sanitation infrastructure is financed by public or private development agencies. The implementation of the scheme is undertaken by a qualified agency. The subsequent operation and maintenance thereof is undertaken by a service provider agency such as a qualified NGO
- A community managed community-based sanitation scheme where initial investment costs are financed by public or private development agencies but where the implementation thereof involves the active participation of the community along with the subsequent management thereof

Key to both schemes is the contribution of user fees to cover maintenance and operation costs (Community Based Sanitation, 2015).

According to Community Based Sanitation (2015), three types of water-based community-based sanitation systems have preference. These include:

- Simplified sewerage systems for settlements where low diameter sewerage systems collect and discharge household wastewater from residences into low maintenance wastewater treatment plants
- Shared septic tank system where a number of residents connect into one septic tank
- Community sanitation centres where public water points, toilets, bathrooms and laundry areas are provided in which the majority of residents reside in rented accommodation and where space is limited for in-house sanitary hardware

Coupled with the relevant community-based sanitation scheme are appropriate sludge stabilisation and treatment plants. The appropriate disposal of sludges accumulated in small scale wastewater treatment systems needs to occur within one to two years intervals (Community Based Sanitation, 2015). As such, the on-site treatment of digested sludge may be viable where sufficient area is available for dewatering or

composting or alternatively local authorities embarking on the large-scale implementation of community-based sanitation schemes with integrated small wastewater treatment facilities that should cater for sludge treatment facilities simultaneously with that of a community-based sanitation scheme (Community Based Sanitation, 2015).

The reuse of wastewater through environmentally-sound technologies can protect the environment along with utilising resources in a more sustainable manner. Wastewater reuse can further result in reduced water consumption and treatment needs within urban areas. As such, in order to optimise water use and cost reduction potential, one needs to analyse the quality and quantity of wastewater against potential reuse applications and water quality requirements (UNEP, 2005). Wastewater reuse can be applied for agricultural, industrial, groundwater recharge and potable water supply purposes (UNEP, 2005).

The reuse of wastewater entails the treatment of wastewater as per the following three categories (UNEP, 2005):

- Physical process: Impurities are removed physically by screening, sedimentation, filtration, flotation, absorption or adsorption or both and centrifugation
- Chemical process: Impurities are removed chemically through coagulation, absorption, oxidation reduction, disinfection and ion-exchange
- Biological process: Pollutants are removed using biological mechanisms such as aerobic treatment, anaerobic treatment and photosynthetic process (oxidation pond)

A summary of the wastewater treatment process and their associated purposes are illustrated in Table 3.4.

Table 3.4: Wastewater treatment process and their associated purposes

	PRELIMINARY	PRIMARY	SECONDARY	TERTIARY AND ADVANCED
Purpose	Removal of large solids and grit particles	Removal of suspended solids	Biological treatment and removal of common biodegradable organic pollutants	Removal of specific pollutants such as nitrogen or phosphorous, colour and odour
Sample technologies	Screening, settling	Screening, sedimentation	Percolating / trickling filter, activated sludge, anaerobic treatment, waste stabilisation (oxidation pond)	Sand filtration, membrane bioreactor, reverse osmosis, ozone treatment, chemical coagulation, activated carbon

Source: UNEP (2005)

Considering the potential treatment process listed in Table 3.4, potential reuse applications thereof are illustrated in Table 3.5.

Table 3.5: Categories of wastewater reuse

CATEGORY OF REUSE	EXAMPLES OF APPLICATIONS
Urban use	
• Unrestricted	Landscape irrigation of parks, playgrounds, school yards, gold courses, cemeteries, residential, green belts
• Restricted	Irrigation of areas with infrequent and controlled access
• Other	Fire protection, disaster preparedness, construction
Agricultural	
• Food crops	Irrigation for food crops grown for human consumption
• Non-food crops and crops consumed after processing	Irrigation for fodder, fibre, flowers, seed crops, pastures, commercial nurseries, sod farms

CATEGORY OF REUSE	EXAMPLES OF APPLICATIONS
Recreational use • Unrestricted • Restricted	 No limitation on body contact: Lakes and ponds used for swimming Fishing, boating and other non-contact recreational activities
Environmental enhancement	Artificial wetlands creation, natural wetland enhancement, stream flow
Groundwater recharge	Groundwater replenishment for potable water, salt water intrusion control, subsidence control
Industrial reuse	Cooling system water, process water, boiler feed water, toilets, laundry, construction wash down water, air conditioning
Residential use	Cleaning, laundry, toilet, air conditioning
Potable reuse	Blending with municipal water supply, pipe to pipe supply

Source: UNEP (2005)

Table 3.5 illustrates the potential categories of wastewater reuse. Practices of wastewater reuse are dependent on target applications and technology which is, in turn, dependent on the socio-economic circumstances of the location in which wastewater reuse is applied.

The applicability of a relevant scheme or system, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant scheme.

3.7 COMPACT CITIES

Maximising the densification and compaction of a city and, by implication, harnessing mixed land use and mixed income residential areas, has a direct impact on infrastructure systems, capacities, infrastructure thresholds along with infrastructure costs. The consequence of such is that the increased density of a city, its future growth and hence its future sustainability are inherently integrated.

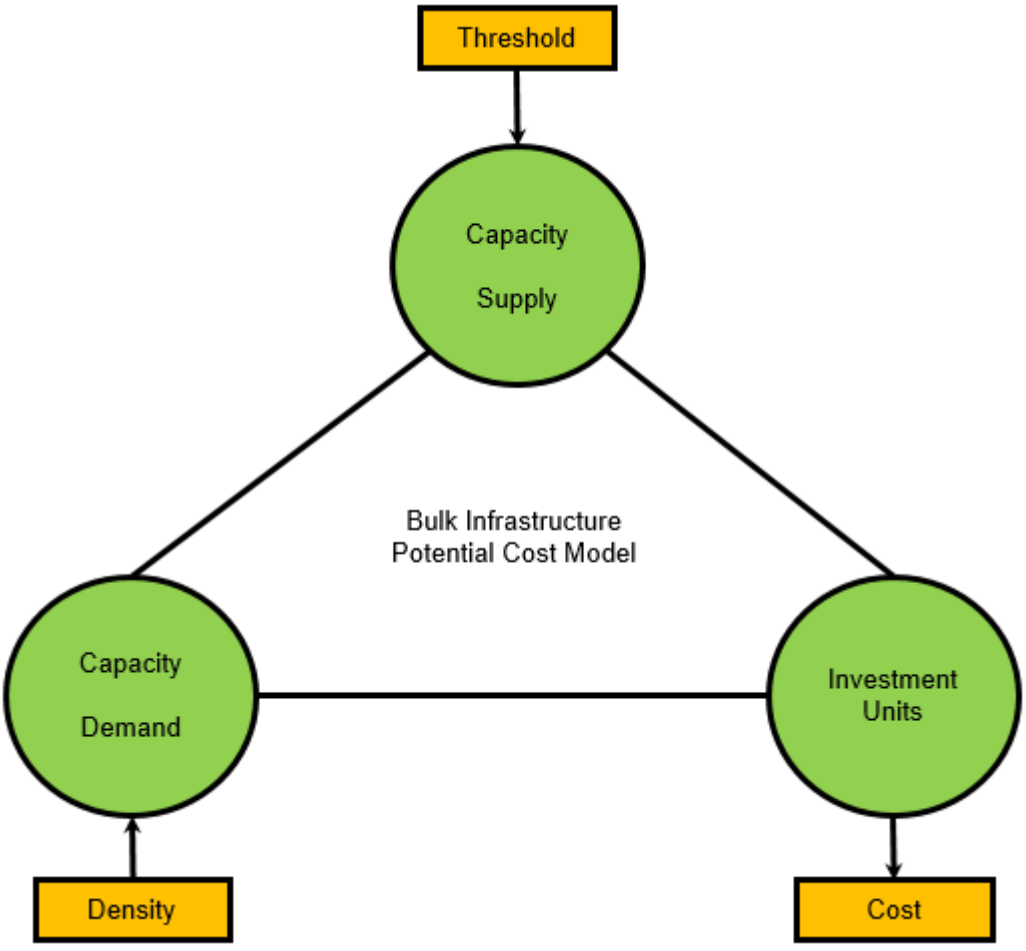
Development policies within South Africa promote the densification and compaction of urban areas to achieve efficiencies with respect to economies of scale along thereby

ensuring sustainable and integrated development. Bulk infrastructure costs do not, however, always decrease with increasing density owing to the interrelationships between infrastructure thresholds, capacities, location and density over time and space (Jenks & Burgess, 2004). Jenks and Burgess (2004) state that this is primarily due to three factors, namely:

- Historically-distorted patterns of infrastructure development
- Development that has not occurred according to predication
- Specific locational differences in environmental and land-use conditions that result in varying infrastructure costs

Jenks and Burgess (2004) discuss a bulk infrastructure cost model, which is comprised of three elements. Figure 3.5 graphically depicts the model.

Figure 3.5: Bulk infrastructure cost model



Source: Jenks and Burgess (2004)

The bulk infrastructure cost model as depicted in Figure 3.5 illustrates that there are three primary elements in determining appropriate bulk infrastructure cost, namely, capacity supply, capacity demand and investment units. These elements are interrelated and, as such, influence each other.

Jenks and Burgess (2004), in illustrating the bulk infrastructure cost model, utilise a base density of fourteen persons per hectare as a foundation for the model. From thereon, three density scenarios are set, namely, a low-density scenario of twenty persons per hectare, a medium density scenario of forty persons per hectare and a high density scenario of sixty persons per hectare. Applying these scenarios, in terms of the model, would be able to illustrate cost on increasing density scenarios.

Within the cost model water, sanitation and electricity components were included. The resultant bulk infrastructure costs model demonstrated the following:

- From the perspective of location, the more compact the development in terms of infill and city centre development, the less cost effective as compared to peripheral, edge development
- Increased residential densities do not necessarily reduce per capita infrastructure costs

The implication of this model is that further high-density development, on existing developed land, does not necessarily equate to lower infrastructure costs with respect to water, sanitation and electricity provision. This, therefore, emphasises the fact that increased densities must be catered for from inception with respect to greenfield developments and not catered for incrementally as and when development occurs. In this instance, economies of scale are not only catered for in terms of land use and transport provision but also within the context of bulk infrastructure provision relating to water, sanitation and electricity across varying density scales.

Jenks and Burgess (2004) stipulate that the levying of bulk service contributions should thus be cognisant of the source of housing provision, in other words, public or private provision. In the case of public housing providers, the lower the engineering cost, the more is available for other infrastructure needs. With respect to private developers, locational decision-making can result in increased infrastructure costs.

The principle is that local authorities need to recover real bulk infrastructure costs by charging the real cost of services all within stated development parameters. Bulk infrastructure provision ideally should not be provided on an incremental basis as housing increases.

The applicability of relevant interventions, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant interventions.

3.8 PUBLIC TRANSPORT

Transportation within a city may be viewed from both mobility and accessibility contexts. According to Tumlin (2012), mobility investments enable the population to travel freely and are mainly in the form of capital facilities such as an added highway lane or an additional bicycle path. Accessibility investments, on the other hand, enable the population to obtain the objects they need and want by bringing the product closer to the consumer such as locating a school and a retail centre in the middle of a neighbourhood thereby reducing the need for people to move long distances in accessing both facilities. Accessibility investments may, therefore, include interventions such as mixed-use zoning that reduce the need for movement (Tumlin, 2012). Systems that overemphasise mobility by implication tend to require excessive capital investments, which ultimately result in dispersed land-use patterns whilst mobility-orientated systems create challenges with respect to automobile dependency (Tumlin, 2012).

According to Tumlin (2012), there are a number of interventions in which a city may reduce traffic and hence, by implication, the use of private vehicles. These include:

- Universal transit pass creation and requiring them in new developments
- Parking cash-out
- Bicycle facility requirements
- Car sharing
- Transportation resource centre

Universal transit passes involve the establishment of a transit agency which then partners with universities, employers, developers and residential neighbourhoods.

Transit passes are issued to individuals which allow unlimited rides on local or regional transit providers for low monthly fees, which may then be absorbed by the employer, school or developer. This intervention seeks to increase transit mode share whilst simultaneously reducing emissions and congestion. The successful implementation of a universal transit pass system relies on negotiating a bulk rate for the universal transit passes and creating a price structure that is at least revenue-neutral.

Parking cash-out is a programme in which employers offer free or reduced-price parking to their employees whilst simultaneously offering an equal transportation fringe benefit to employees who use modes of transport other than driving alone to arrive at work. This benefit could be utilised to purchase transit passes or cover carpooling expenses. In effect, parking cash-out programmes ensure that all commute modes are equally subsidised thereby creating an incentive for employees to carpool, make use of transit arrangements or to either walk or cycle to work.

Bicycle facilities can be enhanced through a revision of development standards that require the provision of bicycle storage, showers and lockers as part of a development agreement to adopt the following objectives:

- Ensuring the appropriate provision of bicycle facilities at destinations such as transportation centres, park and ride facilities, public institutions, community facilities, multi-family housing estates and employment centres
- Encouraging showers and storage facilities at destinations where practical
- Promoting cycling for the purposes of recreation, commuting and shopping through education, enforcement and incentive programmes

Car sharing traditionally has the following characteristics:

- Cars are leased or owned by a car sharing organisation
- Vehicles are disbursed across an area as opposed to being located at a central facility
- Reservations are made via the internet or phone
- Once the vehicle has been reserved, access to the vehicle is restricted to the reserving member

- Vehicles that have been shared must be returned to the location from which they were acquired

Technology has, however, enabled a new form of car sharing where car owners may place their vehicle within a car-sharing scheme thereby obtaining rental revenue from his or her vehicle. The owner, therefore, has the obligation to ensure that the vehicle is in an appropriate working condition.

The establishment of a transport resource centre is central to all forms of sustainable transport initiatives as a central point of communication is required to serve as a front office that provides comprehensive travel information relating to car pool matching, transit routes and schedules, transit passes, bicycle routes and other transport-related information.

The applicability of relevant interventions, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant interventions.

3.9 ENERGY

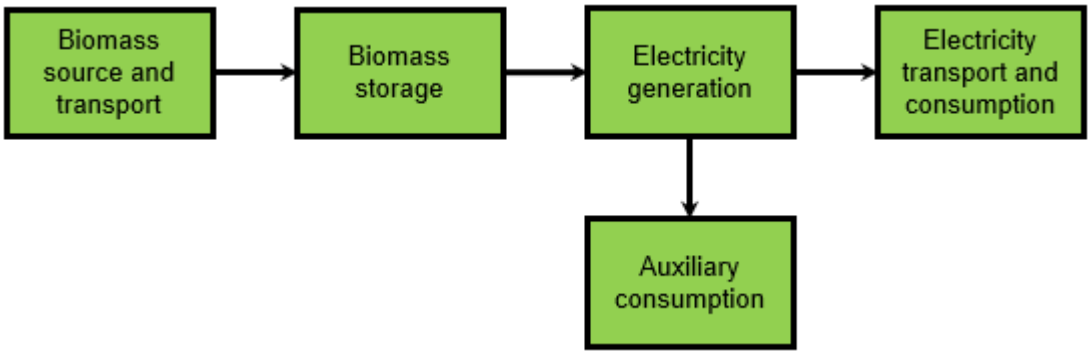
Growth in renewable energy technologies is required due to the need for energy security, the economic impacts associated with energy security and the need to reduce carbon dioxide emissions (Abolhosseini, Heshmati & Altmann, 2014). Abolhosseini *et al.* (2014) state that the number of countries producing above 100 megawatts (MW) of renewable energy will significantly increase by the year 2017. Possible main forms of renewable energy supply, for the purposes of this study include:

- Biomass
- Wind power
- Solar power

3.9.1 Biomass

Biomass power generation involves the generation of energy through the combusting of biomass fuels in a high-pressure steam boiler. A typical conversion process from biomass to energy is reflected in Figure 3.6.

Figure 3.6: Conversion process from biomass to energy

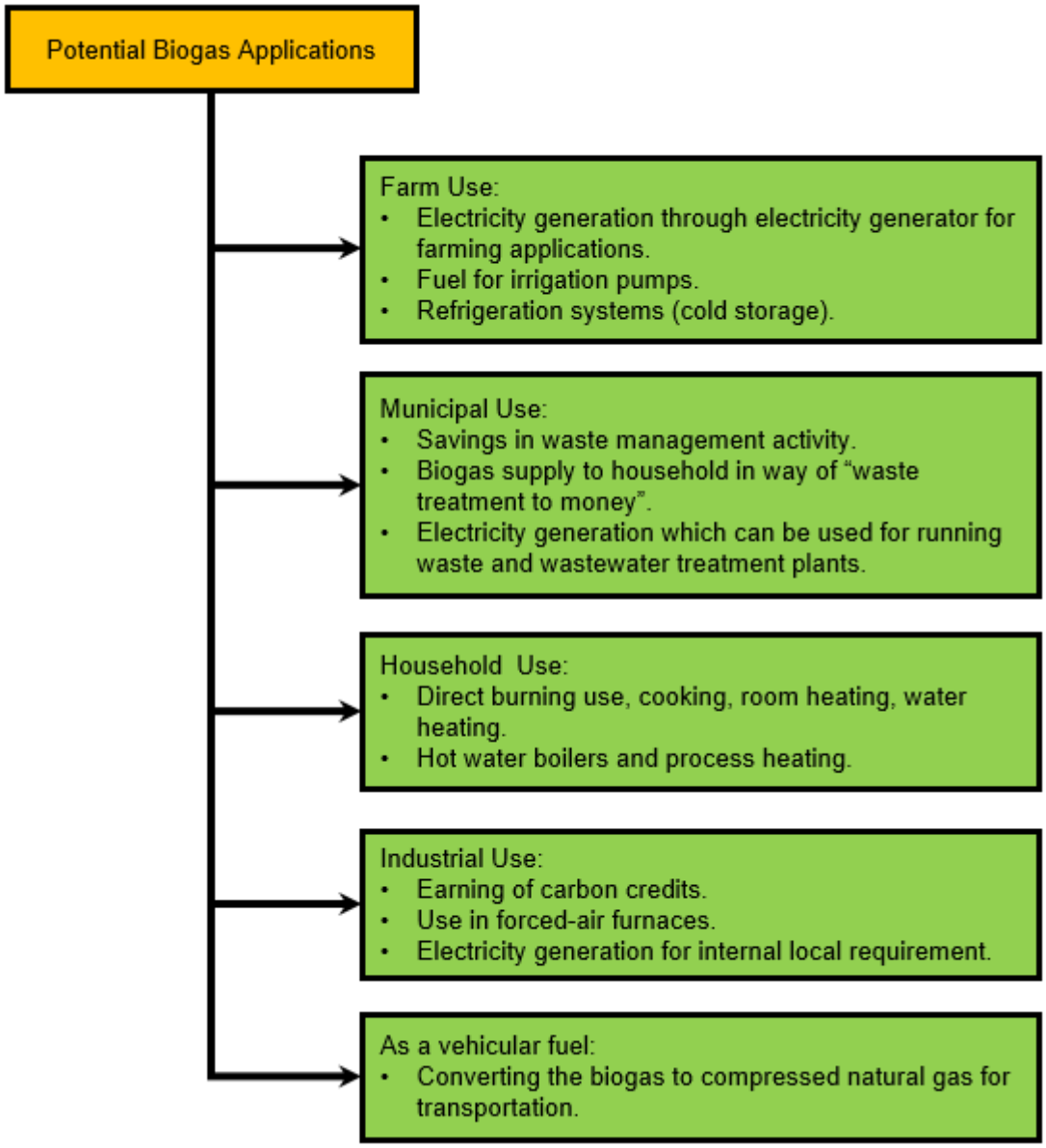


Source: Hofman, Phylipsen, Janzic and Ellenbroek (2004)

The production of biogas through gas generated from the anaerobic digestion of organic matter such as animal-human excreta, kitchen-agricultural residues, municipal waste and algal-plant biomass is a source of renewal energy such as that of solar and wind (Minde, Magdum & Kalyanraman, 2013).

Potential biogas applications are reflected in Figure 3.7.

Figure 3.7: Potential biogas applications



Source: Minde *et al.* (2013)

As illustrated in Figure 3.7, there are potentially five categories in which the production of biogas can be applied. Figure 3.6 further illustrates how biogas not only plays a role in energy generation but how it can also contribute to waste management, environmental cleaning along with continuity of fuel supply.

The applicability of relevant biomass interventions, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant biomass interventions.

3.9.2 Wind Power

According to Abolhosseini *et al.* (2014), the installed capacity of wind power worldwide has increased from 4.8MW in 1995 to more than 239GW in 2011. As such, wind power capacity has increased continuously and is expected to further increase to 1,100GW by 2035 subject to further investment in wind power technology.

The advantages of wind energy as opposed to conventional energy generation include lower water demand, no air emissions and a reduced potential for toxic spills (DuVivier, 2014).

Wind speed is the major determinant of turbine capacity (Ross, 2014). Given the capital costs of wind farms, areas with mean wind speeds in excess of six meters / second at a height of eighty meters are required in order to achieve capacity figures of thirty percent or higher (Ross, 2014). According to Ross (2014) wind speed increases with the measurement of height and, as such, installing a taller turbine can improve the capacity factor. Further factors include the size of the rotor relative to the generator. A larger rotor can capture more wind but is significantly more expensive.

The clustering of wind turbines together is commonly referred to as a wind farm. The economic advantages of wind farms include reduced site development costs, simplified connections to transmission lines along with the more centralised access for operations and maintenance (Masters, 2004). Masters (2004) states that the optimal number of wind turbines located within a wind farm needs to take into consideration the fact that too closely located turbines will result in upwind turbines interfering with the wind received by those located downwind. As such, the rule of thumb is that spacing between towers is three to five rotor diameters between towers and five to nine rotor diameters between the varying rows of wind turbines.

The applicability of a relevant wind farm intervention, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant wind farm intervention.

3.9.3 Solar Power

The photovoltaic exploitation of solar energy involves converting directly radiated light into electricity. The transformation of energy from solar to electricity is made possible

through photovoltaic panels made up of solar photovoltaic cells (Labouret & Villoz, 2010).

According to Labouert and Villoz (2010), the energy output of a solar panel is dependent on the following factors:

- Solar panels dimensions
- Relevant technology of the solar panel
- Radiation received by the solar panel
- Duration of the solar panel to sunlight

Loubouret and Villoz (2010) further explain that with optimal solar radiation of 1000 W/m², a crystalline silicon PV module of 1m² produces an instant power output of approximately 130W. As such, within the African context, a 1m² panel can generate between 400 and 800 Wh/day.

The two predominant categories of PV generators include (Lobouret & Villoz, 2010):

- Grid connected installations where electricity is produced and subsequently fed into a collective grid
- Stand-alone installations where the energy generated from the PV panels is used directly without electrical storage

Photovoltaic are viewed as a renewal source of energy as solar photovoltaic technology preserves natural resources, reduces the amount of energy consumed to produce electricity, electricity generated by a PV panel does not emit any greenhouse gases along with it being viewed as a reliable and sustainable energy source (Lobouret & Villoz, 2010).

The applicability of a relevant solar photovoltaic intervention, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant solar photovoltaic intervention.

3.10 URBAN AGRICULTURE

The objective of increasing food supplies from urban farms along with building local food retail markets stems from the need to balance public and environmental health along with the associated freedom of choice from the consumer. Currently, the dominant food choice option is that of the industrial food system. Altering that system by providing an alternative option, through an intensive urban agriculture scheme, strikes a balance between promoting public health and environmental health objectives whilst maintaining personal consumer freedoms (Spencer, 2014). Introducing food production, through intensive urban agriculture, into the immediate urban environment affects the visibility, price and convenience of consumers' food choices (Spencer, 2014).

A typical example of a successfully implemented urban agriculture scheme is demonstrable in Cuba. Owing to varying motives, Cuba implemented an intensive urban agriculture scheme which has seen enormous gains in vegetable food production (Koont, 2008). The urban agriculture scheme has resulted in a one-thousand fold increase from 4,000 tons to 4.2 million tons between 1994 and 2005 (Koont, 2008). This corresponds to a 78% annual growth rate.

Underpinning the success story are 'organoponicos', a thirty meter by one meter rectangular wall construction containing raised beds of a mixture of soil and organic material originally initiated on two acre plots in 1991 (Koont, 2008). The subsequent expansion of the 'organoponicos' concept has resulted it in being one of the mainstays of vegetable cultivation in Cuban urban agriculture (Koont, 2008). Typical units of urban agriculture and the associated form of ownership along with the status of tenancy are reflected in Table 3.6.

Table 3.6: Cuban units of urban agriculture

NAME OF UNIT	FORM OF OWNERSHIP	STATUS OF TENANCY
CCS (a form of a cooperative)	Mixed collective / individual	Mixed private / usufruct
UBPC (a form of a cooperative)	Collective	Usufruct
Urban state farms	State	State ownership
Parcela-plot	Individual	Ususfruct
Patio-backyard	Individual	Private

Source: Koont (2008)

The various units as reflected in Table 3.6 range from between one-and-a-half to several hectares in size. Key to the success of the urban agriculture scheme was the principle of organisation. According to Koont (2008), a strong, disciplined and coherent central direction combined with decentralised action in the form of input provision, marketing and production were key to the scheme's success.

Koont (2008) states that four crucial areas are responsible for the success of the urban agriculture scheme. These include:

- Research and development. Universities have a role to play with respect to providing training in agro-ecology
- Sufficient training and education of the operators of such a scheme
- Provisioning of inputs. The establishment of municipal seed farms which will produce and / or sell seeds, organic fertilisers, biological pest control operations, technical services and advice to the urban agriculturists
- Material and moral incentives. The structure of process that the producers receive, which can be free market determined or fixed by government authorities or contracts at various levels, is such that productive units are expected to be profitable. The profits, in turn, form the basis of incentive payments, which typically lead to incomes in urban agriculture. In addition, moral incentives are offered where opportunities are provided for further education whilst simultaneously attempting to dignify urban agricultural work by ensuring sufficient scientific and technical content.

The applicability of an urban agriculture scheme, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant scheme.

3.11 SOLID WASTE

According to Dahlen and Lagerkvist (2010), household waste collection systems vary throughout the world from no collection through to the collection of ten separated recyclable materials. Within those systems, household waste collection can be classified into property close (kerbside) collection and collection at drop-off points (bring systems).

The success or failure of a waste collection and recycling programme is dependent on the following (Dahlen & Lagerkvist, 2010):

- Quantity of collected recyclables
- Quality of collected recyclables also known as the contamination rate
- Recycling rate in terms of recovered material
- Participation rate in the collection and recycling scheme
- Willingness the participate (potential participation)
- Inhabitants' degree of satisfaction

Depending on these factors, the following options may be pursued with respect to a waste collection and recycling scheme (Dahlen & Lagerkvist, 2010):

- Differentiating between a property close (kerbside) or bring (drop-off) system
- Differentiating between differences in number and type of recyclable materials collected separately
- Instituting mandatory or voluntary recycling programmes
- Investigating the use of economic incentives
- Recognising the value in differing information strategies
- Recognising the varying residential structures with respect to single and multi-family households along with distinguishing urban and rural areas
- Recognising socio-economic differences within the community with respect to education and income

- Possibly assimilating households with private composting facilities
- Ensuring the availability of alterative recycling centres

The applicability of these categories, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of how the varying categories were applied.

3.12 GREEN BUILDINGS

Guidance on ensuring that building materials and design are based on the assessment of the environmental and social impact is taken from the Green Building Council of South Africa's (GBCSA) (2012a) building rating tools. One of the categories within the respective rating tools is that of materials assessment. The materials assessment category seeks to optimise the use of resources, for the construction of structures, through the selection and reuse of materials along with efficient management practices. This would imply minimising the use of natural resources in the construction process whilst simultaneously reusing and recycling materials.

The materials category relevant to the respective GBCSA building rating tools is further depicted in Table 3.7.

Table 3.7: Material category in GBCSA building rating tool

CATEGORY	CREDIT AIM
Recycling waste storage	To encourage and recognise the inclusion of storage space that facilitates the recycling of resources used within buildings to reduce waste going to disposal
Building reuse	To encourage and recognise developments that reuse existing buildings to minimise materials consumption
Recycled content and reused materials	To encourage and recognise designs that prolong the useful life of existing products and materials and encourage uptake of products with recycling content
Concrete	To encourage and recognise the reduction of embodied energy and resource depletion occurring through use of concrete
Steel	To encourage and recognise the reduction in embodied energy and resource depletion associated with reduced use of virgin steel

CATEGORY	CREDIT AIM
PVC minimisation	To encourage and recognise the reduction in use of Poly Vinyl Chloride (PVC) products in South African buildings
Sustainable timber	To encourage and recognise the specification of reused timber products or timber that has certified environmentally responsible forest management practices
Design for disassembly	To encourage and recognise designs that minimise the embodied energy and resources associated with demolition
Dematerialisation	To encourage and recognise designs that produce a net reduction in the total amount of material used
Local sourcing	To encourage and recognise the environmental advantages gained in the form of reduced transportation emissions by using materials and products that are sourced within close proximity to the site
Masonry	To encourage and recognise the reduction of embodied energy and resource depletion associated with a reduction of virgin material in masonry units

Source: GBCSA (2012a)

Table 3.7 illustrates that there are eleven components to the materials category. The applicability of these categories of materials along with overall criteria in relation to the rating of green buildings, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of how the varying materials categories were applied.

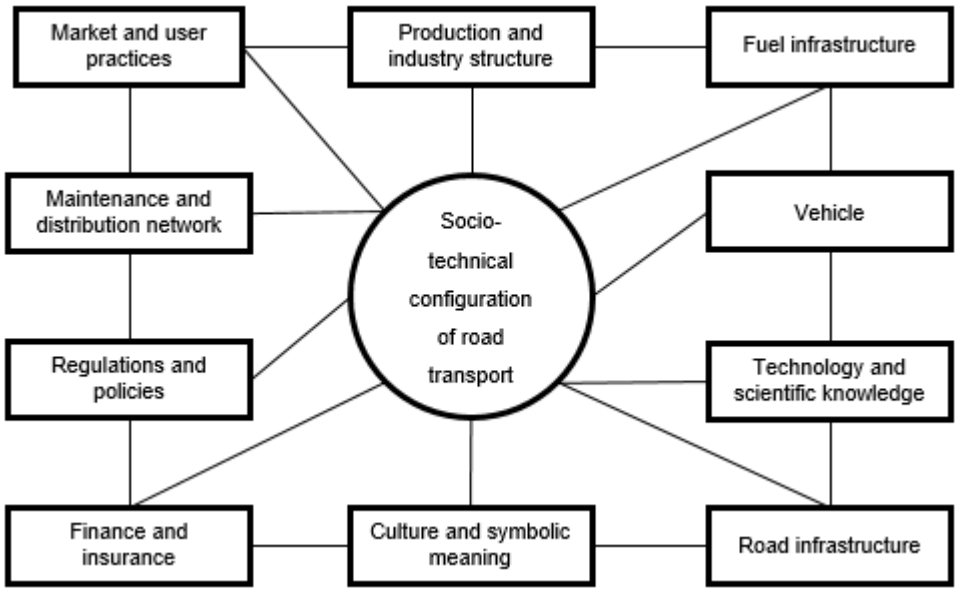
3.13 AIR POLLUTION

An intervention that may contribute to a reduction in air pollution within cities is that of electric vehicles.

The transport sector accounts for 22% of global CO^2 emissions (Xue, You & Shao, 2014), hence the need to transform existing transport systems into more sustainable forms of operation. Given the challenges in reducing the volume of traffic, electric vehicles provide an alternative in transforming existing transport systems into a more sustainable form of operation.

Xue *et al.* (2014) state that influencing sustainable change not only requires technological change but also changes in fuel infrastructures and policies. This implies a socio-technical approach with respect to road transport systems which relates to elements including technology, policy, markets, consumer practices and infrastructure (Xue *et al.* 2014). Figure 3.8 demonstrates the socio-technical aspects of road transport, all of which needs to be co-ordinated in support of each other to ensure the future increased utilisation of electric vehicles.

Figure 3.8: Socio-technical configuration of road transport



Source: Xue *et al.* (2014)

Figure 3.8 demonstrates that both social and technical barriers exist to the potential reconfiguration of transportation in support of electric vehicles. As such policy adjustments are required in support of the eventual reconfiguration of road transportation.

Xue *et al.* (2014) identify four key components that may assist the advancement of electric vehicles given the socio-technical complexities. These include:

- A central initiator is required in phase one. Phase one would entail organising and mobilising key stakeholders to participate in the value network.

- Market segments should vary between phase one and phase two. Phase one markets should be narrowed and focussed and focus on public service sectors and multi-car households. Phase two can then be expanded to a wider audience.
- Value propositions need to be multi-dimensional. Environmental advantage or low cost use alone does not attract private customers. The value proposition as such needs to shift from product to product-service.
- Partners need to emphasise the use of electric vehicles, forge a coalition to transfer and share profits and encourage both top-down and bottom-up approaches.

The applicability of the possible electric vehicle intervention, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant intervention.

3.14 PUBLIC HEALTH

Within the context of the South African health care system, the provision of basic health services is referred to as Primary Health Care. Primary health care within South Africa seeks to provide an integrated package of essential primary health care services that are available to the entire population thereby promoting equity in health care.

Certain norms and standards are attached to the envisaged primary health care services included, which are facilities that were relevant to the context of this study. These pertained particularly to norms and standards for health clinics as well as norms and standards to community level home based care.

The norms and standards relevant to health clinics (Department of Health, 2000) are as follows:

- Respective clinics should render comprehensive integrated primary health care utilising a one-stop approach for at least eight hours a day, five days a week.
- Access to the health clinic will be measured by the proportion of people living within a 5km radius of the clinic which, in turn, would serve between five thousand and ten thousand people.

- Clinics must receive a supporting monitoring visit at least once a month in order to support personnel along with monitoring the quality of service whilst simultaneously identifying additional needs and priorities.
- Clinics must have at least one member of staff who has completed a recognised primary health care qualification.
- Doctors along with specialised professionals will be required to be accessible for consultation, support and referral along with providing periodic visits.
- Clinic managers are to receive training in facilitation skills as well as primary health care management.
- There will be an annual evaluation of the provision of the primary health care service to reduce the gap between the needs of the community and the provision of the service.
- Subsequent annual plans will be based on this evaluation.
- Clinics will have a mechanism for the monitoring of the service provided and the associated quality assurance including at least one annual service audit.
- Community perceptions of the service provided will be tested at least twice a year through patient interviews or anonymous patient questionnaires.

The norms and standards relevant to community level home-based care (Department of Health, 2000) are as follows:

- It is recognised that every community provides some form of home-based care and as such will have a partnership between the clinic-based health service and that of the community-based service.
- All clinics serving communities within the catchment area need to identify home-based carer co-ordinators for formal and informal sector activities.
- All communities with access to home-based care will have access to a referral system and to comprehensive support services.
- All clinics will have access to home-based care guidelines along with palliative care guidelines in order to assist communities and families.

The applicability of primary health care, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof both in terms of population served along with the extent of the relevant primary health care.

3.15 BIODIVERSITY

As urban populations increase urban ecosystems become increasingly important in shaping a populations viewpoint on natural ecosystems (Savard, Clergeau & Mennechez, 2000). Sarvard *et al.* (2000) further state that urban ecosystems will become increasingly important as they will be able to provide useful insights into the management of biodiversity in other ecosystems.

Biodiversity and its relation to urban ecosystems can be divided into three major groups (Sarvad *et al.*, 2000), namely:

- Those related to the impact of the city on adjacent ecosystems
- Those dealing with the maximisation of biodiversity within the urban ecosystem
- Those related to the management of undesirable species within the ecosystem

Biodiversity is expressed on varying spatial scales and, as such, one needs to define those scales to guide the form of the intervention. Savard *et al.* (2000) define such a hierarchical approach as reflected in Table 3.8.

Table 3.8: Actions related to increased biodiversity as per varying spatial scales

SCALE	MANAGEMENT LEVEL	PLANNING	DESIGN	MANAGEMENT
Adjacent landscapes	Regional government or equivalent	• Zone landscape use • Identify and protect important natural areas • Identify green corridors linking the city to natural areas • Create regional parks	Design parks and green corridors to optimise their biodiversity use, design roadways to minimise fragmentation of natural areas	Plant vegetation and restore habitats to improve parks and corridors, promote management options that favour biodiversity

SCALE	MANAGEMENT LEVEL	PLANNING	DESIGN	MANAGEMENT
City	Municipal government	• Extend green corridors within the city • Identify important areas for biodiversity within the city • Identify important species	Shape, structure and size-up corridors to optimise biodiversity, design parks to increase biodiversity	Plant vegetation in parks, green corridors and along streets
City sectors (industrial, commercial, residential, recreational)	Local authorities	• Establish vegetation objectives • Interact with higher levels to ensure optimal location of natural areas, parks and corridors • Create management plan for parks that will preserve and enhance biodiversity	Design type, structure and distribution of vegetation to favour biodiversity	Enhance or restore vegetation in industrial or commercial areas, reduce use of herbicides and pesticides
Individual lots	Owner	• Landscape property to increase biodiversity, co-ordinate with neighbours to maximise vegetation volume	Select vegetation most compatible with location	Avoid use of pesticides and herbicides

Source: Savard *et al.* (2000)

Table 3.8 illustrates the extent to which biodiversity intervention should occur across the varying city landscape scales. It is important to note that no one scale has preference over the other, but that interventions are co-ordinated between the varying scales.

The applicability of the varying biodiversity interventions, for the purposes of this study, are discussed further in Chapter 4 along with the associated scale thereof, both in terms of population served along with the extent of the relevant intervention.

3.16 CHILD-CENTRED DEVELOPMENT

Enhancing child-centred development and learning is a philosophical proposition in which child-centred education is core to the philosophy. Although a philosophical proposition, the values and principles on which it is based can influence how a component of a city is structured and designed.

Child-centred development and learning, according to Doddington and Hilton (2007), reflects on childhood as a time in which an adult is developed authentically if during that childhood period the child is afforded the space, opportunity and time to develop at his or her own pattern of consciousness. As such the child's body and mind should be afforded the freedom through his or her instinct to play in order that the child begins to know and understand the world (Doddington & Hilton, 2007). The child that plays and experiments is able to gain knowledge in sensual, affective and active ways that enables him or her to understand its substance. In that way, the child is able to create knowledge for themselves as opposed to absorbing and replicating it (Doddington & Hilton, 2007).

Doddington and Hilton (2007) suggest that through child-centred development and learning an education system is constructed where:

- Senses and perceptions are strengthened through experience
- Beliefs are explored
- Expression of things that matter are encouraged

Through this form of child-centred development, each child's capacity for thought and agency is valued in that teachers encourage the expression of personal ideas

(Doddington and Hilton, 2007). Doddington and Hilton (2007) state that schools operating within this value system would thus ensure that educational experiences reflect the primacy of sense and perception. Learning, as such, is designed to give opportunities and activities that are sense-based and involve physical activity. Doddington and Hilton (2007) provide the following example of a typical child-centred physical activity. In the concept of magnetism, various conventional exercises can be used to develop an understanding through the use of real magnets. In child-centred learning, to deepen understanding and awareness, a child might experience the idea through collaborative movement imagining that he or she are being drawn or repelled across the room.

Although child-centred development and learning is based on the values and principles of childhood understanding and experience, the physical structure and design of city components can contribute to the philosophy. For the purposes of this study, it is proposed that formal central learning facilities, with facilities that inculcate the principles of child-centred development are provided within a region, both across class and income divides. Schools, regardless of class or income, would not provide these facilities within their own premises but be forced to use the facility as part of the delivery of the curriculum. It is further proposed that the informal delivery of such facilities be provided in the form of appropriately designed parks in a mode which supports the curriculum on the basis of child-centred development and learning. Both formal and informal facilities need to be designed that encourage child interaction and experience within the context of the South African school curriculum, which includes the following subjects, according to the Department of Basic Education (2015):

Group A: Fundamentals (Compulsory)

- Two official languages
  - Home Language
  - First Additional Language
- Mathematics or Mathematical Literacy
- Life Orientation

Group B: Electives

- Accounting

- Agricultural Management Practices
- Agricultural Sciences
- Agricultural Technology
- Art
- Business Studies
- Civil Technology
- Computer Applications Technology
- Consumer Studies
- Dance Studies
- Design
- Dramatic Arts
- Economics
- Electrical Technology
- Engineering Graphics & Design
- English: "Advanced Programme English" (Literature)
- Geography
- History
- Hospitality Studies
- Information Technology
- Life Sciences
- "Advanced Programme Mathematics" (calculus, further algebra, and one of: matrices, statistics, mathematical modelling)
- Mechanical Technology
- Music
- Physical Science
- Religion Studies
- Second Additional Language
- Third Additional Language
- Tourism
- Visual Arts

The applicability of ensuring child-centred development and learning within city structure and design, for the purposes of this study, are discussed further in Chapter

4 along with the associated scale thereof, both in terms of population served along with the extent of the intervention.

3.17 THEMES AND ASSOCIATED INTERVENTIONS SYNOPSIS

Considering the information as contained within Sections 3.3 to 3.16, Table 3.9 summarises the respective themes of sustainable city development coupled with the associated interventions of sustainable city development along with key influencing factors. The basis of investment per theme is provided in Chapter 4.

Table 3.9: Themes and associated interventions of a sustainable city

COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	KEY INFLUENCING FACTOR
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Consideration of locational characteristics • Growth reconciled with development limitations	Location	• Regional • Local area	• Spatially-referenced gross value addition (GVA)

COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	KEY INFLUENCING FACTOR
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Water	• Rainwater harvesting • Utilisation of grey water • Utilisation of reclaimed water	• Reducing the total consumption of water • Reducing the dependence on large-scale water capture systems • Distinguishing the between centralised and decentralised provision of infrastructure
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Sanitation	• Low diameter sewerage systems collect and discharge household wastewater from residences into low maintenance wastewater treatment plants • Shared septic tank system where a number of residents connect into one septic tank • Community sanitation centres	• Sewerage is treated and reused for all income groups • Distinguishing between a provider managed community-based sanitation system and that of a community managed-based sanitation system • Categories of wastewater reuse

COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	KEY INFLUENCING FACTOR
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Compact cities	• Bulk infrastructure (water, sanitation and electricity) cost provisions	• Capacity demand, capacity supply and investment units • Greenfields versus brownfields development • Incremental versus upfront infrastructure services provision
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Public transport	• Creating universal transit passes • Parking cash-out • Bicycle facilities • Car sharing • Transportation resources centres	• Reduce use of private vehicles • Accessibility versus mobility
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Energy	• Biomass • Wind power • Solar power	• Applications of use • Scale • Grid connections versus stand-alone installations

COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	KEY INFLUENCING FACTOR
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Urban agriculture	• Urban agriculture scheme	• Increasing food supply from urban farms • Build local food retail markets • Form of ownership • Status of tenancy • Incentives
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Solid waste	• Property close systems • Drop-off systems • Mandatory versus voluntary programmes	• Recycling solid waste • Quantity of collected recyclables • Quality of collected recyclables • Recycling rate • Participation rate • Willingness to participate
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Green buildings	• Green building rated development	• Optimise use of resources • Efficient management practices

COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	KEY INFLUENCING FACTOR
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Air pollution	• Electric vehicles	• Reduce air pollution • Socio-technical configuration of road transport • Multi-dimensional value proposition
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Health care	• Responsive clinics • Access to clinic based on proportion of people with a certain radius of the clinic	• Primary health care
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Biodiversity	• Adjacent landscapes interventions • City interventions • City sector interventions • Individual lot interventions	• Co-ordination between scales of intervention • Maximising biodiversity within an urban ecosystem

COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	KEY INFLUENCING FACTOR
• Trade-offs between the social, environmental and economic dimensions of sustainability • Urban governance • Locational characteristics • Growth reconciled with development limitations	Child-centred development	• Shared formal learning facilities • Informal learning facilities	• Child-centred education • Child offered space, opportunity and time to develop

Source: Author's own compilation

Table 3.9 depicts, for the purposes of this study, the components of sustainable city development along with the associated sub-components. Proposed funding mechanisms and instruments per the varying components need to take cognisance of the stated influencing factors as highlighted in Table 3.9.

3.18 SUMMARY

In Chapter 3, the nature of a sustainable city was defined along with the stated themes and associated interventions thereof. The following themes were discussed, namely, location, water, sanitation, compact cities, public transport, energy, urban agriculture, solid waste, green buildings, air pollution, health care, biodiversity and child-centred development. Each of the identified themes incorporated interventions in support of the relevant theme. Furthermore, key influencing factors per theme were identified which would influence the nature and scale of development as per the relevant interventions within each theme.

In Chapter 4, a hypothetical city with set population parameters and growth trajectories is developed. Within the hypothetical city, the structuring elements of the city are defined inclusive of the themes discussed and associated interventions of sustainable city development. From thereon, tools and instruments were utilised to determine the

sustainability of the varying themes and associated interventions, the resultant acceptance of each theme and associated interventions within the context of defined parameters within a hypothetical sustainable city.

CHAPTER FOUR

A HYPOTHETICAL SUSTAINABLE CITY

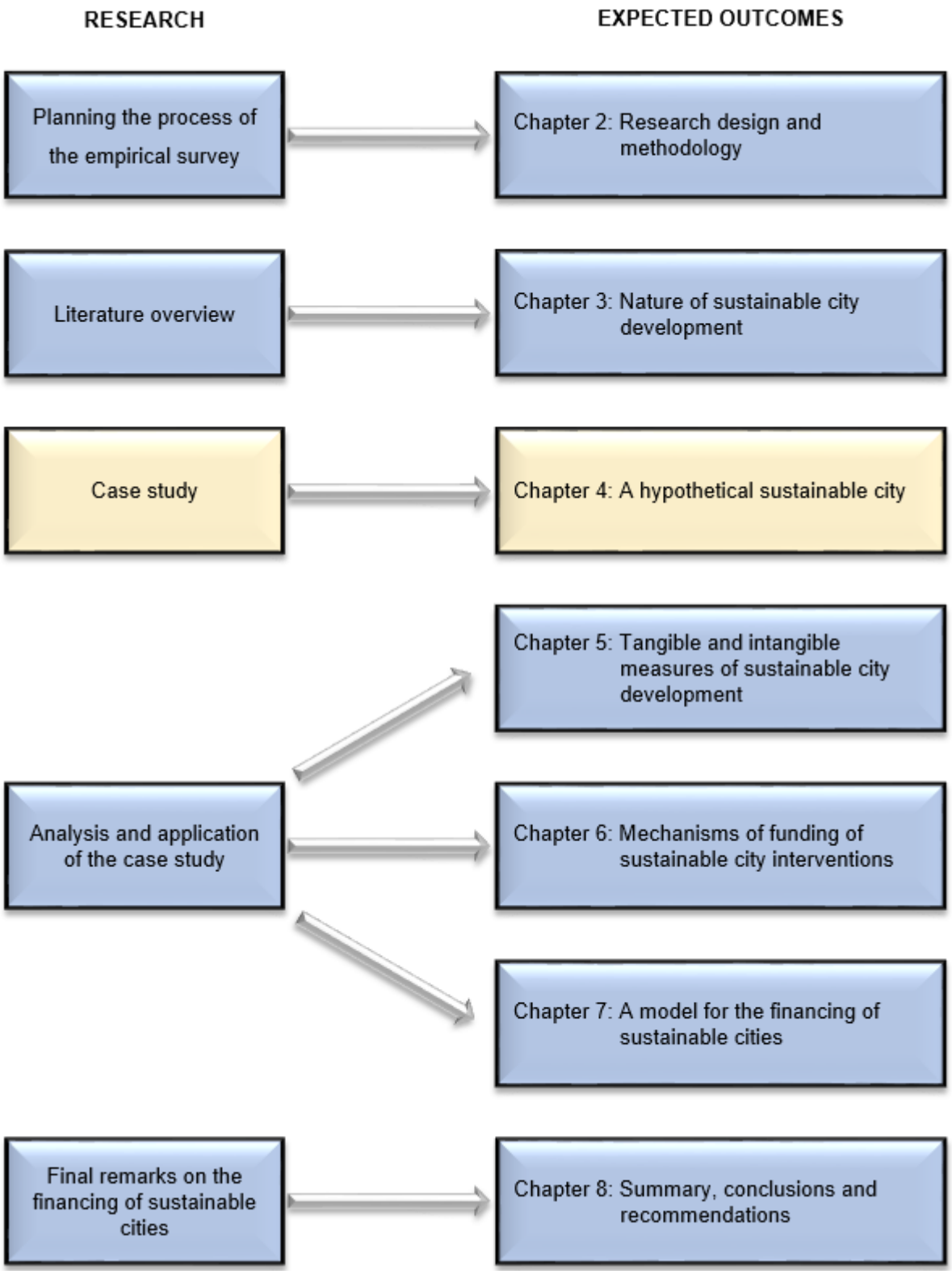
4.1 INTRODUCTION

In Chapter 3, the nature of city development along with the themes and associated interventions thereof were defined. Twelve primary themes were defined as being integral to sustainable city development. Each of the primary twelve themes were subsequently discussed further with regard to the extent of their envisaged intervention impact. In Chapter 4, a hypothetical sustainable city with set population parameters and growth trajectories is developed. Within the hypothetical city, the structuring elements of the city are described inclusive of the identified themes and associated interventions of sustainable city development. These themes were used as a basis for investment decisions for acceptable interventions.

4.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 4.1.

Figure 4.1: Study framework



Source: Author's own compilation

As depicted in Figure 4.1, this study comprises of eight chapters. Chapter 4 relates to a case study of a hypothetical sustainable city.

4.3 ELEMENTS OF A CITY STRUCTURE

For Du Plessis and Boonzaaier (2014), the South African city form is characterised by distorted spatial patterns, underdeveloped public transport infrastructure, unequal access to economic and social opportunities along with inappropriately located lower income settlements. In order to address these imbalances, spatial planning policy has sought to rectify the imbalances by enshrining the policy objectives of increased compact urban form, higher densities, the promotion of mixed land uses along with integrated transport and spatial planning directives (Du Plessis & Boonzaaier, 2014). As such, Du Plessis and Boonzaaier (2014) classify the predominant elements of city structure as follows:

- Density: refers to the degree of intensity within a defined space which can relate to residential land use, land consumed by urban expansion, population density and urban density
- Spatial scale and composition: extent to which varying land uses interact
- Urban form: spatial structure of the city

The City of Victoria (2013) state that urban structure is comprised of the following three elements:

- Space: includes the natural features and landscape of an area which influences the look and character of neighbourhoods that exist upon the land base
- Movement: relates to the system of roads, sidewalks, cycling lanes and pathways coupled with the transportation infrastructure and services they accommodate
- Building form: relates to the range of building types as defined by physical scale, mass, orientation and height along with their associated interaction

Troy (2004) defines urban areas as per the following two criteria, namely:

- Structure: relates to the spatial relationships between cities and their services and activities whether in the form of linear relationships or that of an interconnected set of nodes

- Form: relates to the density of development wherein city centres are generally of a higher density to that of suburban areas

It is within the context of urban form, density, scale and structure that a city's size is determined.

4.4 CALCULATING A HYPOTHETICAL CITY SIZE

Statistics South Africa (2014) estimate annual population growth rates from 2002 to 2014 for South Africa. Table 4.1 illustrates the annual percentage population growth rates for South Africa.

Table 4.1: Annual population growth rates (2002-2014)

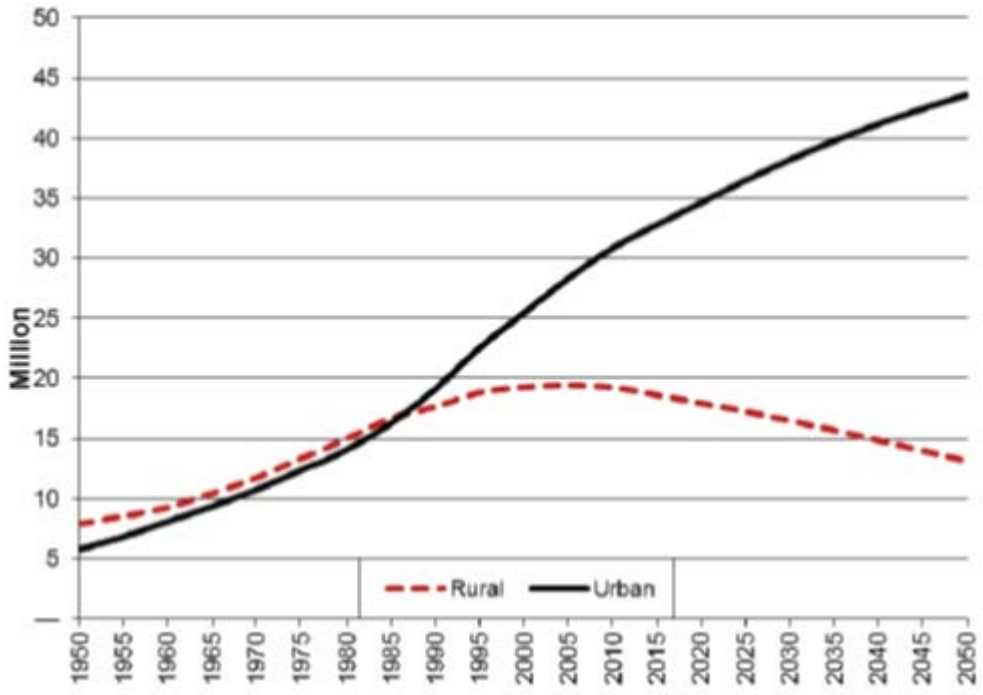
PERIOD	MALE (%)	FEMALE (%)	TOTAL (%)
2002-2003	1,35	1,19	1,27
2003-2004	1,38	1,21	1,29
2004-2005	1,41	1,24	1,32
2005-2006	1,44	1,26	1,35
2006-2007	1,48	1,28	1,38
2007-2008	1,51	1,31	1,40
2008-2009	1,54	1,33	1,43
2009-2010	1,57	1,35	1,46
2010-2011	1,61	1,38	1,49
2011-2012	1,64	1,40	1,52
2012-2013	1,67	1,43	1,55
2013-2014	1,71	1,45	1,58

Source: Statistics South Africa (2014)

As depicted in Table 4.1, annual population growth rates have increased in South Africa from an annual growth rate of 1,27% in 2002-2003 to annual growth rate of 1,58% in 2013-2014. On average, this equates to a 1,42% increase per year.

According to Turok (2012), approximately two-thirds of South Africa's population reside in urban areas. The increasing migration from rural to urban areas results from cities outperforming the rest of the country with respect to economic employment growth. Cities are, by their nature, more productive in terms of the value of goods and services produced along with the efficiency with which they are produced (Turok, 2012). Turok (2012) compares the extent of urban and rural population trajectories between 1950 and 2050 as reflected in Figure 4.2.

Figure 4.2: Total population of urban and rural areas in South Africa (1950-2050)



Source: Turok (2012)

As depicted in Figure 4.2, the disparity between urban and rural population growth is set to increase from 2016 until 2050.

Capello and Camagni (2000) confirm the widely-held opinion that optimal city size cannot be determined by urban location costs and benefits, which state that economies of scale can only apply up to a certain urban size after which diseconomies of scale apply owing to congestion effects and the resulting decrease of average revenues of an urban location. Rather, city size is influenced by a multitude of factors including:

- Cities differ from one another in terms of varying functions and specialisations: As such, city size can vary based on the function and structure of the city
- Cities exist in an interurban environment: As such, the spatial characteristics in which a city is located needs to be considered
- Cities generate a large number of externalities owing to their qualitative characteristics

Capello and Camagni (2000) stipulate that as a result, city size and shape is influenced by the physical (natural and built environment), the economic environment and the social environment. Each of the three environments generate advantages and disadvantages and influence one another with respect to human activity within the city. These influences are further depicted in Table 4.2.

Table 4.2: City effect and urban overload

	INTERACTION BETWEEN THE ECONOMIC AND PHYSICAL ENVIRONMENTS	INTERACTION BETWEEN THE ECONOMIC AND SOCIAL ENVIRONMENTS	INTERACTION BETWEEN THE SOCIAL AND PHYSICAL ENVIRONMENTS
City effect	• Efficient energy use • Efficient use of non-renewable natural resources • Economies of scale in the use of urban environmental amenities	• Accessibility to good housing facilities, skilled jobs, social amenities, social contacts, education facilities and health services	• Green areas for social amenities • Residential facilities in green areas • Accessibility to urban environmental amenities
Urban overload	• Depletion of natural resources • Intensive energy use • Water, air pollution • Depletion of green areas • Traffic congestion	• Suburbanisation forced by high urban rents • Social friction in the labour market • New poverty	• Urban health problems • Depletion of historical buildings • Loss of cultural heritage

Source: Capello and Camagni (2000)

Table 4.2 reflects the relationship between the physical, economic and social environments within a city context. As depicted in Table 4.2, ensuring optimal city management is more critical than defining optimal city size.

Krugell (2011) states that cities tend to be oversized in many developing countries owing to the absence of large-scale land developers, a lack of strong land markets along with weak local fiscal autonomy and political institutions that encourage over concentration. South African cities, however, may broadly be defined as undersized owing to how apartheid planning created a spatial economy characterised by inefficient land use, excessive transport costs and under investment in infrastructure such as transport, telecommunications and electricity (Krugell, 2011). Krugell (2011) further stipulates that apartheid planning further resulted in segmented labour and consumption markets thus creating artificial internal barriers to trade, all of which contribute to sub-optimal city size.

The implication of optimal city sizing could suggest that the most efficient route to longer-term economic growth within an undersized city is to ensure growth through increased urbanisation as opposed to planning for a new metropolitan area should cities be oversized (Krugell, 2011). Given South Africa's history with respect to apartheid city planning along with the current challenges those fragmented cities produce, one cannot apply oversized or undersized city criteria to future urban growth as stimulating identified economic areas can very well exacerbate existing spatial inequalities within cities. Rather, the premise behind future urban growth should include identifying localities that can benefit from investments in human capital, investment in transport services and infrastructure along with investments in urban planning (Krugell, 2011). Coupled with these investments is ensuring optimal city management informed by the economic feasibility of the investment.

For the purposes of this study, a hypothetical city and / or urban extension was used as the basis of defining and detailing the financing tools, mechanisms and instruments for sustainable city development. The size and shape informants of the hypothetical city and / or urban extension do not necessarily follow specific optimal city size criteria but rather are informed by the nature of city function, the environment in which the city is located along with varying externalities applicable to the city. The hypothetical city

and / or urban extension was informed by the predominant structural elements and associated elements of city development as discussed in Section 4.3.

Given that the forty largest cities in South Africa have populations of 250,000 or more (Krugell, 2011), the hypothetical city and / or urban extension, for the purposes of this study, was initially based on an envisaged population of 250,000.

Applying an annual average increase of 1,42% in the annual population growth rate, from a base population figure of 250,000, would equate to a population growth rate for this study's hypothetical city / urban extension as reflected in Table 4.3.

Table 4.3: Base population rate and growth rate for the hypothetical city / urban extension

PERIOD	AVERAGE ANNUAL POPULATION GROWTH RATE	TOTAL POPULATION
Base population: 250,000		
Year 1	1,42%	253,550
Year 2	1,42%	257,150
Year 3	1,42%	260,801
Year 4	1,42%	264,504
Year 5	1,42%	268,259
Year 6	1,42%	272,068
Year 7	1,42%	275,931
Year 8	1,42%	279,849
Year 9	1,42%	283,822
Year 10	1,42%	287,852

Source: Author's own compilation

As depicted in Table 4.3, for the purposes of this study, a hypothetical population base rate of 250,000 would result in a total population of 287,852 within year ten based on an annual population growth increase of 1,42%.

The quality of city and / or urban development is fundamentally an economic issue as opposed to a design issue (Urbed, 2014). First and foremost is the determination on whether or not the envisaged locality of such a development possesses an adequate basis of investment. The acceptance of establishing a greenfield's development / urban extension within a stipulated locality needs to be determined upfront through mechanisms such as spatially-referenced gross value addition (GVA). From thereon, the scale and resultant acceptance of the identified sustainability interventions needed to be determined based on an initial base population of 250,000. The basis of acceptance is discussed further in Section 4.5.

To investigate the investment decision of a sustainable city, the acceptability of each of the themes and associated interventions of sustainable city development was undertaken. This assessment was made from a tangible perspective along with an intangible perspective. The tangible perspective displays an evident benefit to a particular intervention whereas an intangible perspective utilises measures to guide the extent of the envisaged intervention. Both the tangible and intangible perspective utilised a base population of 250,000.

4.5 TANGIBLE INVESTMENT PERSPECTIVE AS A BASIS FOR INTERVENTION ACCEPTANCE

According to Lumby and Jones (20113), alternatives in any decision-making process need to be valued to be compared. As such, a financial analysis assists in assessing the acceptance of a firm or project by determining whether a satisfactory return is being earned for the possible risks undertaken (McGuigan, Moyer, Rao & Kretlow, 2008). McGuigan *et el.* (2012) further state that a financial ratio, as formulated through a financial analysis, enables an analyst to compare a company's or project's financial condition over time or between firms or other projects.

4.5.1 Type of Interventions

According to du Toit, Erasmus, Kotze, Ngwenya, Thomas and Viviers (2010), an investment appraisal method is dependent on the type of project, or in the instance of this study, the varying sub-components of sustainable city development. Typical project types (du Toit *et al*., 2010) include:

a) Replacement projects: refer to an investment that needs to occur on a regular basis, namely. the replacement of a company's assets owing to the asset reaching the end of its lifetime. Replacement projects are appraised by considering the cash flows generated by the existing asset versus cash flows generated when the asset is replaced. The objective is to determine whether the cash flows generated by the replacement asset are adequate to justify the initial investment.
b) Expansion projects: refer to the investment required when a company wants to expand its current level of operations. Expansion projects are evaluated by considering the incremental cash flows generated by the envisaged expansion thereby determining whether or not there is justification for the initial investment.
c) Independent projects: refer to projects unrelated to any other asset or investment within an organisation. Independent projects are evaluated by means of an investment appraisal method wherein criteria are set, which will justify the use of capital.
d) Mutually-exclusive projects: imply the implementation of one project at the expense of all other alternative projects. Mutually-exclusive projects are evaluated in terms of individual profitability along with the incremental return of each project.
e) Complementary projects: imply that the adoption of one project will result in a positive effect on an organisation's other projects. As a result, one project will become the prerequisite for the other.
f) Substitute projects: refer to projects where the implementation of one project could negatively affect the cash flows generated by other projects. Opportunity costs are thus considered in evaluating the project.
g) Conventional projects: require a substantial cash outflow at the initial stages of a project followed by cash inflows throughout the project lifecycle. These projects do not typically require additional investments as annually generated cash inflows are larger than the cash outflows.
h) Unconventional projects: display initial cash outflows typically at the beginning of a project followed by positive cash flows and negative cash flows. Additional investment may be required during the project lifecycle.

4.5.2 Investment Appraisal Methods

Typical investment appraisal methods from which to assess projects (du Toit *et al*., 2010) include the following methods:

a) Average return method: considers the initial cash investment required of a project whilst comparing this with the average annual cash flow generated by the project over its lifespan. The calculation is represented by the following equation, where:

$$AR = \frac{(\sum_{t=1}^{n} C_t)/n}{C_0} \text{ x } \frac{100}{1}$$

AR = Average return

C_0 = Initial investment required

C_t = Cash flow in period *t*

n = Project lifetime

The project's annual return is compared with the organisation's cost of capital in order to determine the financial feasibility. If the annual return exceeds the cost of capital, the project is deemed acceptable whereas if the annual return is less than the organisation's cost of capital, the project is deemed as non-viable.

b) Payback period method: This method calculates the expected number of years after which the initial investment amount required of a project is recovered from the project's net cash flows. The calculation is represented by the following equation;

$$\text{PBP} = \text{years before full recovery} + \frac{\text{unrecovered cash flow at beginning of year}}{\text{cash flow during the year}}$$

The payback period is calculated by accumulating the cash flows until the amount is just less than the initial investment. The portion of the following year's cash flow that is required to ensure that the accumulated cash flow is equal to the initial investment is then determined.

c) Discounted payback period method: ensures that cash flows are discounted at the company's cost of capital as the time value of money is ignored in both the average

return method along with the payback period method. As such the method calculates the expected number of years required to recover the initial investment through the consideration of discounted net cash flows generated by the project.

The calculation for the discounted payback period is similar to the payback period method except that the cash flows are first discounted by the company's cost of capital and then accumulated until the initial investment amount is recovered.

d) Net present value method: refers to the difference between the present value of all anticipated net cash inflows and the present value of all anticipated net cash outflows calculated over the lifespan of a project. The calculation is represented by the following equation, where:

NPV = Present value of expected cash flows – initial investment

$$= \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} - C_0$$

C_0 = Initial investment required

C_t = Cash flow in period *t*

n = Project lifetime

The calculation of net present value depicts whether an organisation should invest in a project where the present value of the expected future cash inflows will be greater than the present value of all the cash outflows.

As Masters (2004) states, determining an appropriate discount rate for an investment in energy efficiency is often the most difficult step. Furthermore, one needs to consider what benefits will be determined by an investment year after year. As per Masters (2004), in determining the choice between two investments, the present value is compared resulting in a difference termed the net present value (NPV).

Masters (2004) illustrates this net present value by way of the following example:

An investment in a good motor and a premium 100-hp electric motor are being considered. The good motor consumes 79kW whilst costing $2400. The premium motor consumes 77.5kW whilst costing $2900. Both motors operate 1600 hours per year at an electricity cost of $0.08/kWh. What would be the net present value of the cheaper alternative over a twenty-year lifespan at a discount rate of 10%? Masters (2004) depicts the solution as follows:

The annual electricity cost per motor is calculated as:

- Good motor = 79kW x 1600 h/yr x $0.08/kWh = $10,112 / yr
- Premium motor = 77.5kW x 1600 h/yr x $0.08/kWh = $9,920 / yr

The subsequent present value factor for 20 year cash flows at a 10% discount rate is calculated as:

$$PVF(d,n) = \frac{d(1+d)^n - 1}{d(1+d)^n} = \frac{(1+0.10)^{20} - 1}{0.10(1+0.10)^{20}} = 8.5136\ yr$$

Based on this calculation, the present value of the two motors, inclusive of both initial and annual costs is reflected as:

- Good motor = $2400 + (8.5136 yr x $10,112/yr) = $ 88,489
- Premium motor = $2900 + (8.5136 yr x $9,920/yr) = $ 87,354

Based on these calculations, the premium motor is the preferred investment option with a net present value of:

NPV = $88,489 - $87,354 = $1,135

e) Internal rate of return method: evaluates a project by considering the initial investment required, the expected future cash flows that will be generated, which in turn compares the rate of return of the project with the organisation's cost of capital. The internal rate of return method attempts to determine the discount rate that equates to the present value of the expected net cash inflows and the present

value of the net cash outflows or where the discount rate will result in a net present value of zero. This is represented by the following equation:

$$= \sum_{t=1}^{n} \frac{C_t}{(1 + IRR)^t} - C_0 = 0$$

C_0 = Initial investment required

C_t = Cash flow in period *t*

IRR = Internal rate of return

In utilising the internal rate of return method, only those projects whose internal rate of return values are greater than the organisation's cost of capital should be accepted.

f) Modified internal rate of return method: seeks to improve the internal rate of return method by including a more conservative view of the reinvestment rate earned on the cash flows generated during a project's lifespan. The modified internal rate of return is calculated by establishing the present value of all the cash outflows of a project whilst comparing this value with the future value of all cash inflows at the end of a project's lifespan. The modified internal rate of return is calculated as the discount rate that will result in the present value of the cash outflows equalling the present value of the terminal value. This is represented by the following equation:

$$\text{PV cash outflows} = \frac{\text{FV of cash inflows}}{(1+\text{MIRR})^n}$$

g) The profitability index method: determines the relationship between the initial investment amount and the expected payoff of an envisaged project or the profitability in relation to the amount invested in the project. This is represented by the following equation:

$$PI = \frac{\sum_{t=1}^{n} \frac{C_t}{(1 + i)^t}}{C_0}$$

C_0 = Initial investment required

C_t = Cash flow in period *t*

i = Discount rate

Typically, a profitability index value of less than one is indicative of the eventual cash flows being less than the initial investment amount. As such, insufficient future cash flows exist to justify the initial investment.

The advantages and disadvantages of the various investment appraisal methods are depicted in Table 4.4.

Table 4.4: Advantages and disadvantages of investment appraisal methods

METHOD	ADVANTAGES	DISADVANTAGES
Average return method	• Measure can be utilised in comparing investments wherein the project lifespans are more or less the same	• Measure tends to be insensitive to fluctuations in cash flow across the project lifecycle • Measure does not account for the time value of money
Payback period method	• Measure can be utilised as a measurement of risk assuming that risk increases over time • Measure can be utilised as a criterion of liquidity as the more rapidly the initial investment is recovered, the earlier the generated cash is available for alternative use	• Payback period is subjective • Measure does not take into account cash flows that occur after the payback period which by implication does not address overall project profitability • Time value of money is not considered. • Cost of capital is not considered • Varying projects are not distinguished in terms of capital requirements and lifecycles

METHOD	ADVANTAGES	DISADVANTAGES
Discounted payback period method	• Measure considers the company's cost of capital when calculating the discounted values of expected future cash inflows	• Payback period is subjective • Cash flows are not considered after the discounted payback period has been reached thereby not displaying overall project profitability • Varying projects are not distinguished in terms of capital requirements and lifecycles
Net present value method	• Cash flows of the project along with associated discounts are appropriately utilised	• Calculations may be difficult to understand.
Internal rate of return method	• Measure has an intuitive economic meaning • Measure is appropriate for simple acceptance / rejection problems	• Calculations with respect to positive and negative cash flows are problematic • Assumed that interim positive cash flows are reinvested at the same rates of return as the project that generated them. This may result in an overly-optimistic picture of the investment scenario
Modified internal rate of return	• Measure is more realistic with regard to the reinvestment of cash inflows • Can be more appropriately-utilised in the evaluation of unconventional projects	• With respect to mutually-exclusive projects, calculations with respect to positive and negative cash flows are problematic

METHOD	ADVANTAGES	DISADVANTAGES
Profitability index	• Measure is one of the most appropriate methods when utilised in accepting or rejecting a decision that has to be made • Measure is useful in cases where investment funds are limited • Measure is particularly relevant to evaluating independent projects	• Mutually-exclusive projects are difficult to evaluate when utilising this measure

Source: du Toit *et al.* (2010)

4.6 INTANGIBLE INVESTMENT PERSPECTIVE AS A BASIS FOR THE ACCEPTANCE OF INTERVENTIONS

Measuring intangible elements is challenging given that objectivity forms the basis of any eventual measurement. Marr (2007) states that given the difficulty in measuring intangibles, intangible measurements should not as such be utilised as a measurement system to determine quantifiable value, but rather as a mechanism in which to guide decision-making and learning within the overall strategy of an institution. In this manner, behaviour and action is directed to stated targets.

4.6.1 Intangible Measurements

The National Development Plan (2030) lists numerous objectives and actions with respect to developing the capabilities of the country to ensure growth whilst raising the standard of living for all. In particular, reference to city development is to stimulate the economy whilst reducing unemployment, developing economic infrastructure and ensuring environmental sustainability and resilience. For the purposes of this study, these objectives have been adapted into the following intangible components:

- Building the middle class
- Integrating communities
- Leveraging public resources
- Linking the city to the regional economy

- Building leadership and partnerships
- Fostering policy reform

In addition to the tangible acceptance of identified interventions within the various themes of a sustainable city, a balance is sought with intangible measurements to direct longer-term performance. Essentially, intangible measurements are utilised to inform management decisions along with challenging strategic assumptions thereby allowing organisations, such as a city, to learn and improve continually (Marr, 2007). Therefore, for the purposes of this study, the stated intangible measurements served the basis of sustainable city decision-making within the context of the stated themes of a sustainable city.

4.6.2 Quantifying Intangible Measurements

As Marr (2007) states, intangible measurements should be utilised as performance assessors rather than that of measurements to go beyond the quantification and assignment of numerals. Value creation is thus ensured whereby the elements within the context of a city contribute to a sustainable business model.

a) Building the middle class: For the purposes of this study, each theme and intervention of sustainable city development was assessed on whether or not the intervention satisfies the identified components of building the middle class. The identified components of building the middle class included:
   - o Ensuring that each job within the identified intervention promoted sufficient wages and benefits. As such, as far as practically possible, salaries for employees within each component of each theme identified were assessed on the equity of wages and benefits offered.
   - o Determining the scale to which employment within each component of the respective themes was outsourced or not. Limiting outsourced employees were viewed as contributing to building the middle class.
   - o Determining the scale to which the workplace within each component of the respective themes was pro-family. Increased pro-family orientation was viewed as contributing to building the middle class.

b) Integrating communities: For the purposes of this study, each theme and intervention of sustainable city development was assessed on whether or not the intervention satisfied the identified components of integrating communities. The identified components of integrating communities included:
   - Extent to which each component within the respective themes contributed to the development of mixed income districts.
   - Extent to which each component within the respective themes contributed to the development and utilisation of public transportation.
   - Extent to which each component within the respective themes contributed to equal education amongst mixed income groups.
   - Extent to which each component within the respective themes contributed to equity of access with respect to opportunity and services.

c) Leveraging public resources: For the purposes of this study, each theme and intervention of sustainable city development was assessed on whether or not the intervention satisfied the identified components of leveraging public resources. The identified components of leveraging public resources included:
   - Involvement of stakeholders within each component of the respective themes within a variety of ways.
   - Pre-identification of the goals of the collaborative efforts of the varying components of the respective themes.
   - How quality standards would be promoted in the development and implementation within each component of the respective themes.

d) Linking the city to the regional economy: For the purposes of this study, each theme and intervention of sustainable city development was assessed on whether or not the intervention potentially linked the city to the regional economy. The identified components of potentially linking the city to the regional economy included:
   - Interventions within the respective themes contributed to core city development and, as such, contributed to successful regions.
   - Interventions within the respective themes contributed to the competitiveness of a city and by implication regional performance.

e) Building leadership and partnerships: For the purposes of this study, each theme and intervention of sustainable city development was assessed on whether or not the intervention contributed by way of building leadership and partnerships. For Bouton, Cis, Mendonca, Pohl, Remes, Ritchie & Woetzel (2013), the identified components of building leadership and partnerships included:
   - How interventions within the respective themes achieved smart growth by way of:
     - Adopting a strategic approach
     - Catering for change within concept development
     - Integrating environmental considerations
     - Promoting opportunities for all residents
   - How interventions within the respective themes were able to contribute to improved service delivery at a reduced cost by way of:
     - Exploring partnerships
     - Ensuring investment accountability
     - Embracing technology

f) Fostering policy reform: For the purposes of this study, each theme and intervention of sustainable city development was assessed on whether or not the intervention contributed by way of fostering policy reform. The identified components of fostering policy reform included:
   - How interventions within the respective themes were able to contribute to creating the demand for green innovation.

Based on the advantages and disadvantages of the stated tangible methods of assessment along with the applicability to the stated interventions to sustainable city development, a structure to evaluate the acceptance of sustainable projects was proposed.

4.7 STRUCTURE TO ASSESS A HYPOTHETICAL SUSTAINABLE CITY

Table 4.5 provides the tangible and intangible methods of measurement / assessment that were applied to the relevant interventions of sustainable city development along with the associated rationale thereof. Table 4.5 further expands on the identified interventions of sustainable city development (as developed in Chapter 3, Table 3.9),

by illustrating how the various themes of sustainable city development were assessed in terms of acceptance, calculated from a base population of 250,000.

Table 4.5: Proposed structure of tangible and intangible methods of assessment to the interventions of sustainable city development

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
Location	• Regional • Local area	• Tangible determination: o Gross Value Addition • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Linking the city to the regional and national economy o Building and sustaining leadership and partnerships	• Given that gross value addition can measure the value of goods and services produced within a particular locality, it is an appropriate tool in assessing the applicability of location. • Theme of location plays a critical role in contributing to the development of mixed income districts, the development and utilisation of public transportation, equal education amongst mixed income groups along with equity of access with respect to opportunity and services. • Theme of location influences city development and regional performance. • Theme of location influences integrating environmental considerations along with promoting opportunities for all residents.
Water	• Rainwater harvesting • Grey water utilisation • Reclaimed water utilisation	• Tangible determination: o Discounted payback period • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• Cost of capital is considered in conjunction with discounted values of expected future cash inflows. • Ensure equity of access with respect to opportunity and services. • Ensure water-related interventions contribute to creating the demand for green innovation.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
Sanitation	• Low diameter sewerage systems collect and discharge household wastewater from residences into low maintenance wastewater treatment plants • Shared septic tank system where a number of residents connect into one septic tank • Community sanitation centres	• Tangible determination: o Discounted lifetime costs • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• Cost of capital is considered in conjunction with discounted values of expected future cash inflows • Ensure equity of access with respect to opportunity and services. • Ensure water-related interventions can contribute to creating the demand for green innovation.
Compact cities	• Bulk infrastructure (water, sanitation and electricity) cost provisions	• Tangible determination: o Direct comparison of recurrent and capital costs of a compact city versus a city characterised by urban sprawl • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Leveraging public resources and assets for private investment	• Utilised by comparing investments wherein the project lifespans are more or less the same. • Theme of promoting densification plays a critical role in contributing to the development of mixed income districts, the development and utilisation of public transportation, equal education amongst mixed income groups along with equity of access with respect to opportunity and services. • Theme of densification and mixed land use development involves a range of stakeholders that required collaborative efforts and quality standards.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
		o Building and sustaining leadership and partnerships	• Increased densification and mixed use development could contribute to smart growth and improved service delivery at a reduced cost.
Public transport	• Creating universal transit passes • Parking cash-out • Bicycle facilities • Car sharing • Transportation resources centres	• Tangible determination: o NPV • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Leveraging public resources and assets for private investment o Fostering state level policy reform	• Enables one to assess cash flows of each project along with associated discounts. • Assessing how each component of public transportation theme contributes to the development and utilisation of an overall public transportation system • Theme of public transportation involves a range of stakeholders that required collaborative efforts and quality standards • Public transportation interventions could contribute to creating the demand for green innovation.
Energy	• Biomass • Wind power • Solar power	• Tangible determination: o NPV • Intangible determination: o Building the middle class o Building and sustaining leadership and partnerships	• Enables one to assess cash flows of each project along with associated discounts. • Ensuring that each job within the identified intervention promoted sufficient wages and benefits, the scale to which employment within each component of the respective themes is outsourced or not. • How interventions within the respective themes would achieve smart growth and how interventions

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
		o Fostering state level policy reform	were able to contribute to improved service delivery at reduced cost. • How interventions within the respective themes were able to contribute to creating the demand for green innovation.
Urban agriculture	• Urban agriculture scheme	• Tangible determination: o NPV • Intangible determination: o Building the middle class	• Enables one to assess cash flows of each project along with associated discounts. • Ensuring that each job within the identified intervention promotes sufficient wages and benefits. • Scale to which employment within each component of the respective themes was outsourced or not. Limiting outsourced employees were viewed as contributing to building the middle class. • Scale to which the workplace within each component of the respective themes was pro-family. Increased pro-family orientation were viewed as contributing to building the middle class.
Solid waste	• Property close systems • Drop off systems • Mandatory versus voluntary programmes	• Tangible determination: o NPV • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• Assess cash flows of the project along with associated discounts. • Ensure equity of access with respect to opportunity and services. • Solid waste related interventions could contribute to creating the demand for green innovation.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
Green buildings	• GBCSA's material assessment component	• Tangible determination: o NPV • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• Enables one to assess cash flows of each project along with associated discounts. • Ensure equity of access with respect to opportunity and services. • Building material related interventions could contribute to creating the demand for green innovation.
Air pollution	• Electric vehicles	• Tangible determination: o NPV • Intangible determination: o Leveraging public resources and assets for private investment o Fostering state level policy reform	• Enables one to assess cash flows of each project along with associated discounts. • Theme of electric vehicles involved a range of stakeholders that required collaborative efforts and quality standards • Electric vehicle interventions could contribute to creating the demand for green innovation.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Public health	• Responsive clinics • Access to clinic based on proportion of people with a certain radius of the clinic	• Tangible determination: o Cost effectiveness ratios • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities	• To illustrate the principles of cost effectiveness of primary health care interventions as opposed to locality specific analysis • Theme of health care played a critical role in contributing to the development of mixed income districts and equity of access with respect to opportunity and services.
Biodiversity	• Adjacent landscapes interventions • City interventions • City sector interventions • Individual lot interventions	• Tangible determination: o Consolidated ecosystem value • Intangible determination: o Leveraging public resources and assets for private investment o Building and sustaining leadership and partnerships	• Contingent valuation was used to estimate the value of use, option and existence. • Involves a range of stakeholders that will require collaborative efforts and quality standards. • Biodiversity can contribute to smart growth and improved service delivery at a reduced cost.
Child centred development	• Shared formal learning facilities • Informal learning facilities	• Tangible determination: o IRR • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities	• Measure can be utilised for simple acceptance / rejection problems. • Theme of child-centred development played a critical role in contributing to the development of mixed income districts and equity of access with respect to opportunity and services.

Source: Author's own compilation

Table 4.5 depicts, for the purposes of this study, the interventions of sustainable city development along with the intended basis of determining an investment within the respective intervention. This is categorised, per theme, into tangible and intangible elements.

4.8 HYPOTHETICAL SUSTAINABLE CITY CASE STUDY APPLICATION FOR ONE INTERVENTION

In determining the tangible and intangible acceptability of the identified interventions of sustainable city development, an initial application is made against one of the identified interventions, namely, the theme of energy and the associated intervention of photovoltaic power. Photovoltaic power was selected as the case study as the application of renewable energy in electric power systems is growing fast and was arguably the most prominent sustainable theme within the context of this study. The application and resultant outcome of the tangible and intangible determinants of photovoltaic were then confirmed via the testing of the process through identified city development experts. The outcomes of the testing exercise in applying the tangible and intangible measures specific to photovoltaic power were then considered and applied across all identified interventions of sustainable city development as further elaborated upon in Chapter 5. The identified tangible and intangible criteria relevant to energy provision from photovoltaic power are assessed in Table 4.6.

Table 4.6: Identified tangible and intangible criteria relevant to photovoltaic energy provision

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
Energy	• Photovoltaic power	• Tangible determination: o NPV	o Enables one to assess cash flows of each project along with associated discounts

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
		• Intangible determination:	
		o Building the middle class	o Ensuring that each job within the identified intervention promoted sufficient wages and benefits, the scale to which employment within each component of the respective themes was outsourced or not.
		o Building and sustaining leadership and partnerships	o How interventions within the respective themes would achieve smart growth and how interventions were able to contribute to improved service delivery at reduced cost.
		o Fostering state level policy reform	o How interventions within the respective themes were able to contribute to creating the demand for green innovation.

Source: Author's own compilation

As depicted in Table 4.6, a single tangible assessment criterion was applied to the intervention of photovoltaic power whilst three intangible criteria were applied.

For the purposes of this study, a base population of 250,000 was utilised. If one applies an average of four persons per household, this equated to 62,500 households. According to Eskom (2015), one megawatt of power could supply power to approximately 650 average households. For a base population of 250,000, this would equate to a 96MW plant.

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to photovoltaic power, these include application of use, scale and grid connections versus standalone installations.

In applying stated tangible and intangible measures to photovoltaic power, for the purposes of this study, the following applied with respect to key influencing factors:

- Application of use

According to Murphy, Ondechek, Bracho and McKenna (2014), partnerships between industry members, the entrepreneurial clean energy community and the financial industry can leverage resources that are needed to promote the development and commercialisation of clean energy technologies, which, in turn, can lead to the accelerated and global utilisation of clean energy. Murphy *et al.* (2014) further explains that the need for these partnerships is driven by global growth in energy demand along with the need for a spectrum of long-term environmental benefits. As such, for the purposes of this study, the application of use with respect to photovoltaic power within a city context would be within the context of a public private partnership where the city / municipality purchases power from a provider in the form of a stipulated power purchase agreement.

- Scale

As previously discussed, a base population of 250,000 people would typically require 96MW photovoltaic power plant. For the purposes of testing the application and resultant outcome of the tangible and intangible determinants of photovoltaic power, it was presumed that a full 96MW power plant would be developed. Chapter 5 then scales the identified interventions of sustainable city development in relation to one another to provide for a base population of 250,000.

- Grid connections versus standalone installations

For the purposes of this study, the photovoltaic installation was presumed to be grid connected purely based on the reasoning that the grid may be complimented with conventional energy supply should the need arise. Standalone installations would not allow for that flexibility.

Given the stated application of use, scale and grid connectivity, the following parameters would be relevant to an envisaged 96MW photovoltaic power plant. These parameters were selected based on initial investigations undertaken at the Nelson Mandela Metropolitan University (2015) for the establishment of a 1MW photovoltaic power plant. The assumptions provided related to the location of and envisaged PV

farm, namely, within Port Elizabeth, South Africa, temperature, orientation and the type of the PV panel that was utilised. Table 4.7 illustrates the assumptions and variables that shall apply to the envisaged establishment of a 96MW photovoltaic power plant.

Table 4.7: Assumptions and variables to the establishment of a 96MW photovoltaic power plant

PV Yield	161,760,000	kWh per year
Municipality rate- Year 1	R1.00	per kWh
Inflation	6.5%	Per year

Source: NMMU (2015)

As depicted in Table 4.7, it was assumed that a 96MW photovoltaic power plant would result in an annual yield of 161,760,000 kWh per year. This was based on factors such as local climatic conditions, and a municipal energy tariff R1 per kWh was assumed.

In addition to information contained within Table 4.7, further parameters that would influence the tangible measurements of net present value with respect to the establishment of a 96MW grid tied PV system were:

- Hypothetical 96MW PV system were grid tied
- Approximate PV yield equates to 161,8 MWh
- Solar service provider installed and managed the PV installation. By implication, a local authority would enter into a power purchase agreement with the solar service provider over a ten year period wherein the local authority purchases energy produced by the solar service provider at pre-determined tariffs.
- No capital outlay was required by the local authority

Table 4.8 depicts the net present value to a local authority over a twenty-year period wherein a ten year power purchase agreement was entered after which the running of the facility was managed by the local authority after ten years. The local authority purchased power from solar power producer as opposed to a state entity such as Eskom.

Applying the net present value calculation to an envisaged 96MW photovoltaic power plant is depicted in Tables 4.8 and 4.9.

The basis of the calculations in Table 4.8 is that a local authority would enter into a power purchase agreement with the independent solar service provider for an initial period of ten years. The independent solar service provider would provide all capital equipment at his / her own cost. After a ten year period, the local authority would have the option to renew the power purchase agreement or to inherit the capital equipment as part of the power purchase agreement and operate the photovoltaic farm on its own.

Table 4.8: NPV Calculation for 96MW power plant based on an envisaged PPA with an independent solar service provider

Assumptions and Variables		
PV Yield	161,760,000	kWh per year
NMBM Rate Year 1	R 1.00	per kWh
Inflation	6.5%	per year

Energy Costs (Conventional) vs Energy Costs (Solar Service Provider) Year 1-10						
Year	**Power Purchase Agreement Cost**	**Typical anticipated conventional power increase**	**Conventional Power Cost**	**Conventional Cost – Power Purchase Agreement Cost**	**Cumulative Saving (Break-even Analyses)**	**Annual Savings NPV**
1	R 274,992,000	0%	R 161,760,000	R -113,232,000	R -113,232,000	R -113,232,000
2	R 291,168,000	15%	R 186,024,000	R -105,144,000	R -218,376,000	R -98,726,761
3	R 308,961,600	15%	R 213,927,600	R -95,034,000	R -313,410,000	R -83,787,608
4	R 326,755,200	15%	R 246,016,740	R -80,738,460	R -394,148,460	R -66,839,261
5	R 347,784,000	15%	R 282,919,251	R -64,864,749	R -459,013,209	R -50,420,867
6	R 367,195,200	14%	R 322,527,946	R -44,667,254	R -503,680,463	R -32,601,773
7	R 389,841,600	13%	R 364,456,579	R -25,385,021	R -529,065,484	R -17,397,221
8	R 414,105,600	12%	R 408,191,369	R -5,914,231	R -534,979,715	R -3,805,845

9	R 438,369,600	11%	R 453,092,419	R 14,722,819	R -520,256,896	R 8,895,987
10	R 464,251,200	10%	R 498,401,661	R 34,150,461	R -486,106,435	R 19,375,374
Energy Costs (Conventional) vs Energy Costs (Solar Service Provider) Year 11-20						
11	R -	10%	R 548,241,827	R 548,241,827	R 62,135,392	R 292,062,695
12	R -	10%	R 603,066,010	R 603,066,010	R 665,201,402	R 301,661,000
13	R -	10%	R 663,372,611	R 663,372,611	R 1,328,574,013	R 311,574,741
14	R -	10%	R 729,709,872	R 729,709,872	R 2,058,283,885	R 321,814,287
15	R -	10%	R 802,680,859	R 802,680,859	R 2,860,964,745	R 332,390,343
16	R -	10%	R 882,948,945	R 882,948,945	R 3,743,913,690	R 343,313,970
17	R -	10%	R 971,243,840	R 971,243,840	R 4,715,157,529	R 354,596,588
18	R -	10%	R 1,068,368,224	R 1,068,368,224	R 5,783,525,753	R 366,249,997
19	R -	10%	R 1,175,205,046	R 1,175,205,046	R 6,958,730,799	R 378,286,382
20	R -	10%	R 1,292,725,551	R 1,292,725,551	R 8,251,456,350	R 390,718,329
Totals	R 3,623,424,000		R 11,874,880,350	R 8,251,456,350	-	R 2,954,128,359

Source: NMMU (2015)

Table 4.9 illustrates the net present value to a possible institution such as a local authority wherein power is purchased from an independent solar service provider through a power purchase agreement for a stipulated period of time

Table 4.9: Net Present Value Calculation for 96MW power plant based on the independent solar service provider's perspective

Service Provider Perspective		
Year	**Service Provider NPV of Income**	**Financed System NPV of PMT**
1	R 274,992,000	R -2,844,388
2	R 273,397,183	R -2,670,787
3	R 272,398,863	R -2,507,781
4	R 270,503,996	R -2,354,724
5	R 270,340,534	R -2,211,009
6	R 268,008,740	R -2,076,065
7	R 267,171,749	R -1,949,356
8	R 266,479,527	R -1,830,382
9	R 264,876,584	R -1,718,668
10	R 263,394,417	R -1,613,773
	R 2,691,563,592	R -21,776,934

Source: NMMU (2015)

Considering the NPVs for the two scenarios as indicated in Table 4.8 and Table 4.9, the scenario in Table 4.8 is preferable.

Table 4.8 illustrates a net present value, to a potential local authority, of R2,954,128,359 for a twenty-year period for a 96MW photovoltaic based on a potential power purchase agreement with an independent solar service provider. Although a 96MW photovoltaic power plant has been utilised as a basis of calculation for an envisaged population of 250,000, the initial energy costs payable to an independent solar service provider may be deemed as prohibitive. This, however, did not detract from the principle of entering into a power purchase agreement albeit at a reduced megawatt capacity. The net present value would still reflect positively. This was all

dependent on the resources of a typical local authority. Both parties, namely, the local authority and the independent solar service provider, therefore, benefited in entering into a power purchase agreement.

Measuring intangible measurements, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible measurements relevant to the theme of photovoltaic power included building the middle class, building leadership and partnerships and fostering policy reform.

a) Building the middle class

Elements relevant to building the middle class included equity of wages along with the extent of outsourcing within that particular theme. Table 4.10 illustrates employment factors relevant to various forms of energy generation as applicable to South Africa. Although minimum wage is governed by legislation in South Africa, the current and future employment potential of the photovoltaic industry as depicted in Table 4.10 indicates a greater leaning towards job security in the photovoltaic energy production sector.

Table 4.10: Employment factors per energy sector

	CMI JOBS		O&M AND FUEL	
	Construction / installation	Manufacturing	Operations and Maintenance	Fuel
	Job years/MW		Jobs/MW	Jobs/GWh
Coal (existing and refurbished)	5.2 (local)	1.5	0.3 (local)	0.13 (local)
Supercritical coal	10.4 (local)	1.5	0.294 (local)	0.11 (local)
Gas, oil and diesel	6.2	0.07	0.09	0.22
Nuclear	10.8	1.2	0.66 (local)	0.002
Biomass	6.9	0.8	5.51	0.4

	CMI JOBS		O&M AND FUEL	
	Construction / installation	Manufacturing	Operations and Maintenance	Fuel
	Job years/MW		Jobs/MW	Jobs/GWh
Hydro	19.4	0.9	0.04 (local)	
Wind	4.5	22.5	0.72	
Photovoltaic	52.3	16.8	0.73	
Geothermal	5.6	5.9	1.33	
Solar thermal	10.8	7.2	0.54	
Ocean	16.2	1.8	0.58	
Solar water heating	11.7 (local)	10.7 (local)		
Energy efficiency	0.5 jobs per GWH			

Source: Rutovitz (2010)

As illustrated in Table 4.10, the photovoltaic energy sector has the potential to create 52.3 construction jobs years per MW, 16.8 manufacturing job years per MW and 0.73 jobs per MW with respect to operations and maintenance. This compares favourably against the current coal energy sector.

According to EScience Associates, Urban-Econ Development Economists & Ahlfeldt (2013), the photovoltaic industry in South Africa can achieve local content levels of between 39% and 59%. This local content can potentially increase to 66% with the addition of short-term manufacturing capabilities. Further localisation efforts and investment in local capabilities are also possible through (EScience Associates, 2013), namely:

- Local content encouragement by offering preferential financing for projects involving local companies
- Technology risk sharing by government of locally-manufactured components

- Scaling-up of existing manufacturing facilities support as opposed to the construction of new facilities

Given existing local content levels along with the potential to increase local content within the photovoltaic energy sector, the potential for mass outsourcing relevant to the photovoltaic energy sector appeared relatively low thus satisfying one of the intangible criteria relevant to sustainable city development.

b) Building leadership and partnerships

Elements relevant to building leadership and partnerships included the achievement of smart growth within a city along with ensuring improved service delivery at a reduced cost. Smart growth, within the context of city development, might be broadly-defined as development that protects natural resources and reduces energy consumption whilst improving municipal finances. Photovoltaic interventions with respect to energy supply to a city might be viewed as a 'smart growth' intervention.

Given existing human resources and financial capacity constraints within South African municipalities, private sector involvement in utility development could be viewed as one of the mechanisms to ensure improved service delivery. Utility development allowed for the leverage of private capital to achieve service delivery targets as private role players share in the risks and rewards of particular projects. Privately-financed photovoltaic development, to contribute to a city's energy needs, was a potential mechanism to ensure improved service delivery.

c) Fostering policy reform

Elements relevant to fostering policy reform included creating the demand for green innovation. According to the World Bank (2012), green innovation, which includes the creation and commercialisation of technologies along with the diffusion and adoption thereof, is a key element to greening growth processes. Achieving green growth requires green innovation policies, along with environmental policies, to create demand where traditional environmental externalities are not fully-reflected in the market price (World Bank, 2012). The use of photovoltaic power amounts to green innovation through the application of innovation in industrial policy tools.

In summary, the intangible measurements relevant to the generation of energy through photovoltaic power are depicted in Table 4.11.

Table 4.11: Intangible measurements: Photovoltaic energy

	BUILDING THE MIDDLE CLASS (a)			BUILDING LEADERSHIP AND PARTNERSHIPS (b)		FOSTERING POLICY REFORM (c)	OVERALL WEIGHTING
	Equity of wages	Scale of outsourcing	Pro-family orientation	Achievement of smart growth	Improved service delivery at reduced cost	Create demand for green innovation	
Photovoltaic energy	Yes	Yes	n/a	Yes	Yes	Yes	
Weighting	1.0	1.0	-	1.0	1.0	1.0	5.0

Source: Author's own compilation

As depicted in Table 4.11, photovoltaic energy provision, for the purposes of this study, satisfied the stipulated intangible measurements of sustainable city development. A weighting of 1 was assigned to each category that satisfied the intangible measurements of sustainable city development. This resulted in an overall weighting of 5.0. This intangible weighting was compared to the additional interventions of sustainable city development as discussed in Chapter 5.

Developing tangible and intangible methods for the assessment of sustainable city development, prior to the associated determination of financing methods and / or tools, resulted in a far more expansive sustainability assessment as opposed to determining appropriate finance methods and / or tools alone. This is supported by Callahan and Pisano (2015) who state that the future of environmental sustainability will be determined by the capacity of the varying levels of government to develop fiscal sustainability. Callahan and Pisano (2015) further explain that in the past, environmental sustainability has been disconnected from financial decisions wherein the financing of operations have had a short-term focus. As such, the goals of environmental sustainability along with financial sustainability were viewed to be both unattainable and incompatible. By altering the decision-making process to display the immediate and long-term costs and benefits, actual environmental and fiscal returns on investment could occur through the alignment of those who benefit and those who pay (Callahan & Pisano, 2015).

Sharif (2014) identifies that cities across the globe are competing to become environmentally-friendly and investor-friendly destinations. As such, there is a greater

need for municipalities to tap into alternative sources of funding to deal with the challenges of transportation, water availability, sewerage and other infrastructural-related items (Sharif, 2014). Prior to sourcing alternative forms of funding, the acceptance of a respective intervention, be it in the form of transportation, water provision or energy provision, needed to be determined both from a tangible and intangible perspective.

Rai, Funkhouser, Udwin and Livingston (2015) state that venture capital in clean energy technologies has since the late 1990s experienced irregular investment activity, which by implication has resulted in scepticism in innovation owing to perceived notions of required capital intensity and policy risk. This investment activity has now transformed, as sector-wide learning with respect to government agencies, financial venture capital and strategic corporate investment has resulted in a greater appetite for clean energy technologies albeit within heterogeneous approaches and mechanisms (Rai *et. al.*, 2015). Increased heterogeneous approaches and mechanisms for the development and financing of interventions that related to the sustainable development of a city could only but contribute to the potential for increased sustainability within cities.

Furthermore, Jimenez (2014) asserts that local government is a system that functions much like a market-like arrangement whereby citizens or consumers are offered a choice of jurisdictions offering varying bundles of public services and taxes. Although this arrangement may facilitate class-based population sorting, it is possible that the public market enhances the power of all consumers whereby communities are able to ensure that their government responds to their service needs (Jimenez, 2014). This is only ensured if institutional and policy responses effectively address issues of economic segregation and fiscal disparity (Jimenez, 2014).

Migendt, Schock, Taube, von Flotow and Polzin (2014) state that innovation systems that seek to address climate change often neglect the financial framework in which to do so. Financing innovation may be mentioned, however, it rarely ventures beyond venture capital as part of an entrepreneurial support network (Migendt *et. al.,* 2014). As such policy-makers need to be aware constantly of the interdependent nature of policy-making with respect to innovation and finance. Financing innovation requires

an understanding of financial markets along with the impact of operating within an innovative environment (Migendt *et. al.*, 2014).

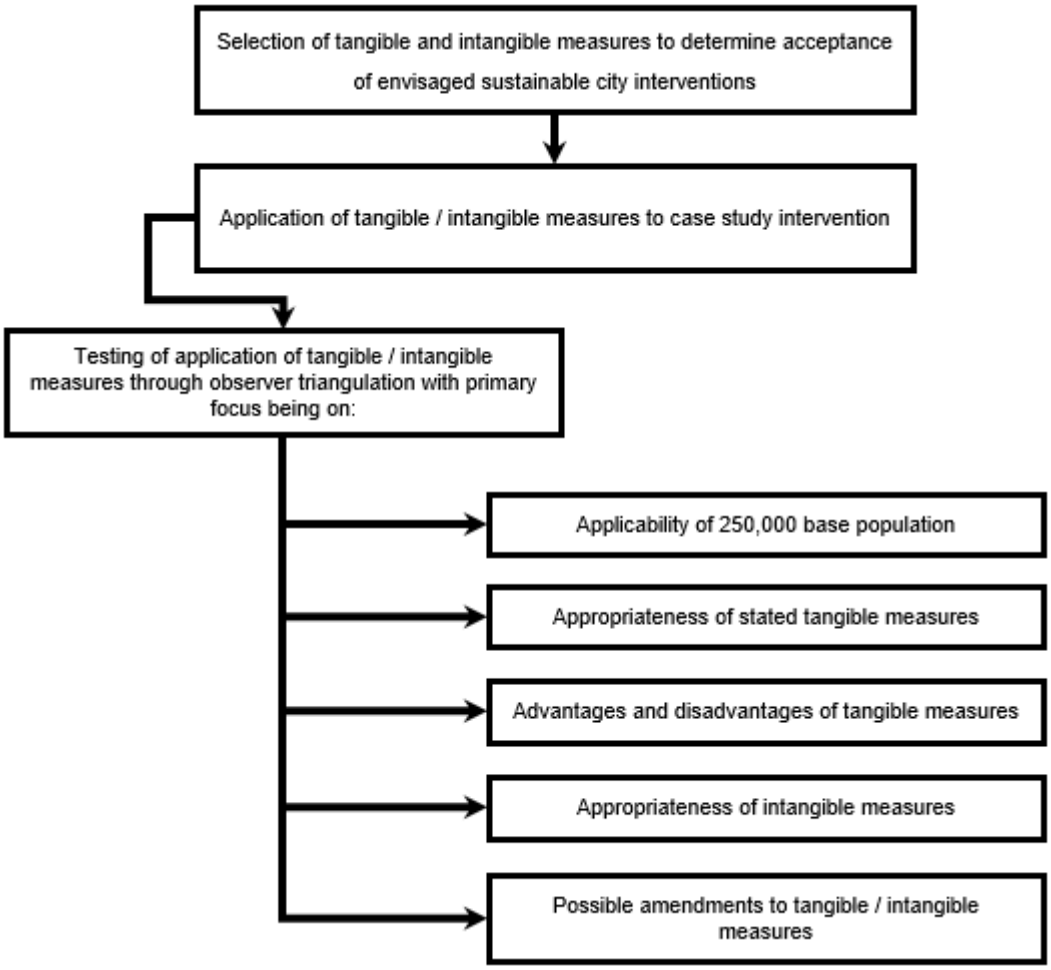
In addition, for innovation and finance, Zeynalov (2013) argues that the abundance of natural resources does not guarantee sustainable economic growth. Rather good institutional governance is key to sustainable economic development. In addition, resource abundance needs to be accompanied by good governance in the form of accountability, political stability, adequate regulations along with powerful anti-corruption policies (Zeynalov, 2013).

PriceWaterhouseCoopers (2014) further state that capital project viability, and the resultant access to funding, are the most common challenges emerging from the African continent with respect to necessary infrastructure development. PriceWaterhouseCoopers (2014) also stipulate that in order to address this issue, African countries must address issues of inadequate regulatory frameworks, capacity limitations, political instability, policy incoherence and corruption.

4.9 APPRAISAL OF TANGIBLE AND INTANGIBLE TOOLS

The appraisal of tangible and intangibles measures as a basis of determining acceptability occurred via the means of reviewer input. City development expert reviewers were used as independent reviewers to evaluate the tangible and intangible measures (as part of the hypothetical case). The independent reviewers interviewed in this study included professionals within the realm of city planning and development. The process followed is depicted in Figure 4.3.

Figure 4.3: Appraisal of tangible and intangible measures as a basis of determining acceptability



Source: Author's own compilation

Interviews were scheduled to elicit information from independent city developer experts. It should be noted that only four interviews were reported as saturation of information took place during interviews five and six.

Brief profiles of those city development experts that participated in the independent reviews to ascertain the appropriateness of identified tangible and intangible measurements and methods included:

- Profile: City development expert 1

  City development expert 1 was a professional engineer with diverse experience from industrial and retail development to public sector management and consulting in IT and engineering services. Her specialities included infrastructure planning,

procurement, empowerment, value-driven management, urban, town and transportation planning, project marketing and solution determination along with infrastructure economics.

City development expert 1 was currently employed as the Executive Director: Utilities for a major city within South Africa. She was responsible for utility services including electricity, solid waste as well as water and sanitation for the metropolitan area. The municipality provided basic utility services to over a million households ranging from informal settlements, backyard homes to formal freehold and cluster housing, and aspired to do so in a sustainable, equitable and affordable way.

- Profile: City development expert 2
  City development expert 2 was a director of a unit at a well-known university. He was an expert in differential patterns of urbanism, African urbanism, regional development policy, long-term strategic planning, cultural planning and politics along with sustainable development.

  City development expert 2's current research interest included various aspects of the city, how to theorise it from the vantage point of emergent urbanisms in the global South but also how to think about meaningful policy discourses and interventions to make the city more just, open and accessible for all who choose to make it a place of dwelling or a node in an ongoing journey.

- Profile: City development expert 3
  City development expert 3 had been with a well-known university within South Africa for over thirty-nine years. Over this time, he had become one of the university's most respected scholars. He was author or co-author of nine books and over 200 monographs and articles on city and regional planning. He also consulted widely in Southern Africa and had been core consultant to the City of Cape Town in drawing up a spatial development framework for the city.

- Profile: City development expert 4
  City development expert 4 was an expert in city growth management and planning along with development planning and facilitation unit. Currently, he was employed in the city of Cape Town, and took a strategic view of planning across the city and

was responsible for the development of the spatial development framework (SDF) for the city and its related strategies.

The basis of the interviewee input was based on their comments on the following:

- Selection of stated tangible and intangible measures as a determining factor in assessing the acceptance of sustainable city development
- Application of the stated tangible and intangible measures to the varying themes and associated interventions of sustainable city development.
- Applicability of a 250,000 base population as a foundation from which to assess sustainable city development
- Case study outcome of stated tangible measures of sustainable city development
- Perceived advantages and disadvantages of the stated tangible measures of sustainable city development
- Case study outcome of stated intangible measures of sustainable city development
- Possible amendments to the stated tangible and intangible measures to sustainable city development

Appendix A depicts the interview schedule that was used in this study. Within the interview schedule, an introduction and background was presented to the participants to provide context to the study. The framework of the study was then presented along with how sustainability interventions, tangible measures and intangible measures would be utilised. The results of the case study were then presented to the interviewees, and questions related to the interview schedule were asked.

The subsequent feedback from the interviews is reflected in Table 4.12.

Table 4.12: Feedback from interviews

THEME	INTERVIEWEE'S FEEDBACK	COMMENT
The concept / context of a sustainable city	The study should clarify: • What the current service delivery responsibilities of city government, provincial government and national government are • What the regulatory obligations of a city are	A distinction was made within the proposed model (see Chapter 7), as to where sustainable city interventions and the associated financing mechanisms should be applied.
	The study should elaborate upon how cities within South Africa are typically-financed. The current fiscal framework needed to be demonstrated.	Chapter 6 identifies fiscal frameworks available to local government. Key to the study, however, was the application of financing tools and instruments to the identified components of sustainable city development.
	For the purposes of this study, it was important to depict what the responsibility of the city was in relation to sustainable development along with those pre-conditions that must be established prior to interventions that sought to promote sustainable development.	Pre-conditions for identified role players within the respective interventions of sustainable city development are included in Chapter 6 as a precursor to the financing mechanism / tool per area of intervention.
	For the purposes of this study, it was important to be explicit in terms of what a city had control of and what it did not, for example, land and the application of land tax.	This is addressed in Chapters 6 and 7 for sustainable city development per identified intervention area.

THEME	INTERVIEWEE'S FEEDBACK	COMMENT
	Should the study address the issue of progressive taxes or not as a mechanism of financing sustainable city development?	This is discussed in Chapters 6 and 7 for sustainable city development per identified intervention area.
	The theme of overall education should be added to the identified themes of sustainable city development rather than just focussing on child-centred development. A city becomes more competitive with the increase education of its citizens.	The theme of education is in Chapter 5 of the study.
	Institutions with larger populations would have larger institutional capacity. The potential tax base of larger cities must be considered. Institutional capacity was a major issue within the South African context.	Institutional capacity would be one of the key pre-conditions relative to interventions that relate to sustainable city development.
	Infrastructure in South Africa was too capital intensive. Infrastructure development needed to be more labour intensive.	To a certain extent this issue was addressed within the intangible measurements of 'building the middle class' and the newly-added 'poverty reduction' category. The debate over capital intensive infrastructure versus labour intensive infrastructure was arguably a study on its own.

THEME	INTERVIEWEE'S FEEDBACK	COMMENT
Applicability of the selected 250,000 base population as the basis of a hypothetical city	The socio-political dimension per intervention needed to be clarified upfront, for example, a particular utility might not necessarily need be a government function.	In addition to the pre-conditions relevant to the respective interventions of sustainable city development that is included in Chapter 6 as a precursor to the financing mechanism / tool per area of intervention, the applied socio-political dimension would also be addressed.
	It was necessary to identify current international tendencies in relation to cities. Aspects such as growth, economic globalisation and the rate at which jobs were being shed, how urban economies currently tended to be shedding jobs, how a vibrant local market was a pre-condition to jobs, the issue of water scarcity, the resultant importance of local water capture, food security and fossil fracking dependents needed to be included.	The nature of sustainable cities was elaborated within the study particularly with reference to the principles of sustainable development and their relation to the dimensions of economic, social and ecological development.
	It should be emphasised that the 250,000 base population was a starting point. Reference should also be made to the concept of city thresholds.	This is discussed in Chapter 4 of the study.
	In detailing what comprised a sustainable city, recognition must be given of the notion that a city was a metabolism wherein inputs, outputs and throughputs existed.	The identified interventions of sustainable city development needed to be assessed in terms of the scale, extent and contribution to city functioning. Hence the assessment was needed from both a tangible and intangible perspective.

THEME	INTERVIEWEE'S FEEDBACK	COMMENT
	The 250,000 base population needed to be framed in relation to a South African context, for example, how a 250,000 population compared to the actual population of Grahamstown.	To a certain extent, this was encapsulated within Chapter 4 of the study wherein reference was made to city size within towns and cities within the South African context.
	Recognition should be given of the typical socio-economic profile a population of 250,000 would entail. For example, how many of the stated population were economically-active?	Chapter 7 deals specifically with how poverty alleviation is addressed through possible sustainable city interventions and their associated financing mechanisms.
	Recognise that typically within South African cities, 60% of the population earn below R3,500 per month. Income distribution, therefore, was an issue.	Chapter 7 deals specifically with how poverty alleviation is addressed through possible sustainable city interventions and their associated financing mechanisms.
Appropriateness of stated tangible measures	Within the context of tangible feasibility, it was important to consider the government's greatest asset, namely, land. To what extent could government provide land whilst allowing private sector to implement, namely, the principle that government provided land at greatly-reduced prices.	This issue is discussed in Chapters 6 and 7 for sustainable city development per identified intervention area.
	City planners did not generally utilise economic measures in the assessment of sustainable city development. As such, the stated tangible measures were suitable.	This issue was included within Chapter 4 of the study.
	Quantitative analysis in city planning was becoming more and more important. The stated tangible measures contributed to the quantitative approach.	This issue was included within Chapter 4 of the study.

THEME	INTERVIEWEE'S FEEDBACK	COMMENT
Appropriateness of intangible measures	The stated intangible measures were adequate. It was important that the intangible measures or the resultant weighting of them were not complicated.	This issue was included within Chapter 4 of the study.
	The intangible measure of 'building the middle class' was good as this component was often ignored owing to the focus being on poverty reduction.	This issue was included within Chapter 4 of the study.
	Intangible measures should be utilised to assist in decision-making. As such, they could not be overly-definitive. The study captured the intangible measures well.	This issue was included within Chapter 4 of the study.
Possible amendments to tangible / intangible measures	An intangible measure of poverty reduction should be added.	Poverty reduction is addressed specifically within Chapter 7.
	There should be recognition that the extent of rate payers within a city were diminishing. There should also be recognition on questioning the rate of return of investment on grant funding that was currently applied to city government.	This issue is addressed in Chapters 6 and 7 for sustainable city development per identified intervention area.
	The study should look at how intersections could be optimised, namely, how services within varying sectors such as water and sewerage were integrated? What were the mechanisms for interdependencies?	This issue is addressed in Chapters 6 and 7 for sustainable city development per identified intervention area.
	Within the sectoral interdependencies, network services and social development services should be integrated.	This issue is addressed in Chapters 6 and 7 for sustainable city development per identified intervention area.

Source: Author's own compilation

Table 4.12 depicts the feedback received from the interviewees. It should be noted that the responses in Table 4.12 included all responses and they were not linked to a particular participant. The issues that were raised were addressed within the respective chapters of the study as indicated in Table 4.12.

4.10 SUMMARY

In Chapter 4, a hypothetical city with set population parameters and growth trajectories was developed. Within the hypothetical city, the structuring elements of the city was described inclusive of the themes and associated interventions of sustainable city development. From thereon, tools and instruments were proposed to determine the sustainability of the varying themes and associated interventions of sustainable city development. A case study was prepared demonstrating the outcome of the tangible and intangible tools and instruments utilised in an acceptability assessment. Only one intervention, namely, photovoltaic energy was used to illustrate the case of a hypothetical city. The tools and instruments along with the associated outcomes were confirmed through interviews with city development experts. In Chapter 5, tangible and intangible criteria for sustainable city development are applied across all the identified themes and interventions of sustainable city development.

CHAPTER FIVE

TANGIBLE AND INTANGIBLE MEASURES OF SUSTAINABLE CITY DEVELOPMENT

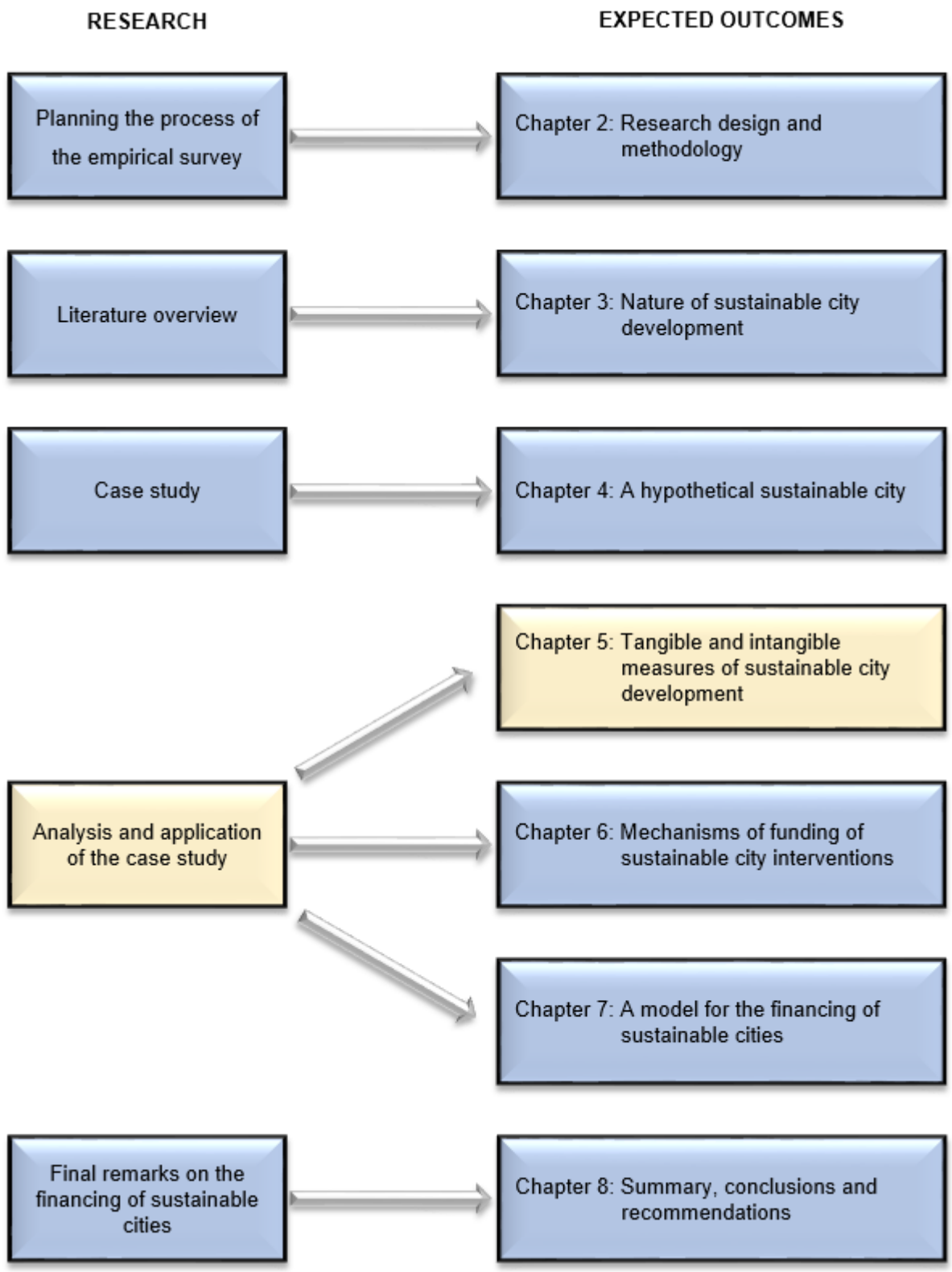
5.1 INTRODUCTION

In Chapter 4, a hypothetical city with set population parameters and growth trajectories was developed. Within the hypothetical city, the structuring elements of the city was described inclusive of the themes and associated interventions of sustainable city development. From thereon, tools and instruments were proposed to calculate the acceptability of the varying sustainability themes and associated interventions for sustainable city development. A case study was prepared demonstrating the outcome of the tangible and intangible tools and instruments utilised in an acceptability assessment for one intervention. The tools and instruments along with the associated outcomes were evaluated through interviews with city development experts. In Chapter 5, tangible and intangible criteria for sustainable city development are applied across all the identified themes and related interventions of sustainable city development. The identified themes (see Table 4.5) include location, water, sanitation, compact cities, public transport, energy, urban agriculture, solid waste, green buildings, air pollution, public health, biodiversity and child-centred development.

5.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 5.1.

Figure 5.1: Study framework



Source: Author's own compilation

As depicted in Figure 5.1, this study comprises of eight chapters. Chapter 5 relates to tangible and intangible measures of sustainable city development.

5.3 TANGIBLE CRITERIA ACROSS VARYING THEMES

Tangible criteria per the varying themes of sustainable city development are discussed in the following paragraphs.

5.3.1 Location

Table 3.9 lists the key influencing factors that may influence interventions with respect to sustainable city development. With respect to location these include.

- Spatially-referenced gross value addition (GVA)
  According to van Huyssteen, Biermann, Naude and le Roux (2009), spatial analysis has the potential to contribute to the understanding of economic spatial patterns along with the associated implications of development policies. Understanding the spatial economy of a region or locality allows for context specific investment and policy responses. Spatial relational and accessibility analysis, such as the accessibility to economic activities along with the accessibility to services, allows for a more nuanced understanding of spatial dynamics (van Huysteen *et al*., 2009). Through a greater understanding of spatial dynamics, the application of spatially-referenced gross value addition (GVA) across the South African landscape has highlighted the impact of the economic and labour market circumstance on development across the country. As van Huysteen *et al*. (2009) state, the application of spatial analysis utilising spatially-referenced gross value addition (GVA) among one of the tools of analysis, facilitates the consideration of diverse and context specific government interventions and investment with respect to varying localities across South Africa.

  The CSIR (Council for Scientific and Industrial Research) in South Africa has performed this spatial analysis by linking localities across South Africa to the regional and national economy through their Geospatial Analysis Platform (GAP) as reviewed in 2011. The Geospatial Analysis Platform (GAP) seeks to articulate a set of spatial priorities and criteria as one of the mechanisms to inform and co-ordinate planning and investment. This was done by demarcating South Africa into

25,000 mesozones, each approximately 50km² in size. These mesozones contained information relating to levels of human activity, linkages to a strategic national road network and where spatial interaction modelling was used to calculate a range of accessibility and proximity measures. The outcome was an enhanced understanding of human / economic geography and the associated interactions within the built and national environment along with profiling local development magnitudes such as needs, potentials, service and economic accessibility levels. As such, volumes of economic activity could be gauged relevant to certain economic sectors of GVA along with overall GVA. Furthermore, indicators such as demands on infrastructure and ecosystem services could be derived thereby providing a basis of investment, which should influence future financing directives.

van Huysteen *et al*. (2009) state that the application of South African mesoframe approach has contributed to a capability link across territorial boundaries wherein relational economic activity between varying regions is displayed. This allowed for a robust basis for the modelling of how economically-active persons, households and enterprises position themselves along with linking across local, nearby and distant economic / livelihood spaces. This has significant implications on where institutions should consider planning for and developing interventions that relate to future sustainable city development.

Although, for the purposes of this study, appropriate location were pre-determined given economic activity within an area, Polese (2013) highlights applicable principles with respect to city location that need to be considered within the context of preferential location based on economic activity, namely:

- No locational advantage is eternal. A new technology may possibly undermine a city's economy overnight. As such, advocating new technologies in support of city development, such as energy provision in the form of wind power and solar energy, can enhance locational advantage.
- Accessible, well-connected cities exhibit higher growth. A key component contributing to the measure of GVA as per Figure B.1 (see Appendix B) is accessibility and connectivity.

- Every industry leaves an imprint on a city. Should a single industry dominate a local economy the long-term effects could potentially be devastating should that particular industry suffer decline. Within the context of city development, diversity with respect to sustainable development provides the opportunity for multiple industries.
- Good governance and appropriate policies do matter.

5.3.2 Water

The theme of water included rainwater harvesting, the utilisation of grey water along with the utilisation of reclaimed water.

(i) RAINWATER HARVESTING

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to rainwater harvesting, these included:

- Reducing the total consumption of water
  - According to UN-Habitat (2009), rainwater harvesting may assist with the problem of water scarcity through the efficient collection and storage of water which enables greater accessibility along with serving as a substitute for poor quality water.
- Reducing the dependence on large-scale water capture systems
  - According to UN-Habitat (2009), rainwater harvesting provides for an alternative source of suitable water quality either seasonally or all year round. Furthermore, the harvesting of rainwater has less of an environmental impact as opposed to other technologies for water resources development (UN-Habitat, 2009).
- Distinguishing between centralised and decentralised provision of infrastructure
  - Rainwater harvesting systems have the advantage of being individual and community / utility-operated and managed (UN-Habitat, 2009).

Tables B.1 and Table B.2 in Appendix B provide the parameters utilised for calculating the payback period of a rainwater harvesting system. Table B.3 lists the assumptions and variables used for such a calculation.

Table B.4 (Appendix B) illustrates the discounted payback period relevant to an individual household rainwater harvesting system. As depicted in Table B.4 (see Appendix B), the initial R15,000 investment was not be paid back at a discount rate of 10% over a twenty-year period. The actual payback period equated to 24.396 years. This implied that it was not acceptable, from a financial perspective, to invest in an individual household rainwater harvesting system. This was relevant to both an individual home owner or to that of a local authority should they consider the potential rollout of a local authority supported household rainwater harvesting system intervention. Although local municipalities should not seek to fund such interventions on a major scale, they must, however, be cognisant of water scarcity issues. As such the onus should be placed on homeowners, considering socio-economic statuses, to ensure water conservation through the application of mandatory punitive measures.

(ii) UTILISATION OF GREY WATER

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to the utilisation of grey water, these included:

- Reducing the total consumption of water
  - According to NSW (2008) utilising grey water from residential premises can assist in substituting grey water for drinking water, thus reducing the demand on drinking water supplies along with reducing the amount of wastewater discharged into the environment.
- Reducing the dependence on large-scale water capture systems
  - Grey water is generated from every residential household and has the potential to be reused as a source of water that does not require drinking water (NSW, 2008). This includes water utilised for irrigation purposes, toilet flushing and washing machine use. Potential dependency is thus reduced on large-scale water capture systems.
- Distinguishing the between centralised and decentralised provision of infrastructure
  - Grey water systems, for the purposes of this study, related to individual household systems thus implying a decentralised provision of infrastructure.

A residential grey water treatment system collects, stores and treats grey water for the purposes of reuse with respect to irrigation, toilet flushing and washing machine use (NSW, 2008). Table B.5 (see Appendix B) demonstrates the assumptions and variables utilised in establishing an envisaged household grey water system.

Table B.6 (see Appendix B) illustrates the discounted payback period relevant to an individual household grey water system. As depicted in Table B.6 (see Appendix B), the initial R11,800 investment was paid back at a discount rate of 10% over a 8.592 years.

This implied that it was acceptable, from a financial perspective, to invest in an individual household grey water system. This was relevant to both an individual home owner or to that of a local authority should they consider the potential rollout of a local authority supported household grey water system intervention.

(iii) UTILISATION OF RECLAIMED WATER

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to the utilisation of reclaimed water harvesting, these included:

- Reducing the total consumption of water
  - Water reuse through the application of reclaimed water can be employed as a water conservation practice thereby ensuring the decreased diversion of fresh water from available ecosystems (Haering, Evanylo, Benham & Goatley, 2009).
- Reducing the dependence on large-scale water capture systems
  - Reclaimed water provision has the potential to reduce the use of potable water by industrial, housing and recreational development projects (Haering *et al*., 2009).
- Distinguishing the between centralised and decentralised provision of infrastructure
  - Reclaimed water typically originates from municipal wastewater treatment plants although certain industries may be able to generate reclaimed water that is suitable for non-potable use.

Reclaimed water, also referred to as recycled water, is water recovered from wastewater treatment plants that has been treated to allow for safe reuse barring human consumption (Haering *et al*., 2009). During primary treatment phase at a wastewater plant, inorganic and organic suspended solids are removed. The subsequent decanted effluent then proceeds through a secondary treatment process which involves the biological decomposition of organic material and settling which separates water from solids. Further advanced treatment consists of the removal of suspended and dissolved solids including nutrients and disinfection. Once advanced treatment is complete the water can be reused for irrigation purposes or non-irrigation purposes inclusive of fire protection, industrial cooling water and industrial process water (Haering *et al*., 2009).

Table B.7 (see Appendix B) illustrates the assumptions and variables utilised with respect municipal reclaimed water project. Table B.8 (see Appendix B) illustrates the discounted payback period relevant to a reclaimed water project. As depicted in Table B.8 (see Appendix B), the initial R177,000,000 investment, at 2016 prices, was paid back at a discount rate of 10% over 5.406 years.

This implied that it was acceptable, from a financial perspective, to invest in a reclaimed water project along those parameters as listed within Table B.7 (see Appendix B).

5.3.3 Sanitation

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to sanitation, these included:

- Sewerage is treated and reused for all income groups
- Distinguishing between a provider-managed community-based sanitation system and that of a community-managed based sanitation system

Ideally, there should be a variety of financing mechanisms to address the costs of water and sanitation needs within communities dependent on the income and asset base of the target population along with the perceived economic benefits of the various stakeholders (Hutton & Haller, 2004). The comparison of the asset base against the economic benefit decentralised community-based sanitation system versus a

centralised sanitation system should guide a city in the mechanism of sanitation provision along with the respective financing thereof.

Given that the identified interventions of low diameter sewerage systems, septic tanks and community sanitation, within the theme of sanitation, encompassed a decentralised approach to sanitation provision, a holistic cost comparison was made with that of a centralised sanitation system, a decentralised sanitation system and that of a hybrid system. The respective discounted lifetime costs, as typically applied to a city, are illustrated in Table B.9 (see Appendix B).

As depicted in Table B.9 (see Appendix B), when assessed from a typical city scenario, conventional sanitation systems possess the lowest discounted lifetime costs. This scenario occurs when predicted population growth becomes a reality or is exceeded (Hutton & Haller, 2004). Should population growth occur at 0.5% lower than projected, source separated systems are more cost effective than conventional systems owing to reduced idle capacity (Hutton & Haller, 2004). Uncertainty with respect to population growth increased discounted lifetime costs as earlier investment was required. Hybrid systems were not acceptable owing to double investments required in treatment and collection systems. The context of South African cities would not allow for the exclusive use of decentralised sanitation systems. As such conventional sanitation systems were preferable from a lifetime cost perspective.

5.3.4 Compact Cities

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to compact cities, these included:

- Capacity demand, capacity supply and investment units
  - According to Berrisford (2012), the spatial distribution patterns of South African cities exacerbate inequalities, resulting in the loss of gross domestic product along with wasted physical resources. Inefficient land use equates to low density dispersed settlements that translate to increased recurrent costs, such as an increase in the maintenance costs on longer pipe networks. Inefficient land use is further influenced by the spatial arrangement of a city which impacts on the capital cost of new infrastructure

and the rehabilitation of existing infrastructure (Berrisford, 2012). Capacity demand, capacity supply and the resultant cost of providing infrastructure capacity is thus dependent upon the efficiencies of settlement patterns.

- Greenfields versus brownfields development
  - Berrisford (2012) states the although it is possible to cost the spatial arrangement of greenfield developments, the exercise in itself is largely futile given that an existing urban fabric exists within all cities. It is far more practical to cost growth trajectories that extend the existing layout of South African cities through a compact city development model (Berrisford, 2012).
- Incremental versus upfront infrastructure services provision
  - For the purposes of this study, incremental versus upfront infrastructure services provision was viewed from a financing perspective. According to PriceWaterhouseCoopers (PWC) (2008), government may possess an increasing reliance on upfront development levies to fund infrastructure, resulting in intermittent infrastructure development that fails to deliver infrastructure on a sufficient scale. As such, alternative funding mechanisms were required in an attempt to address upfront infrastructure services provision.

In order to address the current inefficient, inequitable and unsustainable patterns of urban development within South African cities, the cost quantification of inefficiency needed to be determined upfront to illustrate the costs and opportunity costs of not developing more efficient cities (Berrisford, 2012). As a result, Berrisford (2012) developed a model wherein the greater costs of inefficient land use within South African cities were quantified. The findings of Berrisford (2012) are summarised as follows:

- Fragmented, inequitable, low-density patterns of South African cities lead to higher social, financial and environmental costs
- With respect to recurrent city costs, the following were applicable:
  - A compact city demonstrated a 7% saving in recurrent costs per year ten years after development

  - Low-income households experienced a 24% difference in recurrent household expenditure in favour of a compact city over a period of ten years, which was inclusive of transportation costs

- With respect to capital costs, the following were applicable:
  - Capital investment required for a compact city and an inefficient city structure was almost identical. In addition, infrastructure costs were almost the same.
  - The additional length of connector infrastructure required in terms of an urban sprawl scenario was deemed insignificant in relation to the overall costs of internal and bulk infrastructure required for both a compact city scenario and that of an urban sprawl scenario.
  - With respect to housing and buildings, the capital cost was 6% lower in a compact city mainly attributable to the lower cost per unit for high income residential units. The cost per unit for lower income units was, however, higher in a compact city.
  - The cost of land in a compact city was 91% higher as opposed to the cost of land in an inefficient city structure, however, the cost of land comprised a small portion of the total capital cost in an urban sprawl scenario and was insignificant when compared to the combination of housing and land.
  - Infrastructure in support of public transport was marginally lower within the compact city. In addition, the cost per commuter within the urban sprawl scenario was 33% higher as compared to the compact city scenario.

As illustrated in Figure B.2 (see Appendix B), the total recurrent operating costs of a city total R99 billion in an urban sprawl scenario compared to a R92 billion scenario relevant to a compact city. This was based on a ten year projection utilising recurrent costs from a base year of 2010. This represented a 7% difference in year 10.

As illustrated in Figure B.3 (see Appendix B), the total capital costs over a ten year period totaled R260.9 billion in an urban sprawl scenario compared to a R254 billion scenario relevant to a compact city. This was based on a ten year projection utilising 2010 as a base.

Comparing both recurrent costs and capital costs of an urban sprawl scenario and that of a compact city scenario would indicate, from a cost perspective, that it was more feasible to pursue the compact city scenario.

5.3.5 Public Transport

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to public transport, these included:

- Reducing the use of private vehicles
- Distinguishing between accessibility and mobility

Public transport is often perceived as inferior to individual vehicle use as public transport is generally deemed to underperform as opposed to a private vehicle (Steg, 2003). As a result, private vehicle users would use public transportation infrequently. Therefore, to substitute private vehicle use for public transportation, policies should be developed that seek to reduce the functional, psychological and cultural values of private vehicles whilst simultaneously increasing the performance of public transportation (Steg, 2003). In this manner, the use of private vehicles would be reduced.

Handy (2002) advocates that it is important to distinguish between accessibility and mobility. Mobility relates to the quality of being mobile whilst accessibility relates to how easily public transportation facilities and infrastructure is entered. Both are important considerations in promoting public transportation infrastructure within a city.

Investment in public transport infrastructure and systems enables economic efficiency and productivity in terms of travel times, cost and access (American Public Transport Association (APTA), 2014). Furthermore, the effects of expenditure on various public transportation initiatives create immediate employment and income through the support of manufacturing, construction and public transportation activities.

APTA (2014) states that sustained investment in public transport over time can affect the economy through:

- Promoting travel and vehicle ownership cost savings for those citizens utilising public transportation, thereby leading to shifts in consumer spending
- Reducing traffic congestion resulting in direct travel cost savings
- Ensuring business operating cost savings through increased worker reliability owing to the effects of reduced congestion
- Increasing business productivity as a result of access to broader labour markets
- Increasing regional business growth enabled by business growth
- Promoting capital investment in public transportation programmes and operations

The benefits of public transportation investment, inclusive of universal transit passes, parking cash-out systems, bicycle facilities, car sharing schemes and transport resource centres, could be compared against the capital investment required to achieve those results. APTA (2014) demonstrate scenarios for public transportation ridership growth and associated costs against vehicle and fuel cost savings. Table B.10 (see Appendix B) demonstrates the principle of net present value of public transportation capital investment and vehicle operating cost savings for selected scenarios.

As reflected in Table B.10 (see Appendix B), the principle of investing in public transportation was an acceptable intervention with respect to the net present value gained, in operating cost savings, over various time horizons and scenarios as the NPV increased. This occurred in both public transport investment and vehicle operating costs, through doubling the ridership or striving for a higher growth rate (4.67%) of ridership.

5.3.6 Energy

(i) BIOMASS

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to biomass, these included:

- Application of use: According to Murphy *et. al.* (2014), partnerships between industry members, the entrepreneurial clean energy community and the financial industry can leverage resources that are needed to promote the development

and commercialisation of clean energy technologies, which, in turn, can lead to the accelerated and global utilisation of clean energy. Murphy *et. al.* (2014) further explain that the need for these partnerships is driven by global growth in energy demand along with the need for a spectrum of long-term environmental benefits. As such, for the purposes of this study, the application of use with respect to biomass power within a city context was within the context of a public-funded operation or that of a public private partnership.

- Scale: Given that energy generated from biomass is dependent on the availability of biomass products, for the purposes of this study, an initial biomass plant was assessed based on the biomass plant at De Hoop nature reserve in the Western Cape, which produces between 3045 and 3900 MW of electricity a year from Rooikrans biomass (Mudavanhu, Blignaut, Nkambule, Morokong & Vundla, 2016). The potential utilisation of electricity produced from a biomass plant should be viewed in conjunction with other available sources of electricity. The assessment was whether an intervention of this sort was, in principle, a sustainable intervention.
- Grid connections versus standalone installations: For the purposes of this study, the biomass installation was presumed to be grid connected purely based on the reasoning that the grid might be complimented with conventional energy supply should the need arise. Standalone installations would not allow for this flexibility.

Table B.11 (see Appendix B) demonstrates the cumulative net present value for bio-electricity using Rooikrans as the biomass product. In calculating the net present value for bio-electricity, three scenarios were presented (Mudavanhu *et. al.*, 2016). In the initial scenario (DEA DH), the clearing operations of Rooikrans were funded by the Department of Environmental Affairs alone. The second scenario (DEA DH+) included funding for the Rooikrans clearing operations by the Department of Environmental Affairs along with a 20% private sector co-financier. The third scenario depicted no clearing of Rooikrans along with no associated bio-electricity plant.

The figures contained within Table B.11 (see Appendix B) depict the varying net present value scenarios relevant to biomass electricity generation utilising the alien invasive species of Rooikrans. The areas required to be cleared per annum in order to supply the necessary amount of Rooikrans were 753,6ha for scenario one and

965,2ha for scenario 2 (Mudavanhu, *et. al.*, 2016). The cumulative net present value for scenario one was approximately R44,7 million whereas the cumulative net present value for scenario two totalled R57,3 million. This implied that it was acceptable, from a financial perspective, to invest in a biomass bio-electricity generation project.

(ii) WIND POWER

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to wind power, these included:

- Application of use: According to Murphy *et. al.* (2014), partnerships between industry members, the entrepreneurial clean energy community and the financial industry can leverage resources that are needed to promote the development and commercialisation of clean energy technologies, which, in turn, can lead to the accelerated and global utilisation of clean energy. Murphy *et al.* (2014) further explain that the need for these partnerships is driven by global growth in energy demand along with the need for a spectrum of long-term environmental benefits. As such, for the purposes of this study, the application of use with respect to wind power within a city context was within the context of a public-funded operation or that of a public private partnership.
- Scale: For the purposes of this study, an initial wind power electricity generating farm was assessed based on the wind farm located at Jeffreys Bay, which produced 15 MW of electricity a year (Menzies, 2010). The potential utilisation of electricity produced from a wind farm should be viewed in conjunction with other available sources of electricity. The assessment was whether an intervention of this sort was, in principle, a sustainable intervention.
- Grid connections versus standalone installations: For the purposes of this study, the wind farm installation was presumed to be grid connected purely-based on the reasoning that the grid might be complimented with conventional energy supply should the need arise. Standalone installations would not allow for this flexibility.

Table B.12 (see Appendix B) provides the parameters of the Jeffreys Bay wind farm project, which were used to calculate the net present value for an investment in wind power. As depicted in Table B.13 (see Appendix B), the net present value of the project

was acceptable (positive). This implied that it was acceptable from a financial perspective, to invest in a wind farm project along similar parameters to that of the Jeffreys Bay wind farm project.

5.3.7 Urban Agriculture

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to food supply, these included:

- Increasing food supply from urban farms
  - The predominant task of urban agriculture is food supply and income generation within cities (FOA, 2007). In addition, urban agriculture assists in environmental and biodiversity management, thus contributing to a multi-functionality dimension (FOA, 2007).
- Build local food retail markets
  - Urban agriculture has the potential wherein local food production and consumption systems utilise varying contracts with cafeterias in schools, hospitals and government offices along with restaurants and private individuals, thereby enhancing community-supported agriculture (FOA, 2007).
- Form of ownership
  - Form of ownership within urban agricultural schemes may take a mixed collective or individual form of ownership or alternatively a state form of ownership (Koont, 2008). The form of ownership is dependent on the management structure of the relevant urban agriculture scheme along with the nature of the urban agriculture units.
- Status of tenancy
  - The status of tenancy within urban agricultural schemes may adopt a mixed private / usufruct form of tenancy or alternatively may adopt the form of state ownership or private ownership (Koont, 2008). The status of tenancy is dependent on the management structure of the relevant urban agriculture scheme along with the nature of the urban agriculture units.
- Incentives
  - Urban agriculture schemes may be characterised as shifting cultivation as, although a permanent element of the urban system, locations within the city

may vary over time (FOA, 2007). Alternative lands may be provided by a city when existing sites are required for other purposes along with encouraging private and institutional land owners of vacant open spaces to reciprocate through the provision of tax incentives (FOA, 2007).

FOA (2007) states that the economic impacts of urban agriculture occur at three different levels. These levels include:

- Household level: This relates to urban households involved in agricultural production and the associated effect on self-employment, income from processing, sales of surpluses, savings on food and health expenditures along with the exchange of agricultural products for alternative economic goods.
- City level: This relates to the direct costs of assistance supplied at a city level to urban farmers in the form of training and quality control that are not borne by farmers along with the aggregate indirect costs and benefits of urban agriculture for the city. Added value can occur to the city through enhanced income and / or reduced costs whereas additional investments may be required by the city to facilitate the promotion of urban agriculture.
- Macro level: This relates to urban agriculture, which can potentially contribute to the efficiency of a national food system through the provision of foodstuffs that can act as a substitute for food imports.

For the purposes of this study, the economic impacts of urban agriculture was viewed from a city perspective as the study focused on the funding of interventions in support of sustainable development at a city level. In considering the financing of urban agriculture within a city, key assumptions were required to determine the financial viability of such an intervention. According to Ganguly, Kujac, Leonard, Wagner and Worthington (2011), these assumptions relate to:

- Size of urban agriculture units: Two thousand square meter agricultural lots within the city allow for varying methods of urban agriculture including greenhouse hydroponics, outdoor hydroponics and raised-bed planting.
- Fixed assets: The construction of essential farm structures, built of reclaimed materials can, as a worst-case scenario, equate to $5.00 per square foot.

- Working capital: Net working capital requirements are valued at forty-five days projected revenue for each respective year. This assumes that 75% of produce will be sold on account with an associated collection period of forty-five days as an initial period. It is assumed that retained earnings are reinvested to fund fixed asset investments and working capital requirements but, otherwise, will be disbursed as dividends to the owners.
- Expenses and headcount: Land rental is the largest operating expense equating to $0.30 cents / square foot / month. This equates to 86% of annual expenses, a fixed cost that needs to be carefully-considered in an urban agriculture scheme. Opportunities to reduce this expense which are discussed further in Chapter 6.
- Revenue and gross margins: It is assumed that revenue is primarily gained from the sale of produce to individuals and restaurants along with the sale of value-added products to individuals and high-end retailers.

Based on the assumptions as provided by Ganguly *et. al.* (2011), the net present value was calculated to determine the potential value when investing in such an urban agricultural scheme. Although the calculation depicted and included parameters relevant to the LivelyHood urban agricultural scheme in the United States, the objective of the calculation within the context of this study was to demonstrate the overall financial acceptability of such an intervention. If in principle such an intervention was acceptable when funding tools and instruments could be applied as discussed within Chapter 6 that were relevant to the context of the stated hypothetical city. The net present value calculated according to Ganguly *et. al.* (2011) urban agricultural scheme, applicable to each two thousand square meter lot is depicted in Table B.14 (see Appendix B).

As depicted in Table B.14 (see Appendix B), the calculated net present value from year ten onwards depicted positive net present cashflows. As such, it might be assumed that an urban agricultural scheme, with the broad parameters as described in Section 3.10, was an acceptable intervention within the concept of sustainable city development.

5.3.8 Solid Waste

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to solid waste, these included:

- Recycling solid waste
- Quantity of collected recyclables
- Quality of collected recyclables
- Recycling rate
- Participation rate
- Willingness to participate

The recycling of solid waste, as opposed to landfilling, is distinctly different in terms of financial, social and environmental inventory (De Beer, 2013). Furthermore, the recycling rate of any given system is dependent on the type and quality of waste that is being disposed. As such, storage along with the initial disposal of waste has a major impact on recycling initiatives (De Beer, 2013).

With respect to measuring the net present value of solid waste recycling interventions, De Beer (2013) suggests a model wherein options one to ten in solid waste recycling are proposed. In the model, one was no recycling interventions relying on the disposal of waste to landfill sites only while ten was a complete disposal of waste by recycling measures. Table B.15 (see Appendix B) demonstrates the net present value ranking results of those hypothetical scenarios.

As depicted in Table B.15 (see Appendix B), options two and five depicted the highest net present value ranking for a hypothetical solid waste recycling programme. This would imply that the most acceptable programme with respect to the recycling of solid waste, with respect to a financial perspective, would be to implement a programme that still made use of conventional waste disposal mechanisms whilst employing a recycling programme that sought to recycle waste in equal measures or below those measures.

5.3.9 Green Buildings

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to material assessment, these included:

- Optimise the use of resources

The optimisation of the performance characteristics of buildings and products is an essential prerequisite for improving sustainability (UNEP, 2003). A reduction in the embodied amount of material and energy in building materials along with their improved energy efficiency contributes to the optimisation of a building material resource (UNEP, 2003).

- Efficient management practices

Management and design are key elements of sustainable construction and, by implication, the use of materials employed.

In determining the acceptability of affordable sustainable housing, focus should not be placed on initial capital costs but on life-cycle costing wherein both capital and operating costs over the expected life of a building are considered (Bradshaw, Connelly, Cook, Goldstein & Pauly 2005). Green or sustainable buildings can cost incrementally more to build, however, these costs are recouped over the lifetime of the building (Urban Catalyst Associates, 2005). Although the cost premium for developing green or sustainable buildings equates to an average of 2.4% of total developments costs (Bradshaw *et. al.*, 2005), the majority of this premium relates to increased construction costs. According to the Urban Catalyst Associates (2005), the cost premium for developing green or sustainable buildings ranges from 0.7% to 6.8%. Longer-terms economic benefits are, however, gained from reduced energy consumption, emissions reduction, water consumption savings, reduced waste and operations and maintenance cost savings (Urban Catalyst Associates, 2005). With respect to energy consumption, buildings consume on average 28% less purchased energy than conventional buildings. Furthermore, it is assumed that green buildings attain a 5% reduction in operating and maintenance costs as opposed to conventional buildings along with reducing construction waste by at least 50% (Urban Catalyst Associates, 2005).

According to Urban Catalyst Associates (2005), the savings from energy and water efficiency, construction waste reduction and reduced operation and maintenance costs far outweigh the average premiums paid for green certified buildings. The net present values of the varying components of green buildings are depicted in Table B.16 (see Appendix B).

As depicted in Table B.16 (see Appendix B), the net present values of the varying categories of green buildings reflected a positive leaning towards the investment in green buildings. As depicted in Table B.16 (see Appendix B), the category of productivity and health gains reflected a substantial contribution to the overall net present value calculation. Although Urban Catalyst Associates (2005) acknowledges that the component of productivity and health gains is difficult to calculate, the category was deemed worthy enough to be included in an overall net present value calculation. For the purposes of this study, the productivity and health component was viewed as an intangible component and, as such, would not be considered in the tangible assessment. Considering the exclusion of the productivity and health component, the net present value of the remaining categories still reflected a positive outcome, albeit at a lesser extent.

Bradshaw *et. al.*, (2005) assessed the net present value of green buildings as applied across varying housing developments. The results are depicted in Table B.17 (see Appendix B).

Table B.17 (see Appendix B) depicted the net present value for green buildings as applied to various housing developments. As depicted in Table B.17 (see Appendix B), the benefits of green buildings outweighed the costs of development in all but one of the applied case studies for homeowners. The net present value was, however, predominantly in favour of an eventual resident through cost savings by means of reduced energy and water costs along with replacement cost savings. The developer who constructed the housing units, and, by implication, paid the upfront costs of greening a building, did not always receive benefits that exceeded their costs.

For the purposes of this study, green building interventions were viewed as an acceptable intervention, however, it was recognised that that these interventions were not always absolute and were dependent on who the role player was within the

development and occupation process. As such, applicable funding mechanisms as discussed in Chapter 6 were cognisant of such.

5.3.10 Air Pollution

(i) ELECTRIC VEHICLES

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to electric vehicles, these included:

- Reduce air pollution
- Socio-technical configuration of road transport
- Multi-dimensional value proposition

A clean electricity energy mix with respect to an increasing usage of electric passenger vehicles contributed to substantial environmental benefits in the form of reduced air pollution (Ayalon, Flicstein & Shtibelman, 2013).

With respect to the socio-technical configuration of electric vehicle transport along with the associated value proposition, the following applies to encourage an envisaged electric vehicle programme (Perdiguero & Jimenez, 2012):

- Possibility of electric vehicles utilising high-occupancy vehicle lanes along with a differentiation in tolls charged with respect to environmental contamination
- Establishment of park and ride sites
- Promotion and incentivisation of private companies to install charging stations at the respective firm's car parks
- Financial support with respect to pilot programmes that seek to improve the energy efficiency of companies' transport systems
- Associated information system for electric vehicle users that allows for identification of nearest charging stations

Upfront costs of adopting an electric platform for transportation within a city is viewed as a major deterrent aside from the fact that lower energy and maintenance costs will occur in the future (Zhu, Patella, Steinmetz, & Peamsilpakulchorn, 2016). Zhu *et al*.

(2016) analyse the macroeconomic along with the microeconomic implications of an electric vehicle scheme within a city. In doing so, the costs and benefits of an individual user are assessed along with other prerequisite investments required by government to support an electric vehicle programme.

In respect of an analysis for state intervention such as the provision of free electricity, low-cost financing options and vehicle buy-back schemes, Zhu *et al*. (2016) calculate the flow of annual discounted cost savings when comparing an electric vehicle to a conventional internal combustion vehicle. The results thereof are depicted in Table B.18 (see Appendix B).

As depicted in Table B.18 (see Appendix B), the net present value utilising both discount rates were positive in relation to the varying forms of government interventions. In particular, the provision of free electricity intervention resulted in a 73% and 110% increase in the net present value at the respective discount rates of 5% and 7%.

Although financial, access and timing barriers to entry currently existed, a potential electric vehicle programme was an acceptable alternative for an individual along with government should the necessary supportive schemes accompany such an intervention. The time-access-financial constraints could, however, begin to be addressed through the installation of the requisite infrastructure through appropriate policy determination and sectorial coordination (Zhu *et al*., 2016). The proposed financing tools and instruments are discussed further in Chapter 6.

5.3.11 Health Care

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to health care, these included:

- Primary health care

High levels of sickness and premature death occur in certain locations within South Africa owing to causes such as inadequate health services, poor nutrition and the unavailability of clean water (McIntyre, Bloom, Doherty & Brijlal, 1995). In an attempt to address these issues, the government of South Africa seeks to provide for primary health care broadly inclusive of the following (McIntyre *et al.*, 1995):

- Programmes to educate the general population on taking individual responsibility for their health
- Activities aimed at preventing diseases through environmental improvement or preventative programmes
- Accessible basic medical care provision to prevent the further development of illness and by implication increased costs
- Interventions in which to assist the disabled to be more self-sufficient and productive

According to Cohen, Neumann and Weinstein (2008), generic statements on the cost saving potential of primary health care can be over stated. In certain instances, primary health care can save costs but, in other cases, can add to costs. As such, the focus of primary health care was a key source of cost savings with regard to health care provision. Figure B.4 (see Appendix B) illustrates the distribution of cost effectiveness ratios in relation to primary health care addressing preventative measures along with treatments for existing conditions relevant to New England Medical Centre cost effectiveness registry in the United States of America. The demonstration thereof was intended to illustrate the principles of cost effectiveness of primary health care interventions as opposed to locality specific analysis.

As depicted in Figure B.4 (see Appendix B), cost savings did occur as a result of primary health care interventions, however, this was dependent on the area of focus for primary health care. Further to these savings, the World Health Organisation (2004) stipulates that primary health care is most cost effective in low-income settings.

5.3.12 Biodiversity

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to biodiversity, these included:

- Coordination between scales of intervention
- Maximising biodiversity within an urban ecosystem

The factors of coordination between scales of intervention and maximising biodiversity within an urban ecosystem as relevant to the contexts of adjacent landscapes, the city, city sectors and individual lots is demonstrated in Table 5.1.

Table 5.1: Scales of biodiversity interventions and associated management practices

SCALE	MANAGEMENT LEVEL	PLANNING	DESIGN	MANAGEMENT
Adjacent landscapes	Regional government or equivalent	Zone landscape use, identify and protect important natural areas, identify green corridors linking city to natural areas, create regional parks	Design parks and green corridors to optimise their use by wildlife, design roadways to minimise fragmentation of natural areas	Plant vegetation and restore habitats to improve parks and corridors, promote management options that favour wildlife diversity
City	Municipal government	Extend green corridors within the city, identify important areas for wildlife within the city, identify important species	Shape, structure and size up corridors to optimise wildlife use, design park to increase wildlife abundance and diversity	Plant vegetation in parks, green corridors and along streets

SCALE	MANAGEMENT LEVEL	PLANNING	DESIGN	MANAGEMENT
City sectors (industrial, commercial, residential, recreational)	Local authorities	Establish vegetation objectives, interact with higher levels to ensure optimal location of natural areas, parks and corridors, create management plan for parks that will preserve and enhance diversity	Design type, structure and distribution of vegetation for favour wildlife	Enhance or restore vegetation in industrial and commercial areas, reduce use of herbicides and pesticides, plantation of shrubs, fruit trees, conifers
Individual lots	Owner	Landscape property to attract wildlife, coordinate with neighbours to maximise vegetation volume	Select type of vegetation most compatible with wildlife, design nesting and feeding structures.	Install and maintain nest boxes and bird feeders, avoid use of pesticides and herbicides

Source: Saval *et. al.* (2000)

As illustrated in Table 5.1, various planning, design and management-related interventions could apply to increasing biodiversity with respect to the categories of adjacent landscapes, city interventions, city sector interventions and individual lot interventions.

According to Gauteng City Regional Observatory (GCRO) (2013), there are four categories of ecosystem goods and services that are applied when determining the value of an ecosystem. These include:

- Provisioning services that relate to the products derived from an ecosystem such as food and fuel
- Regulating services that relate to benefits derived from the regulation of ecosystem services such as air quality regulation and water regulation
- Ensuring cultural services which relate to benefits gained from ecosystems in the form of recreation and educational values
- Supporting services which relate to services that are necessary for the production of all other ecosystem services such as soil formation and water cycling

Table B.19 (see Appendix B) depicts the recreational value from open spaces (GCRO, 2013). A contingent valuation was used to estimate the value of use, option and existence whereas hedonic pricing determined the impact of relevant open spaces on property values.

As depicted in Table B.19 (see Appendix B), the varying categories of open spaces had both a positive contingent valuation along with hedonic pricing albeit for vacant land relevant to hedonic pricing. Close proximity to vacant land had a R7,840 per hectare negative value.

In addition to Table B.19, Table B.20 (see Appendix B) depicts indicative estimates per hectares values for varying categories of open spaces relevant to the City of Johannesburg.

As depicted in Tables B.19 and B.20 respectively, there was positive economic value associated with varying categories of open spaces. These categories, in turn, related to the components of adjacent landscapes, city interventions, city sector interventions and individual lot interventions. Biodiversity thus seemed to be an acceptable intervention. Funding instruments and tools relevant to interventions within the respective components are addressed in Chapter 6.

5.3.13 Child-Centered Development

Table 3.9 lists the key influencing factors that might influence interventions with respect to sustainable city development. With respect to child-centred development, these included:

- Child-centred education
- Child-offered space, opportunity and time to develop

In applying stated tangible and intangible measures to child-centred development, for the purposes of this study, the following applied with respect to key influencing factors:

- Child-centred education: Child-centred education along with the associated space, opportunity and time to develop focuses on the child as the primary benefactor of provided facilities whilst being supported by the family and local community. According to the UNDP (2002), the primary objectives of child-centred school planning are:
  - To increase access to students
  - To improve attendance rates
  - To improve retention and completion rates
  - To improve learning achievement
  - To provide safe, inclusive, welcoming environments for all children
  - To build a sense of community within the school whilst simultaneously involving parents and the community
  - To harmonise the school's buildings and surrounds for child interaction
- Child-offered space, opportunity and time to develop: According to UNICEF (2009), Tables 5.2 and 5.3 respectively demonstrate basic planning and design standards for educational facilities and additional functional elements for a child-friendly school. The interventions of shared formal learning facilities along with informal learning facilities, within the context of child-centred development, needed to consider the basic required elements as demonstrated in Table 5.2 along with the additional function elements as depicted in Table 5.3.

Table 5.2: Basic planning and design standards for educational facilities

ITEM	DETAIL
Structure	Ensure building is structurally sound along with being integrated into the environmental and cultural context of the surrounding environment.
Administrative offices	Ensure separate space for administrative personnel-administrative hub
Safe water	Ensure supply of potable water
Hygiene facilities	Provide appropriate cleaning facilities
Toilets	Ensure privacy, cleanliness and safety in the provision of facilities
Light, air, sun, dust, glare, reflection, humidity, noise and odour	Ensure design allows for appropriate ventilation and well-being of its occupants
Colour	Allow for natural colours
Power	Ensure appropriate levels of connectivity
Safety provisions	Consider safety provision in the locational characteristics of the school itself along with auxiliary functions of the school
Health provisions	Ensure schools cater for basic emergencies should they arise
Library	Provide a designated space where learning resources are available needs
Landscaping	Ensure the provision of appropriate school grounds, which allow for unity with the physical infrastructure along with the users of the school

Source: UNICEF (2009)

Table 5.3: Additional functional elements for a child-friendly school

ITEM	DETAIL
Flexible spaces	Ensure flexible spaces, which allow for increased child participation within the classroom along with allowing teachers a more dynamic environment for learning and teaching.
School library and resource room	Ensure the library and the resource room have a connection with the local community for child-centred schools. As such, these facilities should be located and designed so that they are accessible to the community.
Bathrooms	Ensure bathrooms are shared amongst clusters of classrooms.
Relaxation rooms close to learning areas	Provide homelike learning spaces.
Individual spaces	Provide individual learning spaces to allow time for self-reflection and learning.
Open spaces	Provide accessible open spaces to allow contact with the environment along with engaging in physical activities.
Clinic	Ensure that practical cluster social and clinic services are within close proximity to a school.
Protective	Ensure appropriate boundaries to ensure a child's safety.

Source: UNICEF (2009)

Tables 5.2 and 5.3 categorise the basic elements of educational facilities along with the additional elements in support of child-friendly educational facilities. Eight elements were included for child-friendly educational facilities in addition to the basic elements of educational facilities.

The national minimum norms and standards for school infrastructure within South Africa relates predominantly to the components of catchment area and the actual size of the school site (Department of Education, 2009). In terms of the catchment area stipulation, every school is required to possess a catchment area of up to 3kms, thus implying a total walking distance to and from school of up to 6kms. Learners outside the catchment area should be provided with transport or hostel accommodation on a phased pro-poor basis. The minimum stipulated area for primary schools is 2.8ha inclusive of sports fields whilst 4.8ha is applicable to secondary schools. In terms of

primary school provision, one primary school is ideally required for every 4,000 people whereas one high is required for every 10,000 people (Western Cape Government, 2013). For a hypothetical city population of 250,000, this would ideally equate to the required provision of fifty primary schools and twenty-five high schools.

Section 3.16 of this study documented the envisaged intervention in support of child-centred development. Although child-centred development and learning is based on the values and principles of childhood understanding and experience, the physical structure and design of city components can contribute to the philosophy. For the purposes of this study, it was proposed that formal central learning facilities, with facilities that inculcate the principles of child-centred development, were provided so that schools within a region utilised these forms of education, both across class and income divides. Schools, regardless of class or income, would not provide these facilities within their own premises but be forced to use the facility as part of the delivery of the curriculum. It was further proposed that the informal delivery of such facilities be provided in the form of appropriately-designed parks in a mode which supports the curriculum on the basis of child-centred development and learning. Both formal and informal facilities needed to be designed that encouraged child interaction and experience within the context of the South African school curriculum.

In relation to the requirements of child-centred education, it is proposed that the formal and informal facilities as illustrated in Table 5.3 were provided in combination with a community's multi-purpose centre. A population of 250,000 would typically require twelve multi-purpose centres that could house the formal and informal educational facilities as detailed in Table 5.3, which would support fifty primary schools and twenty-five high schools.

According to AECOM (2016), building rates for primary schools range from R5,700m² to R6,600m² (excl. VAT) and from R6,700m² to R7,200m² (excl. VAT) for high schools. The schedule of accommodation as detailed in Table 5.3 could typically be accommodated within approximately 400m² (Department of Basic Education, 2012). These facilities would then broadly equate to approximately R2,880,000 per addition to the multi-purpose centre.

Perkins (2011) stipulates that economic infrastructure comprises investments that raise productivity in the form of investment in infrastructure in transport, power and water systems whereas social infrastructure comprises investments and services that raise the productivity of human capital such as investment in education and health. The economic quantification of how investment in education and health raise the productivity of human capital is problematic. Fourie (2006), however, demonstrates baseline rates of return from infrastructure investment, both from pure economic infrastructure to social infrastructure, relevant to the South African context as illustrated in Table B.21 (see Appendix B).

As depicted in Table B.21 (Appendix B), public sector capital stock ranged from a 0.17 to a 0.9 rating with respect to the relevant rate of return. As such, it might be assumed that child-centred development, within the broad parameters as described in Section 3.16, was an acceptable intervention within the concept of sustainable city development.

Table 5.4 summarises the acceptability of the various themes utilising tangible criteria.

Table 5.4: Tangible acceptability of the themes of sustainable city development

THEME	CRITERIA USED	ACCEPTABILITY OF INTERVENTION
Location	Gross value addition	Acceptable
Water: • Rainwater harvesting • Grey water • Reclaimed water	Discounted payback	 Not acceptable Acceptable Acceptable
Sanitation- decentralised sanitation systems	Discounted lifetime costs	Not acceptable
Compact cities	Direct comparison of recurrent and capital costs of a compact city versus a city characterised by urban sprawl	Acceptable
Public transport	Net present value	Acceptable

THEME	CRITERIA USED	ACCEPTABILITY OF INTERVENTION
Energy	Net present value	Acceptable
Urban agriculture	Net present value	Acceptable
Solid waste	Net present value	Acceptable
Green buildings	Net present value	Acceptable but within limitations
Air pollution	Net present value	Acceptable
Public health	Cost effectiveness ratios	Acceptable
Biodiversity	Consolidated ecosystem value	Acceptable
Child-centred development	Internal rate of return	Acceptable

Source: Author's own compilation

As depicted in Table 5.4, two of the themes of sustainable city development were not deemed as acceptable when assessed in terms of the stated tangible criteria. As such, this would affect the nature of the financing tools and instruments applied to each theme as further detailed within Chapter 6.

5.4 INTANGIBLE CRITERIA ACROSS VARYING THEMES

Intangible criteria per the varying themes of sustainable city development are discussed in Section 5.4.

5.4.1 Location

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of location were:

- Integrating newly-arriving communities and addressing racial disparities
- Linking the city to the national and regional economy
- Building leadership and partnerships

According to Freire (2016), successful urban migration is dependent on a city's permeability or ability to integrate a new community into its old fabric. The ability to integrate is, in turn, dependent on the financial and managerial capacity of that relevant city. It may be argued that a city's financial capacity has a direct relation to economic activity within the city. As a result, a city benefits directly from increased economic activities within the city limits. As discussed in Section 5.3.1, a city's economic activity or GVA is predominantly influenced by locational characteristics. It could, therefore, be concluded that successful urban migration is largely influenced by a city's location, which can support growing economic activity and hence a city's potential financial capacity.

Coyle and Rosewell (2014) advocate that the geographic location of activity between cities is influenced by the structure of production within the respective cities along with the resource mix contained within the city. As such, aspects to consider for a national network of cities include:

- Extent to which scope for specialisation occurs within a city along with gains from trade that may be achieved within national supply chains
- Extent of spill overs between cities, be they positive or negative, along with the associated determinants of these spill overs
- Size distribution of cities within the national network, given the associated implications of scale and their contribution to an economically-successful national system

Although these three aspects for a national network of cities were important, the base determinant of specialisation scope, spill overs between cities and the size distribution of cities within the national network would be appropriate location, especially within the context of this study wherein a greenfield's development was promoted. Specialisation of production could only occur through appropriate location. As such, the location of a city was directly-related to linkages between the national and regional economies of a country.

Elements relevant to building leadership and partnerships included the achievement of smart growth within a city along with ensuring improved service delivery at a reduced cost. Given that a city's financial capacity had a direct relation to economic

activity within the city, by implication, improved service delivery could to a certain extent only occur with the necessary financial means to do so. Locational factors had a direct influence on the city's ability to generate the necessary financial resources for the eventual provision of services to its communities and thus possess an extensive contribution to the intangible criteria of sustainable city development.

5.4.2 Water

(i) RAINWATER HARVESTING

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of water were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Fostering state-level policy reform

The integration of newly-arriving communities related to equity of access to mixed income districts, public transportation facilities, equal education and services as well as opportunity. According to UNEP (2007), increasing population growth along with the associated adequate supply of water to the population was one of the most critical issues to city decision-makers for ensuring equity of access to water. Rainwater harvesting had the potential to address, in part, additional water supply. Equity of access was thus potentially-gained with services that were delivered in the form of water provision. The intervention of rainwater harvesting did not address other components such as mixed income districts, public transportation facilities and equal education. Therefore, rainwater harvesting had a limited contribution to the listed intangible criteria.

Elements relevant to fostering policy reform included creating the demand for green innovation. According to Department of Science and Technology (2014), low cost green technologies could assist in providing potable water to communities, inclusive of rainwater harvesting.

(ii) GREYWATER

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of water were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities Fostering state level policy reform

The integration of newly-arriving communities related to equity of access to mixed income districts, public transportation facilities, equal education and services as well as opportunity. According to the Pacific Institute (2010), increasing water collection options through the employment of grey water systems could contribute to equity in services and opportunity.

Elements relevant to fostering policy reform included creating the demand for green innovation. According to Department of Science and Technology (2014), low-cost green technologies could assist with providing potable water to communities, inclusive of grey water harvesting.

The intervention of grey water did not address other components such as mixed income districts, public transportation facilities and equal education. Therefore, grey water had a limited contribution to the listed intangible criteria.

(iii) RECLAIMED WATER

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of water were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Fostering state level policy reform

The integration of newly-arriving communities related to equity of access to mixed income districts, public transportation facilities, equal education and services and

opportunity. According to the Pacific Institute (2010), increasing water collection options through the employment of alternative water catchment systems could contribute to equity in services and opportunity.

Elements relevant to fostering policy reform included creating the demand for green innovation. According to Department of Science and Technology (2014), low-cost green technologies could assist in providing potable water to communities, inclusive of reclaimed water recycling systems.

The intervention of reclaimed water did not address other components such as mixed income districts, public transportation facilities and equal education. Therefore, reclaimed water had a limited contribution to the listed intangible criteria.

5.4.3 Sanitation

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of sanitation were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Fostering state level policy reform

The integration of newly-arriving communities related to equity of access to mixed income districts, public transportation facilities, equal education and services as well as opportunity. Decentralised sanitation systems could contribute to equity in services and opportunity to lower income communities within city development.

Elements relevant to fostering policy reform included creating the demand for green innovation. Decentralised sanitation systems were not necessarily green innovation but rather an approach in addressing sanitation needs of a community.

The intervention of decentralised sanitation systems did not address other components such as mixed income districts, public transportation facilities and equal education. Therefore, decentralised sanitation systems had a limited contribution to the listed intangible criteria.

5.4.4 Compact Cities

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of compact cities were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Leveraging public resources and assets for private investments
- Building and sustaining leadership and partnerships

The integration of newly-arriving communities related to how a compact city and, by implication, bulk infrastructure and service provision, contributed to the development of mixed income districts, the development and utilisation of public transportation and equity of access to opportunities and services. According to UN-Habitat (2014c), a social mix, or mixed income districts within a compact city, promoted a rational distribution of urban public resources and allowed for varying income groups to have adequate housing thereby ensuring social equity whilst promoting economic efficiency. Rode and Floater (2014) state that compact cities faciliate the development and utilisation of public transportation by reducing travel intensity within cities through greater physical proximity of various urban uses along with diverting from spatially-inefficient private motorised modes of transport to shared and non-motorised transport. UNESCO (2016) advocates that urban development models need to facilitate inclusive processes that enable access, representation and participation. A compact city urban development model, therefore, facilitates these elements.

Leveraging public resources and assets for private investments, within the context of compact city development, related to how varying stakeholders contributed to the development of compact city forms. Municipalities within South Africa, particularly metropolitan municipalities, possess significant own source revenues and borrowing powers that can be utilised in support of spatial transformation policies (National Treasurary, 2013). As such municipalities must assume leading roles in the management of the urban built environment rather than delivering upon pre-determined outputs relating to access to basic services. Strategic spatial targeting

through municipal investment facilitates private sector investment (National Treasury, 2013).

Building and sustaining leaderships related to how smart growth within a city could be achieved by adopting a strategic approach. Stategic spatial targeting through municipal investment that facilitated private sector investment was a municipal leadership role that could contribute to smart city growth. Compact cities thus possessed an extensive contribution to the intangible criteria of sustainable city development.

5.4.5 Public Transport

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of public transport were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Leveraging public resources and assets for private investments
- Fostering state level policy reform

The integration of newly-arriving communities related to how public transportation contributed to the development of mixed income districts, the development and utilisation of public transportation and equity of access to opportunities and services. Public transportation schemes possessed extensive societel benefits wherein improved health, equity of access to services and the influence on a city's development patterns occurred (APTA, 2014).

Leveraging public resources and assets for private investments, within the context of public transportation, through a sustained public investment period of over twenty years could have a total effect on the economy in the range of 3.7 times the amount being spent annually (APTA, 2014)

Elements relevant to fostering policy reform included creating the demand for green innovation. Public transportation schemes that simultaneously addressed mobility and accessibility requirements of the end user could facilitate the demand for sustainable

public transport provision. Public transport thus possessed an extensive contribution to the intangible criteria of sustainable city development.

5.4.6 Energy

(i) BIOMASS

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of biomass power were (see Section 4.6.1):

- Building the middle class
- Building leadership and partnerships
- Fostering policy reform

Elements relevant to building the middle class included equity of wages along with the extent of outsourcing within that particular theme. Table 5.4 illustrates employment factors relevant to various forms of energy generation as applicable to South Africa. Although minimum wage is governed by legislation in South Africa, the current and future employment potential of the biomass industry as depicted in Table 5.5 indicates a greater leaning towards job security in the biomass energy production sector.

Table 5.5: Employment factors per energy sector

	CMI JOBS		O&M AND FUEL	
	Construction / installation	Manufacturing	Operations and Maintenance	Fuel
	Job years/MW		Jobs/MW	Jobs/GWh
Coal (existing & refurbished)	5.2 (local)	1.5	0.3 (local)	0.13 (local)
Supercritical coal	10.4 (local)	1.5	0.294 (local)	0.11 (local)
Gas, oil and diesel	6.2	0.07	0.09	0.22
Nuclear	10.8	1.2	0.66 (local)	0.002

	CMI JOBS		O&M AND FUEL	
	Construction / installation	Manufacturing	Operations and Maintenance	Fuel
	Job years/MW		Jobs/MW	Jobs/GWh
Biomass	6.9	0.8	5.51	0.4
Hydro	19.4	0.9	0.04 (local)	
Wind	4.5	22.5	0.72	
PV	52.3	16.8	0.73	
Geothermal	5.6	5.9	1.33	
Solar thermal	10.8	7.2	0.54	
Ocean	16.2	1.8	0.58	
Solar water heating	11.7 (local)	10.7 (local)		
Energy efficiency	0.5 jobs per GWH			

Source: Rutovitz (2010)

As illustrated in Table 5.5, the biomass energy sector had the potential to create 6.9 construction jobs years per MW, 0.8 manufacturing job years per MW and 5.51 jobs per MW with respect to operations and maintenance. This compared favourably against the current coal energy sector.

According to the Department of Energy (2015), the development of renewable energy along with the associated green economy is a priority sector in promoting rural socio-economic development. The Green Economy Accord targets the creation of 50,000 green economy-related jobs by 2020 along with achieving an industry-wide localisation of at least 35% by 2016. Furthermore, according to the Department of Energy (2015), government is targeting an increase in local content with respect to renewable energy to 75%. Minimum participation requirements within the renewable energy sector for local content, wherein a percentage of the project spend was retained for local suppliers, would encourage the growth of the local industry. Further localisation efforts

and investment in local capabilities were possible through (Department of Energy, 2015), including:

- Defining long-term development commitments within the renewable energy sector thereby permitting adequate time for capacity building and as a result market confidence and investment
- Ensuring a high adoption rate of renewable energy within the commercial, industrial and residential market segments

Given existing local content levels along with the potential to increase local content within the biomass energy sector as part of the overall renewable energy sector, the potential for mass outsourcing relevant to the biomass energy sector appeared relatively low thus satisfying one of the intangible criteria relevant to sustainable city development.

Elements relevant to building leadership and partnerships included the achievement of smart growth within a city along with ensuring improved service delivery at a reduced cost. Smart growth, within the context of city development, might be broadly-defined as development that protects natural resources and reduces energy consumption whilst improving municipal finances. Biomass energy interventions with respect to energy supply to a city might be viewed as a ‘smart growth’ intervention.

Given existing human resources and financial capacity constraints within South African municipalities, private sector involvement in utility development could be viewed as one of the mechanisms to ensure improved service delivery. Utility development allowed for the leverage of private capital to achieve service delivery targets as private role players share in the risks and rewards of particular projects. Privately-financed biomass energy development, to contribute to a city’s energy needs, was a potential mechanism to ensure improved service delivery.

Elements relevant to fostering policy reform included creating the demand for green innovation. According to the World Bank (2012), green innovation, which includes the creation and commercialisation of technologies along with the diffusion and adoption thereof, is a key element to greening growth processes. Achieving green growth requires green innovation policies, along with environmental policies, to create

demand where traditional environmental externalities are not fully-reflected in the market price (World Bank, 2012). The use of biomass generated power amounts to green innovation through the application of innovation in industrial policy tools. Biomass thus possessed an extensive contribution to the intangible criteria of sustainable city development

(ii) WIND POWER

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of wind power were (see Section 4.6.1):

- Building the middle class
- Building leadership and partnerships
- Fostering policy reform

Elements relevant to building the middle class included equity of wages along with the extent of outsourcing within that particular theme. Table 5.4 illustrates employment factors relevant to various forms of energy generation as applicable to South Africa. Although minimum wage is governed by legislation in South Africa, the current and future employment potential of the wind power industry as depicted in Table 5.4 indicates a greater leaning towards job security in the wind power energy production sector. As illustrated in Table 5.4, the wind power energy sector has the potential to create 4.5 construction jobs years per MW, 22.5 manufacturing job years per MW and 0.72 jobs per MW with respect to operations and maintenance. This compared favourably against the current coal energy sector.

According to Urban Econ Development Economists (2015), between one and five new tower manufacturing facilities could be established within South Africa by the year 2024 given the anticipated growth in wind power generation. This would equate to approximately between 150 and 750 new sustainable jobs. Three to four blade manufacturing plants were envisaged based on future wind energy demand across sub-Saharan Africa that would be able to create a minimum of 228 new sustainable jobs. Limited local manufacturing opportunities also existed for hub-manufacturing. Although local manufacturing opportunities with respect to wind power generation

existed, these opportunities were reliant on national support of the industry along with market penetration into sub-Saharan Africa. Further reliance is required of the following (Urban Econ Development Economists, 2015):

- Availability of local subsidies and incentives for manufacturers
- Access to trained and available labour
- Provision of adequate training facilities
- Availability of core input materials in South Africa

Given existing local content levels along with the potential to increase local content within the wind energy sector, the potential for mass outsourcing relevant to the wind energy sector had the potential to be reduced in the future albeit not to the extent of photovoltaic power generation. Given the relative potential to reduce mass outsourcing, for the purposes of this study, wind power generation, satisfied the criteria of increasing local content levels within that particular industry.

Elements relevant to building leadership and partnerships included the achievement of smart growth within a city along with ensuring improved service delivery at a reduced cost. Smart growth, within the context of city development, might be broadly-defined as development that protected natural resources and reduced energy consumption whilst improving municipal finances. Wind power interventions with respect to energy supply to a city might be viewed as a ‘smart growth’ intervention.

Given existing human resources and financial capacity constraints within South African municipalities, private sector involvement in utility development could be viewed as one of the mechanisms to ensure improved service delivery. Utility development allowed for the leverage of private capital to achieve service delivery targets as private role players shared in the risks and rewards of particular projects. Privately-financed wind power development, to contribute to a city’s energy needs, was a potential mechanism to ensure improved service delivery.

Elements relevant to fostering policy reform included creating the demand for green innovation. According to the World Bank (2012), green innovation, which included the creation and commercialisation of technologies along with the diffusion and adoption thereof, was a key element to greening growth processes. Achieving green growth

required green innovation policies, along with environmental policies, to create demand where traditional environmental externalities were not fully-reflected in the market price (World Bank, 2012). The use of wind power amounted to green innovation through the application of innovation in industrial policy tools. Wind power thus possessed an extensive contribution to the intangible criteria of sustainable city development.

5.4.7 Urban Agriculture

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of urban agriculture were (see Section 4.6.1):

- Building the middle class

Building the middle class related to elements surrounding equity of wages, the scale of outsourcing within the urban agricultural scheme along with the concept of pro-family orientation. Urban agriculture, if initiated and driven by a community, tend to be more successful (Golden, 2013). Golden (2013) advocates that the following social and economic impacts occur as a result of community-managed urban agricultural schemes:

- Social impacts: Urban agricultural schemes contribute to creating safe places, facilitate access to land, contribute to community development and education along with ensuring cross-generational and cultural integration.
- Economic impacts: Urban agricultural schemes contribute to job creation and business incubation, economic savings on food as well as market expansion for farmers.

Urban agriculture thus possessed a moderate contribution to the intangible criteria of sustainable city development.

5.4.8 Solid Waste

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city

development. Intangible indicators relevant to the theme of solid waste were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Fostering state level policy reform

The integration of newly-arriving communities related to equity of access to mixed income districts, public transportation facilities, equal education and services and opportunity. According to the Department of Environmental Affairs and Tourism (2005), recycling of solid waste had the potential to create opportunity for lower income communities as recyclables could be exchanged for cash. This was particularly relevant to buy-back centres.

Elements relevant to fostering policy reform included creating the demand for green innovation. The recycling of solid waste within South Africa was currently not subsidised to the same extent as other countries. Economic instruments such as green taxes and government grants did, however, have the potential to increase the demand for green innovation within the context of solid waste recycling (Department of Environmental Affairs, 2005). Solid waste thus possessed a limited contribution to the intangible criteria of sustainable city development.

5.4.9 Green Buildings

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of building materials were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities
- Fostering state level policy reform

The concept of integrating newly-arriving communities related to how sustainable city interventions could contribute to equity of access with respect to mixed income districts, equity of access with respect to public transportation along with equity of access in terms of services. Environmental burdens on the most vulnerable of society originated from the components of energy production, disposal of waste and

transportation (Svara, 2014). Direct interventions that sought to promote sustainable energy production, waste disposal and public transportation by implication had a direct effect in ensuring equity of access to societies most vulnerable groups. Arguably this could not be said of the development of green buildings as in the majority of instances green buildings were developed for a specific end user in mind that was typically not directly-related to vulnerable society. As such, the development of green buildings, as a whole, did not fully-satisfy the intangible indicator of integrating newly-arriving communities.

Elements relevant to fostering policy reform included creating the demand for green innovation. According to the Economic Policy Forum (2014), the extent of green building development is determined by the economic incentives facing developers and property purchasers. As such, governmental regulatory frameworks and fiscal incentives could influence the development of green buildings. Green buildings thus possessed a limited contribution to the intangible criteria of sustainable city development.

5.4.10 Air Pollution

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of air pollution were (see Section 4.6.1):

- Leveraging public resources and assets for private investment
- Fostering state level policy reform

Leveraging public resources and assets for private investments, within the context of electric vehicle programmes, could be achieved wherein governments assist in the electric vehicle market transformation by providing investments in research and development along with consumer incentives (Electric Vehicle Initiative, 2013).

Elements relevant to fostering policy reform included creating the demand for green innovation. An electric vehicle programme within a city has the potential to reduce the dependence on fossil fuels whilst utilising electricity that is inexpensive in comparison (Electric Vehicle Initiative, 2013). Furthermore, the electric vehicle industry has the

potential to create new advanced industries that stimulate job creation along with economic prosperity (Electric Vehicle Initiative, 2013). The theme of air pollution thus possessed a limited contribution to the intangible criteria of sustainable city development.

5.4.11 Health Care

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of health care were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities

The concept of integrating newly-arriving communities related to how sustainable city interventions could contribute to equity of access with respect to mixed income districts, equity of access with respect to public transportation along with equity of access in terms of services. Improved health of a population along with equity of access and the more appropriate utilisation of services can be attributed to a health system with a strong primary health care orientation (Cohen, 2006). Health care thus possessed a moderate contribution to the intangible criteria of sustainable city development

5.4.12 Biodiversity

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of biodiversity were (see Section 4.6.1):

- Leveraging public resources and assets for private investment
- Building and sustaining leaderships and partnerships

Leveraging public resources and assets for private investments, within the context of biodiversity enhancement and development could occur within a suportive policy landscape where incentives to align development with ecological investments and

institutional receptiveness predominant thereby permitting collaborative partnerships (Gauteng City Region Observatory, 2010).

Building and sustaining leaderships related to how smart growth within a city could be achieved by adopting a strategic approach. Stategic spatial targeting through municipal investment that facilitated private sector investment was a municipal leadership role that could contribute to smart city growth. Innovative financing arrangements, such as public-private partnerships, tax-increment financing, development charges and carbon financing present opportunities for investing in green infrastructure owing to the value estimation of ecosystem services (Gauteng City Region Observatory, 2013). Biodiversity thus possessed a moderate contribution to the intangible criteria of sustainable city development.

5.4.13 Child-Centred Development

Measuring intangible indicators, for the purposes of this study, was a mechanism from which to guide decision-making relevant to the identified themes of sustainable city development. Intangible indicators relevant to the theme of child-centred development were (see Section 4.6.1):

- Integrating newly-arriving communities and addressing racial disparities

The concept of integrating newly-arriving communities related to how sustainable city interventions could contribute to equity of access with respect to mixed income districts, equity of access with respect to public transportation along with equity of access in terms of services. Access to quality basic services is crucial to a child's development (UNICEF, 2009). As such, basic education underpins the development of human potential and future opportunities for children (UNICEF, 2009). Given that the stated intervention in support of child-centred development seeks to provide and enhance basic education opportunities, it could be viewed as contributing to equity of access with respect to the relevant service provision. Child-centred development thus possessed an extensive contribution to the intangible criteria of sustainable city development.

Table 5.6 summarises the acceptability of the various themes utilising intangible criteria.

Table 5.6: Intangible acceptability of the themes of sustainable city development

THEME	CRITERIA USED	ACCEPTABILITY OF INTERVENTION
Location	• Integrating newly-arriving communities • Linking the city to the regional economy • Building leadership and partnerships	Extensive contribution to intangible assessment criteria- thus, highly-acceptable
Water: • Rainwater harvesting • Grey water • Reclaimed water	• Integrating newly-arriving communities • Fostering state level policy reform	Limited contribution to intangible assessment criteria- thus, partially-acceptable
Sanitation: • Decentralised sanitation systems	• Integrating newly-arriving communities • Fostering state level policy reform	Limited contribution to intangible assessment criteria- thus, partially-acceptable
Compact cities	• Integrating newly-arriving communities • Leveraging public resources • Building leadership and partnerships	Extensive contribution to intangible assessment criteria- thus, highly-acceptable
Public transport	• Integrating newly arriving communities • Leveraging public resources • Fostering state level policy reform	Extensive contribution to intangible assessment criteria- thus, highly-acceptable
Energy	• Building the middle class • Building leadership and partnerships • Fostering state level policy reform	Extensive contribution to intangible assessment criteria- thus, highly-acceptable
Urban agriculture	• Building the middle class	Moderate contribution to intangible assessment criteria- thus, acceptable

THEME	CRITERIA USED	ACCEPTABILITY OF INTERVENTION
Solid waste	• Integrating newly-arriving communities • Fostering state level policy reform	Limited contribution to intangible assessment criteria- thus, partially-acceptable
Green buildings	• Integrating newly-arriving communities • Fostering state level policy reform	Limited contribution to intangible assessment criteria- thus, partially-acceptable
Air pollution	• Leveraging public resources • Fostering state level policy reform	Limited contribution to intangible assessment criteria- thus, partially-acceptable
Public health	• Integrating newly-arriving communities	Moderate contribution to intangible assessment criteria- thus, acceptable
Biodiversity	• Leveraging public resources • Building leadership and partnerships	Moderate contribution to intangible assessment criteria- thus, acceptable
Child-centred development	• Integrating newly-arriving communities	Moderate contribution to intangible assessment criteria- thus, acceptable

Source: Author's own compilation

As depicted in Table 5.6, the extent to which the themes of sustainable city development satisfied the stated intangible criteria ranged from limited to extensive. This would influence the nature of the financing tools and instruments applied to each theme as further discussed in Chapter 6.

5.5 TANGIBLE AND INTANGIBLE ASSESSMENT SUMMARY

Table 5.7 illustrates the consolidated assessment of the tangible and intangible criteria as relevant to the varying identified themes of sustainable city development.

Table 5.7: Tangible and intangible assessment summary

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Location	• Regional • Local area	• Tangible determination: o Gross Value Addition • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Linking the city to the regional and national economy o Building and sustaining leadership and partnerships	• The theme of location was deemed as an acceptable component of sustainable city development when assessed in terms of GVA as growth and development was facilitated by appropriate economic location. • A city's locational factors, for the purposes of this study, influenced the stipulated intangible indicators of sustainable city development. In terms of integrating newly-arriving communities, a city's location influenced equity of wages and the scale of outsourcing as a result of increased economic opportunities to the city's inhabitants. In terms of linking the city to the national and regional economy, a city's location contributed to equity of access owing to the opportunity for improved service delivery along with encouraging increased utilisation of public transport as a result of network linkages between cities.

Water	• Rainwater harvesting • Grey water utilisation • Reclaimed water utilisation	• Tangible determination: o Discounted payback period • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• Rainwater harvesting: The intervention was not necessarily acceptable with respect to investing in an individual household rainwater harvesting system. This was relevant to both an individual home owner or to that of a local authority should they consider the potential rollout of a local authority supported household rainwater harvesting system intervention. • Grey water: It was acceptable, from a tangible perspective, to invest in an individual household grey water system. This was relevant to both an individual home owner or to that of a local authority should they consider the potential rollout of a local authority supported household grey water system intervention. • Reclaimed water: It was acceptable intervention to invest in a reclaimed water project along similar parameters as stated. • Rainwater harvesting, grey water and reclaimed water only satisfied the factors of ensuring equity of access within the category of integrating newly-arriving communities along with creating a demand for green innovation within the category of fostering policy reform. As such rainwater harvesting, grey water and reclaimed water as a contribution to sustainable city development, when viewed from an intangible perspective was somewhat limited as compared to other themes and interventions of sustainable city development.
Sanitation	• Low-diameter sewerage systems collect and discharge household	• Tangible determination: o Discounted lifetime costs	• Decentralised sanitation systems: When assessed from a typical city scenario, conventional sanitation systems possessed the lowest discounted lifetime costs. This scenario occurs when predicted population growth becomes a reality or is exceeded (Hutton &

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
	wastewater from residences into low maintenance wastewater treatment plants • Shared septic tank system where a number of residents connect into one septic tank • Community sanitation centres	• Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	Haller, 2004). Should population growth occur at 0.5% lower than projected, source separated systems are more cost effective than conventional systems owing to reduced idle capacity (Hutton, 2004). Uncertainty with respect to population growth increased discounted lifetime costs as earlier investment were required. Hybrid systems were not tangible owing to double investments required in treatment and collection systems. The context of South African cities would not allow for the exclusive use of decentralised sanitation systems. As such, conventional sanitation systems were preferable from a lifetime-cost perspective. As such, the interventions of low-diameter sewerage systems, shared septic tank systems and community sanitation centres were not deemed as tangible from the perspective of sustainable city development. • Low-diameter sewerage systems, shared septic tank systems and community sanitation centres only satisfied the factor of ensuring equity of access within the category of integrating newly-arriving communities. As such, their contribution to sustainable city development, when viewed from an intangible perspective was somewhat limited compared to other themes and interventions of sustainable city development.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Compact cities	• Bulk infrastructure (water, sanitation and electricity) cost provisions	• Tangible determination: o Direct comparison of recurrent and capital costs of a compact city versus a city characterised by urban sprawl • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Leveraging public resources and assets for private investment o Building and sustaining leadership and partnerships	• Comparing both recurrent costs and capital costs of an urban-sprawl scenario and that of a compact city scenario would indicate, from a cost perspective, that it was more feasible to pursue the compact city scenario. • The theme of compact cities satisfied the indicators of ensuring equity of access with respect to services and transportation. Furthermore, the theme satisfied the indicators of leveraging public resources along with contributing to the concept of a smart city and reducing the cost of services. As such, the theme was deemed to play a large role in the development of sustainable cities when viewed from an intangible perspective.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Public transport	• Creating universal transit passes • Parking cash-out • Bicycle facilities • Car sharing • Transportation resources centres	• Tangible determination: o NPV • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Leveraging public resources and assets for private investment o Fostering state level policy reform	• The principle of investing in public transportation was an acceptable intervention with respect to the net present value gained over various time horizons and scenarios as the NPV increased, both in public transport investment and vehicle-operating costs, through doubling the ridership or striving for a higher growth rate (4.67%) of ridership. • The theme of public transport cities satisfied the indicators of ensuring equity of access with respect to services and transportation. Furthermore, the theme satisfied the indicators of leveraging public resources along with contributing to fostering state level policy reform. As such, the theme was deemed to play a large role in the development of sustainable cities when viewed from an intangible perspective.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Energy	• Biomass • Wind power • Solar power	• Tangible determination: o NPV • Intangible determination: o Building the middle class o Building and sustaining leadership and partnerships o Fostering state level policy reform	• Although all three interventions were deemed to be acceptable from a tangible perspective, solar energy development should receive precedence over wind power and biomass energy production if locational characteristics allowed for such precedence. • The theme of energy satisfied the indicators of building the middle class along leveraging public resources and contributing to fostering state level policy reform. As such, the theme was deemed to play a large role in the development of sustainable cities when viewed from an intangible perspective.
Urban agriculture	• Urban agriculture scheme	• Tangible determination: o NPV • Intangible determination: o Building the middle class	• The calculated net present value from year ten onwards depicted positive net present cashflows. As such, it might be assumed that an urban agricultural scheme, with the broad parameters as described, was a tangible intervention within the concept of sustainable city development. • The theme of urban agriculture satisfied the indicators of building the middle. As such, the theme was deemed to play a moderate role in the development of sustainable cities when viewed from an intangible perspective.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Solid waste	• Property close systems • Drop-off systems • Mandatory versus voluntary programmes	• Tangible determination: o NPV • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• The most feasible programme with respect to the recycling of solid waste, from a tangible perspective, would be to implement a programme that still made use of conventional waste disposal mechanisms whilst employing a recycling programme that sought to recycle waste in equal measure or below the measure • The theme of solid waste only satisfied the factors of ensuring equity of access within the category of integrating newly-arriving communities along with creating a demand for green innovation within the category of fostering policy reform. As such, when viewed from an intangible perspective, the theme was somewhat limited as compared to other themes and interventions of sustainable city development.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Green buildings	• Green buildings	• Tangible determination: o NPV • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities o Fostering state level policy reform	• The net present values of the varying categories of green buildings reflected a positive leaning towards the investment in green buildings. The category of productivity and health gains reflected a substantial contribution to the overall net present value calculation. Although Urban Catalyst Associates (2005) acknowledges that the component of productivity and health gains is difficult to calculate, the category was deemed worthy enough to be included in an overall net present value calculation. For the purposes of this study, the productivity and health component would be viewed as an intangible component and as such would not be considered in the tangible assessment. Considering the exclusion of the productivity and health component, the net present value of the remaining categories still reflected a positive outcome albeit at a lesser extent. • The theme of green buildings only satisfied the factor of fostering state-level policy reform. As such, its contribution to sustainable city development, when viewed from an intangible perspective, was somewhat limited as compared to other themes and interventions of sustainable city development.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Air pollution	• Electric vehicles	• Tangible determination: o NPV • Intangible determination: o Leveraging public resources and assets for private investment o Fostering state level policy reform	• Although financial, access and timing barriers to entry currently existed, a potential electric vehicle programme was a feasible alternative for an individual along with government should the necessary supportive schemes accompany such an intervention. The time-access-financial constraints could, however, begin to be addressed through the installation of the requisite infrastructure through appropriate policy determination and sectorial coordination. • The theme of air pollution only satisfied the factor of fostering state level policy reform and leveraging public resources. As such its contribution to sustainable city development, when viewed from an intangible perspective, was somewhat limited as compared to other themes and interventions of sustainable city development.

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Public health	• Responsive clinics.= • Access to clinic based on proportion of people with a certain radius of the clinic	• Tangible determination: o Cost effectiveness ratios • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities	• Cost savings did occur as a result of primary health care interventions, however, this was dependent on the area of focus for primary health care. In addition, the World Health Organisation (2004) stipulates that primary health care is most cost effective in low-income settings. • The theme of public health satisfied the indicators of equity of access within the category of integrating newly-arriving communities. As such, the theme was deemed to play a moderate role in the development of sustainable cities when viewed from an intangible perspective.
Biodiversity	• Adjacent landscapes interventions • City interventions • City sector interventions • Individual lot interventions	• Tangible determination: o Consolidated ecosystem value • Intangible determination: o Leveraging public resources and assets for private investment o Building and sustaining leadership and partnerships	• There was positive economic value associated with varying categories of open spaces. These categories, in turn, related to the components of adjacent landscapes, city interventions, city sector interventions and individual lot interventions. • The theme of biodiversity satisfied the indicators of leveraging public resources and building as well as sustaining leadership. As such, the theme was deemed to play a moderate role in the development of sustainable cities when viewed from an intangible perspective

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	OUTCOME OF ASSESSMENT
Child-centred development	• Shared formal learning facilities • Informal learning facilities	• Tangible determination: o IRR • Intangible determination: o Integrating newly-arriving communities and addressing racial disparities	• Public sector capital stock ranged from a 0.17 to a 0.9 rating with respect to the relevant rate of return. As such, it might be assumed that child-centred development, within the broad parameters as described, was a tangible intervention within the concept of sustainable city development • The theme of child-centred development satisfied the indicators of equity of access within the category of integrating newly-arriving communities. As such, the theme was deemed to play a moderate role in the development of sustainable cities when viewed from an intangible perspective.

Source: Author's own compilation

Table 5.7 demonstrates the tangible and intangible assessment criteria applied to each identified theme of sustainable city development along with the associated outcomes of those respective assessments.

5.6 SUMMARY

In Chapter 5, tangible and intangible criteria for sustainable city development were applied across all the identified themes and interventions of sustainable city development. The demonstration of the tangible and intangible assessment criteria to the varying themes and associated interventions sought to seek confirmation that, in principle, the application of stated interventions was acceptable. This, in turn, would guide the financing tools and instruments that could potentially be applied to the relevant interventions. In Chapter 6, applicable financing tools and instruments are applied against the relevant themes and interventions of sustainable city development based on the collective assessment of each as contained within Chapters 3, 4 and 5.

CHAPTER SIX

MECHANISMS OF FUNDING OF SUSTAINBLE CITY INTERVENTIONS

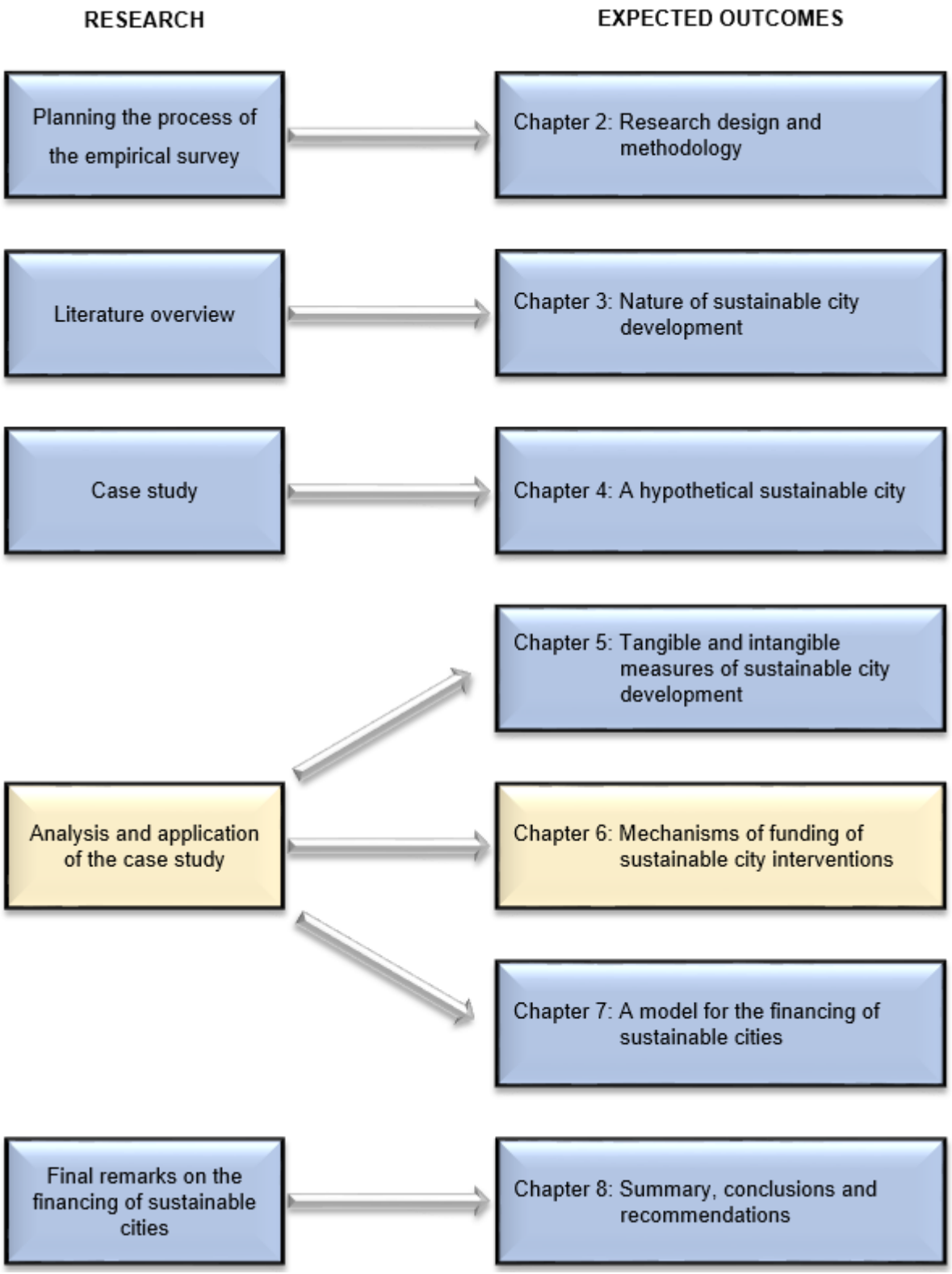
6.1 INTRODUCTION

In Chapter 5, tangible and intangible criteria for sustainable city development were applied across all the identified themes and associated interventions of sustainable city development. The demonstration of the tangible and intangible assessment criteria to the varying themes and associated interventions sought confirmation that, in principle, the application of stated interventions was acceptable. This, in turn, would guide the financing tools and instruments that could potentially be applied to the relevant interventions. In Chapter 6, applicable financing tools and instruments are applied against the relevant themes and associated interventions of sustainable city development based on the collective assessment of each as contained within Chapters 3, 4 and 5.

6.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 6.1.

Figure 6.1: The framework for the study



Source: Author's own compilation

As depicted in Figure 6.1, this study is comprised of eight chapters. Chapter 6 relates to mechanisms of funding of sustainable city interventions.

6.3 FINANCING TOOLS AND INSTRUMENTS OF SUSTAINABLE CITIES

Financing tools and instruments originate in many different forms. For the purposes of this study, a financing tool was the design of a process or action, which by implication, had an eventual impact on the financing of a particular intervention or sector. A financing instrument is a direct financing mechanism such as a bond or a loan that can be used to finance the investment decision.

The management of urban systems can no longer be advanced along the concept of sustainability alone, but through an approach to city investment decision-making that supports cities and sustainable development both at strategic and operational levels (Wojewnik-Filipkowska, 2017). Ultimately, financing decisions with respect to the management of urban development should be guided by the rationalisation of resources.

The funding of sustainable cities is usually beyond the capacities of government along with official development assistance from international donors (International Development Finance Club (IDFC), 2014). According to IDFC (2014), the financing of urban development programmes should be facilitated by governments' improvement in its creditworthiness by securing cash flows from user fees and taxes. Appropriate tax revenue allows for the basis of capital expenditure subsidies required for interventions that may otherwise not prove to be acceptable. Increased creditworthiness may also assist cities to borrow money along with attracting private investment (IDFC, 2014). In the absence of well-developed capital markets, financial intermediaries and development banks may play a strategic role in mobilising the necessary resources required for urban development financing (IDFC, 2014). The IDFC (2014) further lists the following financial approaches to sustainable city development:

- Generation of new capital through the leverage of land assets such as property taxes and sales, betterment levies and impact fees. Besides rigorous tax collection, cities can enhance their funding sources through charging users the full cost of services including environmental damage along with establishing

markets for tradable rights to resources and pollutant permits. The entire cost of individual motor vehicle use, considering aspects such as congestion and pollution, could potentially be priced as a cost to the user. Another option is ration resource pricing in relation to water use wherein water conservation is encouraged along with recycling initiatives and the use of alternative sources of water such as rainwater harvesting.

- Land asset based financing is often a viable financing option as land is often the most valuable asset within a local government's balance sheet. Efficient management capacity is, however, required to address land management. Furthermore, land transactions can be hampered by poor land valuation systems.
- Bond instruments may be utilised to raise funds within well-developed domestic financial markets which results in the lowering of costs along with increased long-term credit sustainability.
- Green funds are accessible as sources of climate change funding for developing countries.
- Development banks are, in instances, able to provide the leverage to tap new markets and private investors along with structuring pooled initiatives to reduce individual investment costs. Often development banks are able to improve investment climates by backing public private partnership projects along with structuring financing vehicles that assist in the risk / return profile that the private sector expects.
- Special purpose vehicles (SPVs) may be created by governments to undertake urban infrastructure investments, at times in partnership with private sector financiers and operators. The transfer of risk to the private sector through service contracts, management contracts, leases and privatisation can assist financially-constrained cities.
- City services may flourish under competitive markets. Concession auctions may succeed in reducing both costs and prices.

World Wildlife Fund (WWF) (2015) provides an overview of financial instruments relevant to financing infrastructure across public, debt and equity finance. The major categories of financial instruments available to a city, according to WWF (2015), are depicted in Table 6.1.

Table 6.1: Overview of public finance instruments relevant to infrastructure

Instrument	Potential impact	Explanation
Land sales	Low	One-off source of finance has limited impact. Difficult to incentivise sustainable infrastructure development once land is sold
Land or infrastructure asset leaseholds	Low	Would depend on government policies and targets. Contracts could stipulate sustainability performance objectives. Difficult to monitor.
Public-private partnerships (PPPs) and private-finance initiatives (PFIs)	Medium	Depends on the type of project and government policies and targets. Could include sustainability targets.
Taxes, for example, property or business tax	Medium to high	Depends on tax design and scope, for example, tax to favour density over urban sprawl or low-carbon energy over fossil fuel sources. Requires coordination across departments and tax incentives.
Land value capture mechanisms, for example, tax-based, building rights and development impact charges or fees	Medium to high	Depends on design and government policies and targets. Could mandate the achievement of sustainability objectives (for example, energy efficiency targets).
User charges and fees	Medium to high	Depends on the integration of externalities and incentives encouraging sustainable usage of infrastructure (for example, public transport) or resource conservation.
Grants and subsidies	Medium to high	Depends on design. Given limited public resources, these instruments should be targeted at projects that have significant potential of leveraging additional sources of finance while delivering sustainable benefits.
Building rights and planning permits	Medium to high	Depends if planning processes and permit allocation is tied to sustainable requirements.

Source: WWF (2015)

Table 6.1 depicts a range of instruments available to a city that may support sustainable infrastructure financing. The application of these instruments is dependent on local contexts along with institutional and legal frameworks.

The European Commission (2013) lists a number of financing mechanisms that may be utilised dependent on the nature of the investment including:

- Models for early demonstration and deployment of innovative solutions using a grant, guarantee and loan blending mechanism:
  - Grant finance is deemed as the most appropriate form of financing during a research period. Soft loans or loan guarantees may follow at the innovation stage through forms such as venture capital
- Project financing:
  - Project financing involves a financial transaction through which public administrations fund public works whose financial responsibility is borne by private capital on the basis of a financial plan to ensure a self-financing process of the operations. The guarantee, with respect to repayments, is represented by the cash flows of the project.
- Smart bonds:
  - Smart bonds refer to bonds that are paid off on the achievement of a specific goal.
- Spread shareholding:
  - Similar to smart bonds, investors buy shares of ownership in infrastructure that are financed through their investment.
- Crowd financing:
  - Crowd financing relates to the collective efforts of networked individuals who pool their resources for investment purposes. Motivation influences participation in such a scheme depending on the nature of the project along with geographical and personal preferences.

Meltzer (2016) argues that seeking green finance requires the development of financial instruments that expose investors to sustainable infrastructure assets. For Meltzer (2016), possible green financial instruments can include:

- Green bonds:
  - A green bond is a fixed income, liquid financial instrument issued by a public or private entity wherein credit ratings are assigned to the bond depending on the rating of the issuing entity along with underlying assets.
- Green equities:
  - Equity investments relate to the investment in projects once operational

The Surrey Wildlife Trust (2014) list a number of financing mechanisms relevant to ecosystem services that may be utilised dependent on the nature of the investment. Although specific to ecosystem services, the financing mechanisms may potentially be applied to other components within sustainable city development. These financing systems are listed as:

- Management grants:
  - Management grants involve a grant paid by a beneficiary, usually the local government or a business, to an ecosystem service provider, often the land owner, on the condition that the provider delivers agreed improvements and management practices. When appropriately-implemented with clearly-defined contractual obligations, effective monitoring and suitable payments, management grants can be cost effective. Management grant schemes are, however, complex to implement requiring extensive resources to establish and maintain.
- Inverse auctions:
  - Inverse auctions allow for providers or sellers of ecosystem services the opportunity to bid for funding that is provided by the buyer outlining the improvements that will be made with an associated amount of funding. The buyer subsequently assesses the cost benefit ratio of the varying bids and assigns funding accordingly. Inverse auctions encourage good value for money whilst simultaneously offering an effective way of delivering high impact ecosystem service benefits. The inverse auction approach prevents the investment of funding in low impact projects as submitted applications are ranked and funded according to the benefits that they deliver. Given the nature of inverse auctions, schemes are often implemented at regional or national level as a large pool of bidders is required. Implementing similar

schemes at local level would require large-scale buy-in from local land owners.

- Offsetting:
  - Offsetting is an indirect intervention where the benefit to the buyer, such as a private business, is achieved for reporting purposes rather than a direct improvement in their services or the reduction of the operational costs. Offsetting is a controversial approach, however, projects are able to be funded through this approach that would otherwise not be funded. Offsetting is dependent on businesses that are willing to pay for offsetting.
- Visitor payback schemes:
  - Visitor payback schemes are funded by public users of services, often with an intermediary channelling funding for projects within an area. Visitor payback schemes allow for users of a particular system to contribute towards their better management in order that users may be sustained along with delivering other services. The visitor payback scheme is only appropriate with a relatively-high number of users.

Besides conventional funding by government, the IDCF (2014) proposed a list of financial approaches such as capital through leverage of land assets, land asset based financing, bond instruments, green funds, development banks, special purpose vehicles and concessions. The WWF (2015) suggest the various instruments that will have a medium to high impact, including land assets, Public Private Partnerships, taxes, user charges fees, grants and subsidies and the usage of building rights. The European Commission (2013) suggests four types of financing, namely, innovative solutions using grants, project financing, smart bonds, spread shareholding and crowd financing. Other types of financing include green bonds, green equities, management grants, inverse auctions, offsetting and visitor payback schemes.

Key to varying financing tools and instruments is the application of those tools and instruments to sustainable interventions with respect to city development supported by possible actions, both at a public level and private sector level, which in the past, may not be viewed as a typical financing instrument.

In this study, financing tools and instruments were proposed as relevant to the identified themes and associated interventions of sustainable city development. The

applicability of the identified financing tool or instrument stems from the nature of the stated intervention as elaborated upon within Chapters 3 and 4 along with the degree of acceptance of those interventions as detailed within Chapter 5.

6.4 IMPLICATIONS FOR FUNDING TOOLS AND INSTRUMENTS RELEVANT TO THE IDENTIFIED INTERVENTIONS OF SUSTAINABLE CITY DEVELOPMENT

The outcomes of Chapters 3, 4 and 5, along with the associated tangible and intangible assessment criteria, provided guidance with respect to the implications to possible financing tools and instruments relevant to the varying stated interventions of sustainable city development. These are listed per theme and associated interventions in Table 6.2.

Table 6.2: Implications for funding instruments and tools per theme of sustainable city development

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Location	• Regional • Local	• National • Provincial • Local	• Targeted development interventions were necessary if contribution to the multiplicity effect of targeted investment was required • Sporadic regional and national investment should be curtailed • Social re-engineering, facilitated by the allocation of government grants and investment, should ideally be employed to contribute to sustainable city development

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Water	• Rainwater harvesting • Grey water utilisation • Reclaimed water utilisation	• Local	• Given water scarcity onus of payment must be on the user • Decentralised water provision to be the domain of the household occupier • Mandatory, punitive approaches were required depending on the extent of water scarcity
Sanitation	• Low-diameter sewerage systems • Shared septic tank system • Community sanitation centres	• Local	• Socio-economic status of a community played a determining factor in the utilisation of community-based sanitation systems • Centralised sanitation systems were more viable than decentralised systems when projected population growth was met • Community-based sanitation systems were highly-dependent on appropriate management structure and monitoring mechanisms.

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Compact cities	• Compact city development	• National • Regional • Local	• Where possible, increased density should be planned / catered for upfront rather than on an incremental basis • Intermittent infrastructure development did not result in the delivery of infrastructure on an appropriate scale • Compact city form should be used as a proviso for future infrastructure development, especially for green field development
Reducing the use of private vehicles	• Universal transit passes • Parking cash-out • Bicycle facilities • Car sharing • Transportation resource centre	• Local • Regional	• Mechanisms were required in which corporations operating within a city incentivised the use of public transportation in partnership with government authorities • Possibly the transportation initiatives should be linked to the concept of city improvement districts

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Energy	• Biomass • Wind power • Solar power	• National • Regional • Local	• Solar power generation, within the context of this study, was preferable as opposed to biomass and wind power given the availability of the input resource along with potential employment potential • Energy demand facilitated the involvement of private sector funding • A combination of financing tools / instruments could be applied relative to the intervention type
Food supply	• Urban agriculture	• Regional • Local	• Notwithstanding individual consumers, private sector supply and demand with respect to retail operations, needed to be involved in an urban agricultural scheme to ensure increased sustainability thereof • Although varying forms of units, ownership and tenancy might occur, focus should be on the extent of usage floor area usage per property type for the purposes of urban agriculture • Local authority's role was to provide for incentives

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Solid waste	• Property close systems • Drop off systems • Mandatory versus voluntary programmes	• Local	• Incentive and punitive strategies should be combined to address recycling of solid waste objectives collectively • Socio-economic differences between communities existed, however, economic opportunities existed within industry for the less privileged
Green buildings	• Green buildings	• National • Provincial • Local	• Green building interventions were viewed as a viable intervention, however, it was recognised that these interventions were not always absolute and dependent on who the role player was within the development and occupation process • Green building standards could not be applied unilaterally across all building types. The scale and extent of intervention was dependent on use type. • Voluntary programmes supported by facilitating regulations and guidelines created an enabling environment for green building development

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Air pollution	• Electric vehicles	• Regional • Local	• A combination of policy adjustment and appropriate incentives were key to the uptake of electric vehicle usage • Major corporations within a city had a large role to play in promoting electric vehicle usage • Synergies could be gained between electric vehicle usage and public transportation
Public health	• Response clinics • Access to clinics	• National • Regional • Local	• Responsive and accessible clinics to be prioritised in low-income settings • Principle of financing tool or instrument was how increased efficiencies / investment could be offset against longer-term economic and social problems
Biodiversity	• Adjacent landscapes • City interventions • City sector interventions • Individual lot interventions	• National • Provincial • Local	• Respective financing tools and instruments should be aligned to the scale of biodiversity type • Increased biodiversity functionality should be a pre-condition in considering any potential financing instrument or tool • Scale of intervention was an important consideration in the application of any relevant financing tool or instrument

THEME	INTERVENTION	SCALE OF FUNDING INTERVENTION	IMPLICATIONS FOR FUNDING INSTRUMENTS AND TOOLS
Child centred development	• Shared formal learning facilities • Informal learning facilities	• National • Provincial • Local	• Private sector had a role to play in the provision of education • Huge disparities in educational facilities necessitated the cross-subsidisation of facilities on the understanding that education was both a public and a private good.

Source: Author's own compilation

As depicted in Table 6.2, implications for financing instruments and tools relevant per theme of sustainable city development are listed. These implications influenced the associated financing instrument and / or tool as further discussed per theme of sustainable city development.

6.4.1 Location

The Presidency (2006), in the National Spatial Development Plan, advocates that impact on poverty is dependent on the proximity poor households to centres of economic activity along with the extent to which these households are connected to the economic activities. As such, the Presidency (2006) of South Africa advocates the following principles with respect to development:

- Unfocused infrastructure spending is not always associated with improved GDP growth
- Unfocused human resource development does not advance GDP growth
- Regions that already possess economic success are more likely to develop than other regions as successful regions possess individuals, firms and industries with the ability to learn from experience
- Successful learning occurs when institutions are locally-specific coupled with the appropriate incentives
- Success is often achieved through focused and polarised investment

- Redirecting public investment from economically-dominant regions to dormant regions does not spur economic activity

Focussed infrastructure spending based on the principles of locations of economic activity is demonstrated by the District Roads Hierarchy Prioritisation project undertaken by Engineering Advice and Services (EAS) (2010). The project sought to prioritise road maintenance and investment needs through not only technical maintenance criteria but also through the socio-economic importance of individual roads within a district road network along with their contribution to the region's economy. Road segments within the region were linked to the 50km mesozone areas, as described in in Chapter 3, relevant to Gross Value Addition (GVA) specific to that particular mesozone. This socio-economic measurement together with technical engineering requirement was then merged demonstrating those road segments which should receive prioritisation in terms of maintenance owing to their contribution to the regions GVA. This is demonstrated in Figure C.1 (see Appendix C).

As illustrated in Figure C.1 (see Appendix C), those road segments highlighted in dark blue are the road segments that should receive priority based on their contribution to the region's GVA. Similar exercises could be applied to other forms of infrastructure such as social facilities as hospitals and schools. The construction and / or maintenance of infrastructure such as hospitals and schools could likewise be prioritised on the basis of spurring development in areas that were economically dominant as opposed to dormant.

The suggested intervention of prioritising infrastructure investment where economic activity was dominant could arguably only be effectively achieved if coupled with a systematic social re-engineering strategy with respect to government investment policies. Although unlikely to be popular, limited government funding necessitated investment decisions and strategies based on areas of dominant economic activity. A deliberate manipulation of the landscape was required for the purposes of social re-engineering. This deliberate manipulation could be achieved from a national level through the following interventions:

- Scaling of social grant amounts relative to areas of higher GVA output
  - Over seventeen million South Africans currently receive a social grant (GroundUp, 2017). Grants available within South Africa include the child support grant, older persons grant, disability grant, grant-in-aid, care dependency grant, war veteran's grant along with the foster child grant. Grants that might potentially influence the future economic activity of its direct or indirect recipients included the child support grant along with the foster child grant. As such, social grants relative to these two categories could be scaled in such a way that the value of the grant was higher in areas of higher economic activity and lower in areas of lower economic activity thereby incentivising the movement of people to greater economic activity as opposed to residing in economically-dormant locations continually.
- Scaling of housing assistance programmes to areas of higher GVA output
  - The fundamental principle of South Africa's various housing assistance programmes is security of tenure through either ownership, leasehold, deed of grant or formal rental arrangements (Human Settlements, 2010). The national norm with respect to the construction of a stand-alone residential dwelling incorporates a gross floor area of forty square meters inclusive of two bedrooms, a separate bathroom along with a combined living room and kitchen (Human Settlements, 2010). Currently, the philosophy of the South African government is to provide for assisted housing on an equitable basis regardless of locational characteristics. Given limited public resources, it was proposed that the principle of overall equity was replaced with the principle of investing in competitive advantage. As such, housing assistance programmes should be amended to provide preference to beneficiaries within areas of higher economic activity as opposed to lower or limited economic activity.
- Scaling of social facilities such as clinics and schools to areas of higher GVA output
  - Primary social and economic amenities associated with housing developments needed to be scaled in a manner that better resourced facilities were provided in areas of higher economic activity as opposed to limited economic activity.

The proposed interventions of scaling relevant social grant allocations, housing assistance programmes along with the provision of social facilities could collectively contribute to successes through focused and polarised investment on the basis of areas defined as possessing higher economic activity.

6.4.2 Water

According to the Department of Environmental Affairs (2011), South Africa is considered to be a water scarce country. Should the current rate of water usage within the country continue, demand is likely to exceed supply. As such, improved water conservation, water quality and water-use efficiency is required as South Africa already exploits approximately 98% of its available water supply resources (Department of Environmental Affairs, 2011).

Given the enormity of the water scarcity problem within South Africa, any financial instrument or tool with respect to the theme of water provision should be developed from the basis of mandatory, punitive platform. An incentivisation approach would arguably not achieve water conservation objectives in a current system wherein water was readily available.

England (2009) lists possible interventions that could be implemented in terms of a water compliance programme. These are reflected in Table C.1 (see Appendix C), which demonstrate simplistic water compliance programmes that could be applied to the categories of gardens and lawns, pools and spas and vehicle washing.

The water compliance options as listed in Table C.1 (see Appendix C) relate to water conservation interventions within a water scarce environment. For the purposes of this study, the primary interventions in relation to the theme of water included rainwater harvesting, grey water systems and reclaimed water systems. The tangible and intangible assessment of these interventions ranged from unacceptable to acceptable, but within limitations. In essence, local municipalities should not seek to fund such interventions on a major scale. Local authorities must, however, be cognisant of water scarcity issues. As such, the onus should be placed on homeowners, considering socio-economic statuses, to ensure water conservation through the application of mandatory punitive measures. As such, proposed financing tools and instruments

specific to those interventions, which seek to promote water conservation, included the following:

- New developments
  - Building regulations to stipulate that all new houses to substitute 70,000 litres per year from rainwater or local recycling
  - Additional land increment tax to be applied to new developments requiring extension to existing water reticulation network
- Existing developments
  - Bylaws introduced wherein no potable water to be utilised for the purposes of garden and lawns, pools or vehicle washing. Only water recycled from rainwater or local recycling to be utilised for such purposes

6.4.3 Sanitation

Carter, Tyrrel and Howsam (1999) advocate that the government's inability, largely owing to a lack of resources, to maintain water and sanitation infrastructure has been a major determining factor in the promotion of community based approaches with regards to water and sanitation provision. The reality, however, is that communities rarely possess the sustainable capacity and the needs to manage their own infrastructure. Carter *et al.* (1999) further stipulate that as communities develop and their needs for water and sanitation systems change, constant education, training and financial subsidy will be required. Without that support, very few community-based water and sanitation systems will achieve anything of any relevant permanence.

An important consideration within the South African context with respect to the theme of sanitation is the occurrence of informal settlements and sanitation provision within those informal settlements. Tsinda and Abbott (2017) state that there are two primary issues with respect to the financing and marketing of sustainable sanitation chains, within the context of sanitation and within informal settlements, namely, who / can finance sanitation and who can / should provide it. According to Tsinda and Abbott (2017), funding can originate from four potential sources, namely, out-of-pocket payments by homeowners / landlords, taxes, tariffs or transfers. The notion of how the sanitation market can be financed ranges from the neoliberal approach wherein it is accepted that the poor currently pay for sanitation services and, therefore, developing

a market base where businesses are encouraged to serve informal settlements profitably to the interventionist approach, wherein a partnership is developed between various stakeholders in offering a community-based sanitation system. Regardless of approach, there is a need to ensure that investment in sanitation results in the eventual real improvement of the sanitation system for the poor (Tsinda & Abbott, 2017).

Utilising the principle that the objective will always be to provide for a conventional supply and / or real improvement in sanitation systems, coupled with the fact that the discounted lifetime costs of centralised sanitation system are cheaper than decentralised systems when encountering projected population growth, focused financing tools or instruments relevant to community-based sanitation systems become senseless. As such interventions, with respect to community-based sanitation systems, should not take the form of direct financing directives, but rather in the form of supportive measures that would lend themselves to the eventual implementation of conventional centralised sanitation systems on the premise that decent sanitation systems were provided for all.

6.4.4 Compact Cities

South African municipalities are faced with severe infrastructure backlogs along with associated deteriorating municipal finance (Horn, 2003). In order to ensure continued municipal service provision in the form of infrastructure delivery, additional infrastructure investment is required. Additional investment can be gained through the issuing of municipal bonds wherein local municipalities issue debt in the form of bonds which are then traded (Horn, 2003). According to Horn (2003), for the concept of municipal bonds to be implemented, creditworthiness of the respective institution is key, which, in turn, can be ascribed to three components, namely, the existence of adequate revenue that supports borrowing, reliable financial information, which is essential for public disclosure and appropriate credit ratings.

In a municipal borrowing bulletin issued by National Treasury (2016), it is recognised that investment in municipal infrastructure is a key determinant in creating an environment conducive to faster more inclusive economic growth and a reduction in poverty. Currently, the secondary market for municipal debt instruments, within the context of South Africa, has not developed as previously expected (National Treasury,

2016). This is in part due to the large amount of municipal borrowing that has occurred in the form of long-term loans as opposed to tradable municipal bonds (National Treasury, 2016). The opportunity still, however, exists for local government, with the necessary creditworthy criteria, to utilise the concept of municipal bonds.

Although municipal bonds might provide a platform from which local authorities may increase investment in infrastructure on the proviso of compact city form, a pure increase in investment potential would not in itself suffice. Key management directives should accompany such investment interventions with the principle concept being compact city form. Kaiser (2013) provides such possible key management directives, namely:

- Spatial considerations and the dynamics associated with those considerations must be taken into account with respect to infrastructure investment
- Enterprise asset management is key to model maintenance requirements in addition to new infrastructure development
- Improved integration within an organisation can improve investment efficacy

The financing of city infrastructure is funded from transfers from national government, own-source funding and borrowed funds. Transfers from national government will continue as per provisions within applicable legislation along with own-source funding through the levying of taxes to a city's residents. Opportunity does, however, exist for further funding from the secondary market. Key to all forms of infrastructure development, regardless of funding source, is that the principles of compact city form are adhered to. Such an approach could be supported by the following interventions:

- Municipal bonds
  - A viable option for municipalities, depending on the creditworthiness of that municipality, is to issue municipal bonds to finance capital projects on the proviso of compact city development. The purchasing of municipal bonds by a community allows for the lending of money to the bond issuer, namely, the municipality, in exchange for regular interest payments.
- Centralised infrastructure investment coordination
  - The strategic planning office and budget office within a municipality should coordinate investment programmes within a city based on compact city

principles. Although utility departments such as roads, water and sanitation plan and implement projects relevant to their portfolios, overall coordination should occur at the central planning office to ensure appropriate investment coordination.

6.4.5 Public Transport

Cities generally lack sustainable revenue from which to implement transportation improvements that will ultimately provide for long-term savings and benefits (Victoria Transport Policy Institute, 2017b). Ideally, investments in transportation should be financed by a combination of grants from multiple levels of government, loans and public private partnerships repaid by user fees and property taxes (Victoria Transport Policy Institute, 2017b).

Victoria Transport Policy Institute (2017b) lists eighteen potential funding options with respect to financing public transit, transportation services or other projects. These are described in Table C.2 (see Appendix C), which include eighteen varying forms of financing public transport and associated public transport infrastructure as has been identified by Victoria Transport Policy Institute (2017b).

The financing options as discussed within Table C.2 (see Appendix C) relate to a multitude of factors within the transportation sector. For the purposes of this study, the primary interventions with respect to the theme of public transport were universal transit passes, parking cash-out, bicycle facilities, car sharing and a transportation resource centre. As such, the proposed financing tools and instruments were specific to those specific interventions and included the following:

- Universal transit passes
  - Discounted bulk passes could be provided by major corporations within close proximity to each other whose staff members had the opportunity to utilise public transportation. A negotiated discounted rate between the city's public transportation system and those corporations was first negotiated. Those bulk passes were then offered to the respective employees as part of their salary package. Those employees utilising private vehicles would not qualify for the benefit.
- Parking cash-out

- Free parking was provided to employees within any organisation within a city that car shared. Any employee that did not partake in a car-sharing scheme would need to pay a substantial monthly parking fee. Funds generated from the parking fees could collectively contribute to a city or sector improvement district wherein smaller scale non-motorised transportation offerings along with the auxiliary infrastructure were developed such as bicycle facilities. In effect, the city or sector improvement district became a transportation resource centre.

6.4.6 Energy

Besides natural environmental factors that influence the development of renewal energy, an enabling environment supported by adequate institutions, regulations and market readiness is a requirement for renewal energy development (Moon, Song & Seojin, 2015). Table 6.3 demonstrates the varying factors influencing renewal energy development.

Table 6.3: Factors influencing renewable energy development

Techno-economic barriers	Non-economic barriers
Barriers that relate to the direct costs of a certain technology, for example, availability or adequacy of required natural environment: sun exposure and wind speed; technology deployment costs: price of solar panels and wind turbines.	Regulatory and policy uncertainty barriers
	Institutional and administrative barriers
	Market barriers
	Financial barriers
	Infrastructure barriers
	Lack of awareness and skilled personnel
	Public acceptance and environmental barriers

Source: Moon *et al.* (2016)

As depicted in Table 6.3, both techno-economic and non-economic barriers influence renewal energy development.

Considering the barriers to renewable energy development, Moon *et al.* (2015) lists possible public interventions within the realm of renewable energy development to induce private sector participation, including:

- Early stage project development: The use of public resources as seed capital at the early stage of a project can contribute to the mobilisation of further investment from the private sector. Further to the application of seed capital, public support for law and regulation review with respect to enabling renewal energy development can attract private investment.
- Guarantees and insurance: Further support can be provided at the stage of financial closure through guarantees or subsidies through tools such as feed-in-tariffs.

Further potential financing tools and instruments relevant to renewable energy development also need consideration. For example, Meltzer (2016) advocates a financing framework for LCR infrastructure along the lines as depicted in Figure C.2 (see Appendix C). As depicted in Figure C.2 (see Appendix C), to overcome the barriers to financing renewable energy infrastructure, projects required matching a risk profile to the various sources of capital in conjunction with the lifecycle of an infrastructure project. At the preparation and construction phases, finance was required to de-risk the cost of capital thereby leveraging public sector finance. Once returns were proven at the operational phase, along with the reduction of risk, opportunities to refinance the project exist.

Ottinger and Bowie (2014) describe financing mechanisms relevant to renewable energy dependent on the scale and nature of the locality and respective operation, including:

- Programmes relevant to areas with no electricity access
  - Microfinance: Microfinance systems, wherein microfinance providers such as non-governmental organisations, cooperatives, government agencies and community-based development groups, provide microfinance products and services in relation to renewable energy installations and infrastructure.
  - International bank financing: The World Bank, Global Environmental Facility along with international and regional banks provide for loans with respect to

renewable energy projects thereby catalysing renewable energy market investment.

  - Margin money finance: Margin money relates to the down payment required for a traditional loan structure, which is often unaffordable for the borrower. Margin money finance support generally originates from government sources through subsidised relief.

- Financing intermediate, community / village scale projects
  - Community micro-grid projects: Community renewable energy projects within the village scale are anchored by larger community structures such as hospitals and schools. The respective institutions anchors help to support electricity for residential use.
  - Crowd funding: The funding of solar power projects can be achieved through crowd funding as demonstrated by Mosaic, an Internet platform that connect investors to solar projects who eventually benefit through the production and sale of electricity.
- Grid served communities
  - On-bill financing: On-bill financing a utility provides a loan to finance the initial capital required to install renewable energy. The repayment of the loan is then amortised and distributed as a charge on a customer's monthly utility bill or alternatively as a surcharge on property tax.
  - Power purchase agreements: Power purchase agreements occur between the generator of electricity and that of the off-taker of electricity. Such agreements are able to facilitate the restructuring of the energy economy along with increasing the availability of financing for renewable energy infrastructure.

Abolhosseini and Heshmatic (2014) describe the predominant support mechanisms in which to finance renewable energy development as:

- Feed-in-Tariff: Feed-in-tariffs are a support mechanism to accelerate investment in renewable energy technologies through offering long-term purchase agreements for the sale of renewable energy. It includes guaranteed access to the grid, stable and long-term power purchase agreements along with process based on the unit costs of power generated.

- Tax incentives: Tax exemption can be employed against the investment, production or consumption segments of electricity generated by renewable energy sources.

Considering the possible varying financing tools and instruments relevant to renewable energy development, for the purposes of this study, key principles relevant to financing tools and instruments relevant to renewable energy development included the following:

- Solar energy development should receive precedence over wind power and biomass energy production if locational characteristics allowed for such precedence
- Private sector should lead in the development and implementation of solar, wind and biomass energy generation schemes
- Government facilitated the development of renewable energy development through ensuring conducive laws and regulations
- Recognising the distinction between interventions on a grid scale versus interventions on a community scale

These principles informed the recommended financing tools and instruments, which are listed as follows:

- Public private partnerships with respect to grid scale interventions
  - Assuming a conducive environment for power purchase agreements with respect to applicable laws and regulations, power purchase agreements between a city and a private energy provider ensured long-term hedging against the risk of fluctuating energy prices along with facilitating a commitment to the usage of renewable energy generation.
- Revaluation of land assigned to solar, wind and biomass energy generation
  - Within the South African context, solar and wind farms were generally developed on agricultural zoned land. The municipal valuation of that land was still assessed in agricultural terms although the usage of that land had been modified through the addition of power-generating activities. It was thus proposed that local authorities developed a municipal valuation for solar and wind farms to increase their rates base should such a facility be

located within their area of jurisdiction. Furthermore, opportunities in terms of ring-fencing such income from the added municipal valuation for further renewable energy project development might occur, particularly should public resources be required, such as seed funding for early stage project development.

- On-bill financing on the principle that upfront charges levied against energy consumers to accumulate funding by the local municipality for the purposes of seed funding for early stage project development
  - This mechanism might possibly be utilised to finance the initial capital required for early stage project development. The estimated cost of early stage project development was distributed as a charge on a customer's monthly utility bill or alternatively as a surcharge on property tax.
- Crowd funding in relation to community interventions
  - Although not related to grid tied renewable energy generation farms, opportunity existed within the individual household sector wherein individual homeowners purchased a stand-alone solar power solution for their household from an independent provider, contracted by the local authority, on the basis that that stand-alone unit was purchased on the principle of a loan offset against monthly power charges. Local municipal Internet platforms, in the form of crowd funding, could be established to allow for the investment by community members in those stand-alone solar power solutions, all managed by the appointed service provider within provisions as stipulated by a local authority.

6.4.7 Urban Agriculture

The process of urbanisation has resulted in monoculture communities wherein society's functions have become dramatically segregated (Boeing, 2016). As such, much of the city form is zoned as residential without the opportunity for front yard agriculture or local food hubs based on urban policy and governance that has developed under the assumption that food supply will be provided from the hinterland (Boeing, 2016). Progressive neighbourhood planning is thus required wherein complete neighbourhoods are promoted in order that choice is provided to a community, particularly, in terms of food choice.

Maylath (2014) recommends the following for implementation by city governments to achieve progressive neighbourhoods in support of urban agriculture:

- Establish a municipal community gardening programme
- Appoint a food policy council to advise the city council on urban food systems
- Appoint a community garden coordinator to recommend and implement streamlined processes for acquiring public land
- Review and modify existing land use policies in support of urban agriculture
- Identify and secure partnerships between government agencies and private non-profit organisations

Miller (2016) argues that economic development is no more than a collection of legal and policy tools that can be deployed to achieve any purpose. Tools such as tax increment financing that is used to attract factories to city centres could equally be used to attract producers of locally-grown produce. Miller (2016) lists the following tools that can be utilised to assist with the development of urban agriculture schemes within cities:

- New markets tax credits, which is a type of transferable tax credit that is offered for placing development in low income communities.
- Cities may allocate pre-zoned urban agriculture schemes for portions of land within the city.
- Tax increment financing, which permits local authorities to bond upfront on the basis of projected tax revenues that would eventually be generated from a specific area for the purposes of urban agriculture. The upfront capital allows for local governments to provide the necessary infrastructure to facilitate projects.
- Tax exemptions, which can be applied where land utilised for agricultural purposes within the city boundaries is exempt from local rates and taxes.
- Social impact bonds, which private investors provide for upfront capital for a city to make social investments for which there is little capital available but where the implementation thereof has positive long-term social and economic spin-offs. The city repays the bonds over time through savings that it would have otherwise have spent on addressing long-term social and economic problems in the absence of that upfront investment.

Numerous financing tools and instruments are available in which to support the development of urban agriculture. Key to any urban agricultural scheme within a city along with the potential associated financing tools accompanied thereof is private sector involvement to drive the supply and demand of foodstuffs cultivated within urban settings. Such a principle guides the following proposed financing tools and instruments as relevant to this study:

- Dedicated provision is made for urban agricultural schemes within a city's town planning scheme
  - Facilitation of urban agriculture is gained through enabling land use regulations that permit and promote the practice of urban agriculture within a city's limits.
- Tax exemptions
  - It is proposed that local rates and taxes exemptions be applied to properties wherein 40% of the property extent, in terms of floor area ratio, is utilised for urban agricultural purposes. Opportunities exist to utilise not only the physical ground of a particular site for urban agriculture but also the built form thereon in terms of vertical farms wherein urban agriculture is possible through hydroponics. The proposed tax exemption would, therefore, apply to 40% of the total gross area available on a particular portion of land.
- Tax increment financing targeted towards major retailers of the food industry
  - A local authority could issue bonds in relation to a city-wide urban agricultural scheme but offer those bonds only to retail operators involved in the food industry. In this manner, retail food operators invest in the local food production sector whilst simultaneously possess an interest in the success thereof through the possible purchase of produce from local producers.

6.4.8 Solid Waste

Key to the financing of sustainable solid waste practices is how incentives and disincentives can be utilised to change behaviour and to correct price distortions in the market (Elagroudy, Warith & Zayat, 2016). According to Elagroudy *et al.* (2016), incentives within the waste sector include taxes and fees, recycling credit and other forms of subsidies, deposit / refund interventions and standards as well as

performance bonds or environmental guarantee funds. Typical incentives that may be utilised with respect to sustainable solid waste management include the following (Elagroudy *et al.*, 2016):

- Operationalizing the polluter pays principle wherein polluters are charged according to the volume and type of waste generated
- Applying the user pays principle wherein users of waste and its subsequent conversion into energy or products are paid for
- Using pay-as-you-throw schemes wherein waste generation is discouraged
- Promoting the use of landfill taxes or landfill disposal bans on certain materials

Furthermore, potential innovative funding mechanisms include the following with respect to solid waste management (Elagroudy *et al.*, 2016):

- Micro-financing
  - Small-scale interventions may utilise micro-financing techniques wherein micro-credit funds are created from donations which are utilised as working capital for the financing of waste transportation and waste-related emergency responses. The funds may also be utilised to extend loans to waste scavengers who repay their loans once payment has been received from recycling depots.
- Eco-entrepreneurship
  - Eco-entrepreneurship encourages small to medium enterprises to engage in solid waste practices through the creation of demand of recycled products.

For the purposes of this study, the primary interventions identified within the solid waste theme included property-close systems, drop-off and mandatory versus voluntary systems. Proposed financing tools and instruments relevant to these included:

- Implementing the polluter pays principle
  - Local authorities could introduce mandatory regulations wherein households were required to separate recyclable material at the household.

Failure to do so could be addressed with increased surcharge applied to a household's monthly rates bill.

- Micro-financing to extend loans to waste scavengers
  - Household recycling, within the South African context, wherein households separated household waste into varying recyclable materials had yet to gain traction. This coupled with suburban waste scavengers, who undertake scavenging for survival purposes, presented an opportunity to drive property-close systems whilst simultaneously assisting in poverty relief with respect to waste scavengers. Funding received through punitive measures from the polluter must pay principle could be utilised as the micro-financing funding source to support waste scavengers.

6.4.9 Green Buildings

Van der Heijden (2014) undertook research to assess voluntary programmes that sought to achieve an improved uptake in the retrofit of buildings based on sustainability parameters. The research sought to understand the opportunities, performance and constraints of such voluntary programmes. Of particular interest were the rewards for participants of voluntary programmes, the stringency of a voluntary programme along with the role of government in a voluntary programme. Van de Heijen's (2014) key findings included:

- There was a challenge in incentivising participants to retrofit buildings
- There was limited success for voluntary programmes with respect to building retrofits

Based on the key findings, it was highlighted that the design conditions of voluntary programmes interacted in causing their effect and, as such, must be cautiously considered. Furthermore, Van der Heijen's (2014) study revealed that not too much should be expected from voluntary programmes in achieving a large number of building retrofits that contributed to the transformation of urban areas. Rather focus should be applied to niche markets, such as the high-end of the commercial sector, in undertaking voluntary retrofit building programmes.

Financial institutions are able to fulfil four predominate roles with respect to green buildings, namely, as owner or user, as investor or private developer as lender and as insurer (UNEP, 2010). Given the four predominant roles that financial institutions play within green building development, the opportunity exists to enhance their involvement in green building development through the greening of their own or leased facilities (UNEP, 2010). Furthermore, based on the collective influence of financial institutions, a greater number of buildings can be induced to achieve green status through the financial institutions investment, lending and insurance activities (UNEP, 2010).

Key to the financing of green buildings, is the ultimate beneficiary of the green building, namely, initial developer versus possible purchaser, coupled with the nature of the developer / owner of the green building. As such, the principle governing the financing of green buildings should be to allow the private sector, particularly financial institutions, to take the lead in developing green buildings supported by governmental and non-governmental institutions in the development of regulations and / or guidelines for green building development. Such an approach could be supported by the following interventions:

- Financial institutions adopt a leadership role in the development of green buildings through tailor-made investment, lending and insurance activities in support of green building development.
    - Arguably, financial institutions possess the most appropriate attributes in leading society towards achieving green building development. Influence on development is achieved through stated parameters relevant to investment, lending and insurance activities.
- Programmes are developed / enhanced between financial institutions and organisations such as the Green Building Council of South Africa (GBCSA) to support the respective financial institutions development of green buildings.
    - The predominant players within the development of green buildings are that of financial institutions and, within the context of South Africa, the GBCSA. Any other organisation or institution is secondary to that. As such the development of programmes wherein the GBCSA assists financial institutions in their investment, lending and insurance offerings based on green building parameters, should be encouraged.

- Local government's only role within green building development is to facilitate such development based on the continual revision of building codes in consultation with bodies such as the GBCSA.
  - Incentivisation schemes, initiated by local government, are deemed unnecessary owing to the potential dominance of financial institutions within the sector along with the associated profitability margins associated with green building development and the end-user thereof.
  - Voluntary programmes for the retrofit of buildings may be undertaken by local government, but only within the context of niche markets such as high-end commercial properties.
  - Revision of building codes should occur relative to the functions of high-end usage.

6.4.10 Air Pollution

The US Department of Energy and US Department of Transport (2016) provide the following guidelines / programmes with respect to the potential funding of plug-in electric vehicles and charging stations:

- Airport zero-emission vehicle and infrastructure incentives
  - This programme provides funding to airports for up to 50% of the cost to acquire electric vehicles along with the installation of infrastructure to support the electric vehicles. The grant funding received must be used exclusively for airport purposes.
- Congestion mitigation and air quality improvement programme
  - This programme provides a funding source for local governments and transit agencies to fund transportation projects that assist in reducing congestion and mobile source emissions.
- Surface transportation block grant programme
  - This particular programme allows for flexibility in local transportation decisions and provides the reciprocal flexible funding to best address local transportation needs. Typical funding provides for the construction of electric vehicle charging stations associated with truck parking facilities along with fringe and corridor parking facilities wherein park-and-ride options are available.

- National highway performance programme
  - This programme provides support for the construction of electric vehicle infrastructure on the national highway system.
- Advanced transportation and congestion management technologies deployment initiative
  - This initiative provides grants to eligible entities to develop model development sites for the large-scale installation and operation of advanced transportation technologies.
- Low and zero-emission vehicle funding
  - Through this programme financial assistance is provided to entities for capital projects involving low or zero-emission public transport vehicles.
- Alternative fuel infrastructure tax credit
  - Tax credits are provided for fuelling equipment for electric vehicles.
- Qualified plug-in electric drive motor vehicle tax credit
  - A tax credit is provided for the purchase of a new qualified electric vehicle.

For the purposes of this study, the primary interventions identified within the air pollution theme included the promotion and utilisation of electric vehicles and associated supporting infrastructure. Proposed financing tools and instruments relevant to these included:

- Providing zero-emission and associated infrastructure incentives to major corporations located within a city
  - Tax rebates could be provided to major corporations within a city of a minimum number of employees to incentivise the use of electric vehicles as either fleet of personal staff vehicles along with the establishment of charging stations at the place of work for the use of fleet or private vehicles. Rebates could take the form of direct taxing or through the municipal tax structure of the city.
- Subsidised public transportation provided to users of electric vehicles in park and ride schemes
  - In developing park-and-ride systems within the city to improve the use of public transportation, electric charging stations could be provided by the local authority at those park-and-ride facilities. Should an owner of an electric vehicle utilise the park-and-ride facility, and, subsequently, the public transportation on offer

from the park-and-ride facility, the cost of that public transportation could be subsidised for the electric vehicle user.

6.4.11 Public Health

Meghani, Abdulwahab, Privor-Dumm, and Wonodi (2015) lists various forms of financing mechanisms in financing primary health care. These are described in Table C.3 (see Appendix C) wherein four predominant forms of financing mechanisms are listed for the purposes of primary health care. Basket funds were pooled funding mechanisms that managed funds from multiple contributors to finance shared priorities. Community-based health insurance programmes pooled low-insurance premiums from community members to establish a common fund that provided access to select preventive services. Results-based financing related to the concept of providing incentives for stated objectives whereas the implementation of public private partnerships could range from the delivery of treatments to health insurance partnerships.

The financing options as listed in Table C.3 (see Appendix C) related more to the envisaged delivery of a comprehensive primary health care service. For the purposes of this study, the primary interventions in relation to the theme of primary health included access to clinics and response clinics. As such, the proposed financing tools and instruments were specific to those two interventions, namely:

- Low income settings
  - Based on the nature of primary health care, along with the objectives, it sought to attain, it was proposed that accessible and responsive clinics be developed in low-income settings only as opposed to being disbursed unilaterally across a city's landscape.
- Scaling of social facilities to areas of higher GVA output
  - As detailed in Section 6.4(i) social needed to be scaled in a manner that better resourced facilities were provided in areas of higher economic activity as opposed to limited economic activity.
- Social impact bonds
  - With this particular financing tool, private investors provided for upfront capital for a city to make social investments in accessible and responsive

clinics. The city repaid the bonds over time through savings that it would have otherwise spent on addressing long-term social and economic problems in the absence of that upfront investment.

6.4.12 Biodiversity

Payments for ecosystem services are tools that translate external, non-marketed values of the natural world into financial incentives for landowners in providing ecosystem services (Belluomini, 2016). Belluomini (2016) further defines payment for ecosystem services as a voluntary transaction wherein an environmental service is bought by a service buyer from a service provider if the service provider secures service provision. For Belluomini (2016), critical aspects of any payment for ecosystem services scheme include:

- Entrance into a payment for ecosystem services agreement occurs on a voluntary basis
- Payments are made directly from service beneficiaries to providers
- Service provider must additionally demonstrate that practices undertaken by the service provider would not normally have been put into practice without a payment for ecosystem services scheme
- Conditionality must be ensured wherein payments are only made if the delivery of the environmental service occurs
- Permanence in respect that interventions should not easily be reversible
- Environmental leakages where bad environmental practices are shifted to an alternative area as a consequence of the initiation of the payment for ecosystem services scheme

Payment for ecosystem services are not in themselves the complete solution for addressing environmental critical issues but are rather to be viewed as tools to be effectively combined with other environmental initiatives (Belluomini, 2016).

Based on the scales of possible diversity management as discussed in Chapters 3 and 5, the possible application of payment for ecosystem services could occur as reflected in Table 6.4.

Table 6.4: Proposed application of payment for ecosystem services based on scale of intervention

SCALE	PLANNING	DESIGN	MANAGEMENT	PROPOSED APPLICATION
Adjacent landscapes	Zone landscape use: • identify and protect important natural areas • identify green corridors linking city to natural areas • create regional parks	• Design parks and green corridors to optimise their use by wildlife • Design roadways to minimise fragmentation of natural areas.	• Plant vegetation and restore habitats to improve parks and corridors • Promote management options that favour wildlife diversity.	• Identify corridors, i.e. rivers and streams with city limits • Identify commercial property owners adjacent to those identified corridors
City	• Extend green corridors within the city • Identify important areas for wildlife within the city • Identify important species	• Shape, structure and size-up corridors to optimise wildlife use • Design park to increase wildlife abundance and diversity	Plant vegetation in parks, green corridors and along streets	Devise management plans for city wide inter-connectivity corridors
City sectors (industrial, commercial, residential, recreational)	• Establish vegetation objectives • Interact with higher levels to ensure optimal location of natural areas, parks and corridors • Create management plan for parks that will preserve and enhance diversity	Design type, structure and distribution of vegetation for favour wildlife	• Enhance or restore vegetation in industrial and commercial areas • Reduce use of herbicides and pesticides • Promote plantations of shrubs, fruit trees, conifers	Devise programmes for the industrial and commercial sector within the city wherein companies within the region can contribute to the restoration of vegetation in industrial / commercial areas
Individual lots	• Landscape property to attract wildlife; • Coordinate with neighbours to maximise vegetation volume	• Select type of vegetation most compatible with wildlife • Design nesting and feeding structures	• Install and maintain nest boxes and bird feeders • Avoid use of pesticides and herbicides	Undertake promotion of voluntary programmes in which to landscape individual properties.

Source: Author's own compilation

As reflected in Table 6.4, the application of a financing toll and / or instrument would be dependent on the scale of intervention type. Based on the scale of intervention type, the following financing tools and instruments were proposed:

- Management grants
  - Management grants involved a grant paid by a beneficiary, usually the local government or a business, to an ecosystem service provider, often the land owner, on the condition that the provider delivered agreed improvements and management practices. It was proposed that property owners adjacent to primary biodiversity corridors within the region be identified and approached to potentially enter into clearly-defined contractual obligations to maintain and rehabilitate sections of the identified corridor that traversed their portion of land. This would be coupled with the effective monitoring of such rehabilitation along with the associated payment thereof.
- Inverse auctions
  - Inverse auctions could be applied for schemes wherein local authorities devised management plans relevant to city-wide biodiversity inter-connectivity corridors. The application of the management plans could then opened on an inverse auction basis wherein sellers of ecosystem services bided for funding, provided by the local municipality, outlining improvements required as per the management plans.
- Offsetting
  - Offsetting could be applied to commercial and industrial businesses wherein the respective businesses contributed to the local municipality for the restoration of vegetation within industrial and commercial areas on the basis that their payment was offset against any direct environmental responsibilities in the operation of their businesses.

6.4.13 Child-Centred Development

Burnett (2010) stipulates that developing countries are not going to be in a position to assign sufficient public resources to finance education needs adequately. As such, there is no option but to utilise both private financing along with private delivery systems to complement the existing public financing and public schooling systems. The viewpoint is made on the basis that the reality of education provision has some

aspects of being a private good, benefiting an individual, whilst possessing some aspects of being a public good, benefiting society. The implication is that for most developing countries, higher and secondary education would have to become much more dependent on student fees (Burnett, 2010). The issues that arise therefrom include the concepts of fee levels, equity and loan mechanisms. Given these pragmatic viewpoints of the financing of education within developing countries, Burnett (2010) recommends the following approaches with respect to education funding:

- Ensuring the recognition that cost recovery and cost sharing with students and their families is a reality for developing countries at the higher level whilst also likely for countries at the secondary level
- Improving integration of the private sector into public policy objectives is required
- Adopting a regulatory framework that recognises the growing role of the private sector along with the decentralisation of the public sector

Based on these approaches, Burnett (2010) advocates that innovative financing mechanisms are required for education owing to the following predominant factors:

- Resource mobilisation: If the financing gap is to be addressed for basic education, and if secondary and higher education continue to expand, total resources for education will need to increase through the possible reallocation of public spending.
- Raising the profile of education: Raising the profile of education can contribute to innovative financing efforts on a global scale.
- Improving the effectiveness, efficiency and equity of educational spending.
- Promoting innovation in education: Education is widely-perceived as a conservative sector. The educational sector can be transformed through the widening of the sector to include new delivery programmes.

The financing options as discussed relate to a multitude of factors within the education sector. For the purposes of this study, the primary intervention with respect to the theme of child-centred development included establishing formal central learning facilities, with facilities that inculcated the principles of child-centred development both across class and income divides. Schools, regardless of class or income, would not provide these facilities within their own premises but be forced to use the facility as

part of the delivery of the curriculum. As such, the proposed financing tools and instruments were specific to that specific intervention and included the following:

- Levy per child applied to pupils at private schools
  - Applying a mandatory levy per child at private schools to be utilised for the financing and development of child-centred facilities at centralised less-privileged localities. In effect, the private school system subsidised the development of child-centred facilities.
- Social impact bonds
  - With this particular financing tool, private investors provided for upfront capital for a city to make social investments in child-centred educational facilities. The city repaid the bonds over time through savings that it would have otherwise have spent on addressing long-term social and economic problems in the absence of that upfront investment.

6.5 PRIVATE SECTOR VERSUS PUBLIC SECTOR FINANCING

Although most of the financing of sustainable cities revolves around public sector finance, the private sector also plays an important role in the financing of sustainable cities. Table 6.5 outlines a summary of the sustainable city finance for the private and public sector.

Table 6.5: Summary of private and public sector finance of sustainable cities

THEME	PUBLIC SECTOR FINANCE	PRIVATE SECTOR FINANCE
Location	• Finance was provided from all levels of government by means of grants and investments and directed social engineering policy directives	• Economic value addition was created through the consolidated investment in infrastructure by government • Private sector supported and gained from such value addition through the acquirement of land utilising both equity and debt financing
Water	• Local government applied building regulations and land increment taxes through a ‘user-must-pay’ policy	• Private individuals would fund these interventions as part of a purchase price or an additional installation charge

THEME	PUBLIC SECTOR FINANCE	PRIVATE SECTOR FINANCE
Sanitation	• Government did not finance decentralised water sanitation systems but focused on the funding of centralised sanitation systems through its own revenues sources such grants, subsidies and its own rates base	• Private individuals indirectly financed through payment of municipal taxes
Compact cities	• Revenue was raised by the issuing of municipal bonds • Government ensured centralised infrastructure investment coordination	• Private sector to invest in municipal bond options
Public transport	• Negotiated discounted rates provided to private sector that participated in bulk pass schemes	• Private sector to fund discounted bulk passes as part of employee remuneration package • Private sector to charge user fees in terms of parking cash-out schemes for contribution to city improvement districts
Energy	• Municipal valuation and land use rights to be amended to allow for applicable rating of land and the subsequent payable taxes thereof	• Private sector to fund through power purchase agreements • Private sector and individuals to fund based on on-bill financing • Crowd funding for stand-alone household solar power solutions
Urban agriculture	• Enabling land-use regulations • Having tax exemptions	• Tax increment financing through the purchase of bonds specific to the retail food industry
Solid waste	• Mandatory directives with associated surcharges applied	• Micro-financing loans

THEME	PUBLIC SECTOR FINANCE	PRIVATE SECTOR FINANCE
Green buildings	• Voluntary incentivisation schemes initiated by local government	• Financial institutions institute tailor made investment, lending and insurance activities in support of green building development • Programmes developed between financial institutions and GBCSA in support of green building development
Air pollution	• Subsidised public transport in support of electric vehicle usage	• Tax rebates to major corporations to incentivise the use of electric vehicles as fleet vehicles
Public health	• Interventions focussed in low income settings • Utilisation of grant funding	• Private sector to invest in social impact bond options
Biodiversity	• Management grants • Inverse auctions	• Private sector to contribute by offsetting payment mechanisms
Child-centred development	• Utilisation of grant funding	• Levy per child located in private school • Private sector to invest in social impact bond options

Source: Author's own compilation

6.6 SUMMARY

In Chapter 6, applicable financing tools and instruments were applied against the relevant themes and interventions of sustainable city development. Based on the influencing factors, the tangible and intangible criteria along with the scale of intervention and the implications for funding instruments and tools, financing directives per theme were applied. Table 6.5 provided a summary of the private and public sector finance of sustainable cities per identified theme. In Chapter 7, the model of these financing tools and instruments are applied to the context of a sustainable city is discussed.

CHAPTER SEVEN

A MODEL FOR THE FINANCING OF SUSTAINABLE CITIES

7.1 INTRODUCTION

In Chapter 6, applicable financing tools and instruments were applied against the relevant themes and interventions of sustainable city development. Based on the influencing factors, the tangible and intangible criteria along with the scale of intervention and the implications for funding instruments and tools, financing directives and alternatives per theme are applied.

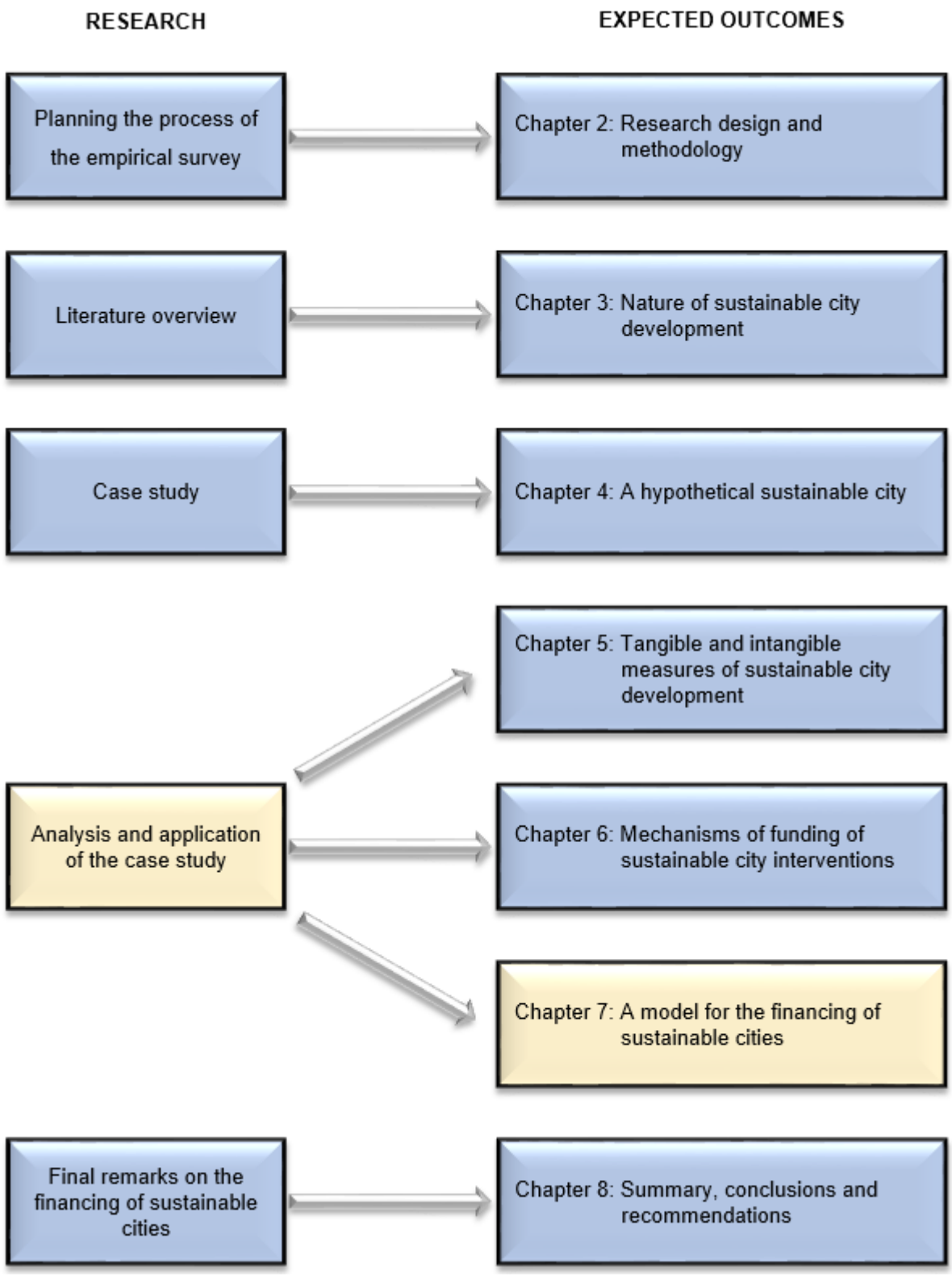
This chapter seeks to propose a model for the financing of sustainable cities within the context of four applications. The first application related to how financing tools and instruments were applied across the varying stated themes and associated interventions of sustainable city development. The second application related to how financing tools and instruments were applied with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention or and enabling intervention. The third application related to how financing tools and instruments were applied with respect to application type in terms of either incentive, opportunity, punitive or mandatory interventions. The last application related to how financing tools and instruments were applied with respect to scale in terms of city-wide, sector-wide, urban or suburban application. In addition to the four applications, an evaluation of how the application of financing tools and instruments related to the addressing of poverty within the city context.

The resultant model for the financing of sustainable cities sought to direct the nature and scale of financing intervention relevant to a particular theme of sustainable city development. By implication, the stated nature and scale of financing intervention should, therefore, provide direction as to what themes of sustainable city development to focus on along with their associated interventions.

7.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 7.1.

Figure 7.1: The framework for the study



Source: Author's own compilation

As depicted in Figure 7.1, this study is comprised of eight chapters. Chapter 7 relates to a model for the financing of sustainable cities.

7.3 THE TRANSITION TO AND FINANCING OF SUSTAINABLE CITIES

The financing of sustainable cities does not only relate to the application of alternative financing tools and instruments, but also to the manner in which a city develops or promotes growth and expansion across its varying sectors. As such, this study first sought to identify the relevant themes of sustainable city development, along with their associated interventions. The acceptability of those themes and associated interventions were then tested through the application of identified tangible and intangible measures, before, finally, applying identified financing tools and instruments to those relevant themes and associated interventions. For the purposes of this study, the identified themes of sustainable city development included:

- Location
- Water
- Sanitation
- Compact cities
- Public transport
- Energy
- Urban agriculture
- Solid waste
- Green buildings
- Air pollution
- Public health
- Biodiversity
- Child-centred development

According to the European Union (2011), cities will need to strive for a holistic model of sustainable city development in which conflicting and contradictory objectives are overcome. Economic growth must be reconciled with the sustainable use of natural resources whereas global competitiveness needs to be inclusive and favour the local economy whilst attractiveness to the global and social elite should not exclude less favoured groups (European Union, 2011).

Carraro, Pandey and Stone (2015) state that there has been growing recognition that fiscal policy plays a crucial role in transforming economies to become more sustainable and inclusive. The cost of externalities from natural resource use in the prices of goods and services needs to be addressed through appropriate fiscal policy. The application of alternative fiscal policy, wherein sustainability is dominant, signals the market to stimulate a shift in production, consumption and investment to lower carbon and socially inclusive options (Carraro, *et al.* 2015). Furthermore, fiscal policies can be utilised to remove the unsustainable use of limited resources, not only for creating fiscal space for investing in sustainable development priorities but by also generating revenues for the nurturing of the environment (Carraro, *et al.* 2015).

Phillips and Stricklan (2015) state that local governments are key to a national effort in promoting community development, economic growth and social justice. Many local authorities have recognised their importance in such efforts by initiating programmes to address economic, environmental and social equity issues.

There has been much focus on the relationship between urban and green infrastructure planning and on the resultant benefits thereof (South African Cities Network, 2016). Sustainability concepts relate to issues surrounding resource efficiencies, the water-energy-food nexus, integrated water resources, management along with resource decoupling (South African Cities Network, 2016). Translating sustainability benefits into a spatial planning context to guide future infrastructure planning and management assists with the identification of applicable financing tools and instruments relevant to the identified themes of sustainable city development. Section 7.4 outlines the model for the financing of sustainable cities that seeks to direct the nature and scale of financing intervention relevant to a particular theme of sustainable city development.

7.4 A MODEL FOR THE FINANCING OF SUSTAINABLE CITIES

For the purposes of this study, an envisaged model for the financing of sustainable cities was comprised of four components, namely:

- Application of financing tools and instruments relevant to the identified themes of sustainable city development

- Application of financing tools and instruments with respect to an immediate interventionist focus, facilitative focus, gradual intervention and enabling intervention
- Financing tool and instrument type in terms of incentive, opportunity, punitive and mandatory interventions
- Application of financing tools and instruments with respect to scale in terms of city-wide application, sector-wide application, urban application or suburban application

The first application related to how financing tools and instruments were applied across the varying stated themes and associated interventions of sustainable city development. This stemmed from the applicability of financing tools and instruments per intervention as elaborated upon within Chapter 6.

The second application related to how financing tools and instruments were applied with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention or and enabling intervention. This stemmed from considering the applicability of the proposed financing tools and instruments in relation to the degree of emphasis required. The application of the proposed financing tools and instruments to the respective themes, related to the relative importance of the theme derived from the tangible and intangible assessment thereof as discussed in Chapter 5. As such themes contributing substantially to sustainable city development from a tangible and intangible perspective were assigned financing tools and instruments that required an immediate interventionist focus. Those themes contributing to a lesser extent were assigned financing tools and instruments that could be managed over a period of time.

The third application related to how financing tools and instruments were applied with respect to application type in terms of either incentive, opportunity, punitive or mandatory interventions. In assigning financing tools and instruments to the relevant themes of sustainable city development, the nature of the tool or instrument was defined being either an incentive tool, a tool to exploit opportunity, a punitive tool or a mandatory tool. Matching the nature of the tool to the themes of sustainable city development was once again derived from the nature of the theme along with the opportunity for private sector financing as elaborated upon in Table 6.5. Should extensive opportunities exist for private sector investment within a particular theme,

incentive financing tools were applied. Should there be a need to conserve scarce resources, punitive tools were applied.

The last application related to how financing tools and instruments were applied with respect to scale in terms of city-wide, sector-wide, urban or suburban application. The identified financing tools and instruments possessed a direct relation to city context. Financing tools and instruments relevant to the theme of compact cities possessed a direct relation to the city in its entirety owing to the extent of infrastructure investment whereas those tools and instruments relevant to child-centred development possessed a direct relation to a sector in the form of the education sector.

Collectively, the four components sought to achieve the financing of sustainable city development that was based on defined themes and interventions of sustainable city development, the acceptance of those interventions from both a tangible and intangible perspective along with the matching of financing interventions that consider the acceptance and nature of the stated interventions. Table 7.1 depicts the application of financing tools and instruments relevant to the identified themes, and associated interventions, of sustainable city development.

Table 7.1: Application of financing tools and instruments relevant to the identified themes of sustainable city development

THEME	INTERVENTION	FINANCING TOOLS AND INSTRUMENTS		
Location		Scaling of social grants relevant to areas of higher GVA output	Scaling of housing assistance programmes relevant to areas of higher GVA output	Scaling of social facilities such as clinics and schools relevant to areas of higher GVA output
Water	• Rainwater harvesting • Grey water systems • Reclaimed water systems	New developments: • Building regulations • Having additional land increment tax • Installing the principle of 'user-must-pay' given water scarcity	Existing developments: • Bylaws introduced to specify the usage of recycled water and introduce penalties in times of scarcity	

THEME	INTERVENTION	FINANCING TOOLS AND INSTRUMENTS			
Sanitation	• Low-diameter sewerage systems • Shared septic tank system • Community sanitation centres	Discounted lifetime costs of centralised sanitation system were cheaper than decentralised systems. As such, interventions, with respect to community-based sanitation systems, should not take the form of direct financing directives			
Compact cities		Municipal bonds		Centralised infrastructure investment coordination	
Public transport	• Universal transit passes • Parking cash-out • Bicycle facilities • Car sharing • Transportation resource centres	Discounted bulk passes		Parking cash-out	
Energy	• Biomass • Wind • Solar	Public private partnerships with respect to grid scale interventions	Revaluation of land assigned to solar, wind and biomass energy generation	On-bill financing	Crowd funding in relation to community interventions
Food supply	Urban agriculture	Dedicated provision is made for urban agricultural schemes within a city's town planning scheme	Tax exemptions	Tax increment financing targeted towards major retailers of the food industry	
Solid waste	• Property-close systems • Drop-off systems • Mandatory versus voluntary systems	Implementing the polluter pays principle		Micro-financing to extend loans to waste scavengers	

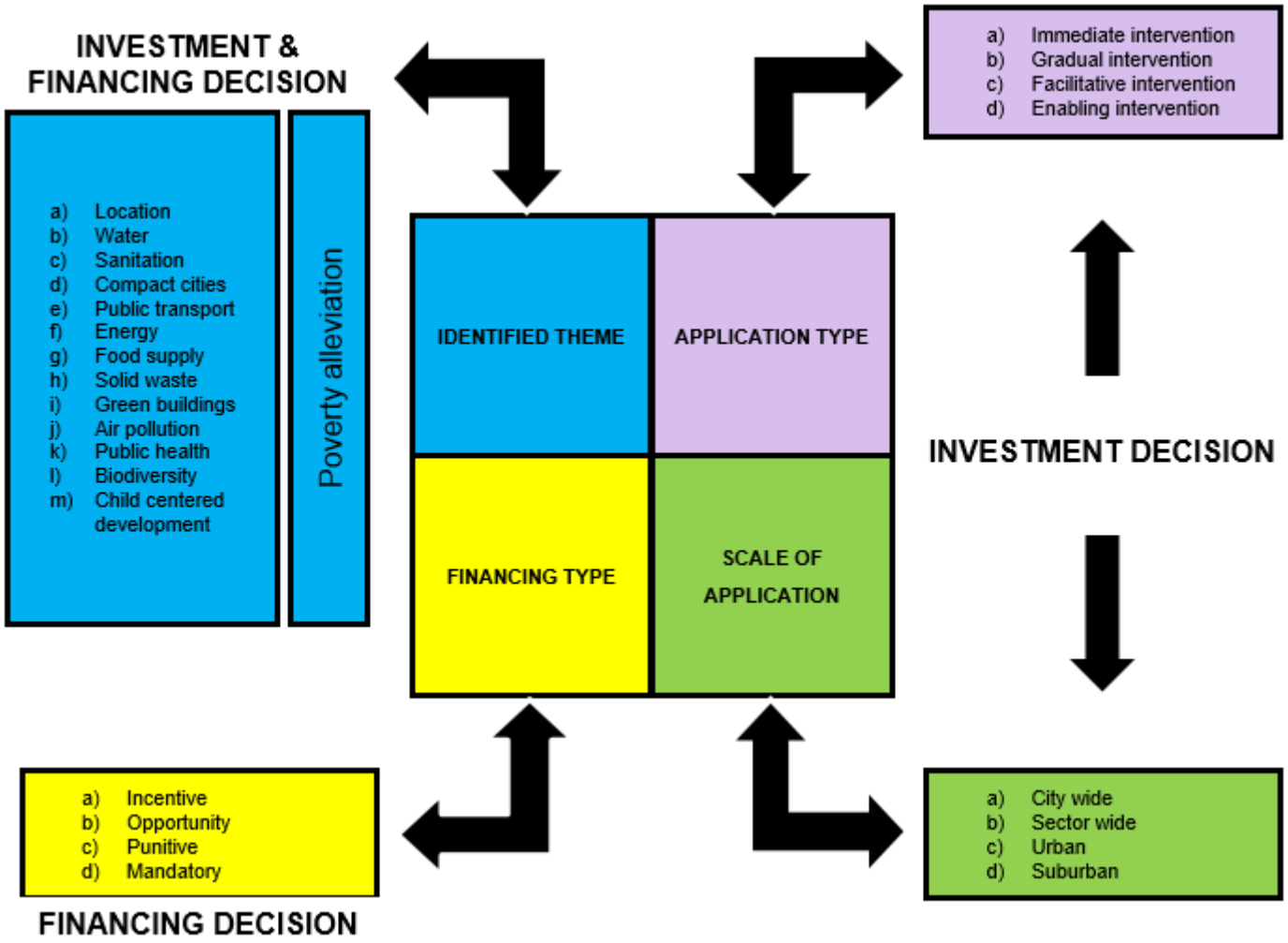
THEME	INTERVENTION	FINANCING TOOLS AND INSTRUMENTS		
Green buildings		Financial institutions adopted a leadership role in the development of green buildings through tailor-made investment, lending and insurance activities	Programmes were developed / enhanced between financial institutions and organisations such as the Green Building Council of South Africa (GBCSA)	Local systems to facilitate such development based on the continual revision of building codes in consultation with bodies such as the GBCSA
Air pollution	Electric vehicles	Tax rebates	Subsidised public transportation	
Public health	• Responsive clinics • Accessible clinics	Low-income settings .	Scaling of social facilities to areas of higher GVA output	Social impact bonds
Biodiversity	• Adjacent landscapes • City interventions • City sectors • Individual lots	Management grants	Inverse auctions	Offsetting
Child centred develop	• Formal and informal learning facilities	Levy per child applied to pupils at private schools	Social impact bonds	

Source: Author's own compilation

As depicted in Table 7.1, financing tools and instruments were assigned to the relevant identified themes of sustainable city development. Depending on the nature of theme, along with the characteristics of the financing tool or instrument, national government, local authorities, financial institutions or the private sector could take a lead role in either directly undertaking the financing tool or instrument or facilitating an environment in which the identified financing tool or instrument might be utilised.

Figure 7.2 illustrates the proposed inclusive model wherein the application of financing tools and instruments relevant to the themes of sustainable city development, the application type, the financing type and the scale of application was portrayed.

Figure 7.2: Model for the financing of sustainable cities



Source: Author's own compilation

Figure 7.2 depicts the four components of an envisaged model for the financing of sustainable cities, namely, the identified themes of sustainable city development, the financing tool or instrument application type, the financing type along with the scale of application. Each of those financing tools and instruments identified and assigned to the varying themes of sustainable city development as listed in Table 7.1, were subsequently assigned to the respective categories within the components of application type, financing type and scale of application. These components are further elaborated upon in Sections 7.4.1 to 7.4.4.

7.4.1 Component 1: Identified Theme

Component 1 related to both investment and financing decisions. Table 7.1 depicts the application of financing tools and instruments relevant to the identified themes, and associated interventions, of sustainable city development. As depicted in Table 7.1, financing tools and instruments were assigned to the relevant identified themes of sustainable city development. Depending on the nature of theme, along with the characteristics of the financing tool or instrument, national government, local authorities, financial institutions or the private sector could take a lead role either directly undertaking the financing tool or instrument or facilitating an environment in which the identified financing tool or instrument might be utilised.

7.4.2 Component 2: Application Type

Component 2 related to investment decisions. The second component of the model, with respect to application type, discussed the application of financing tools and instruments with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention or an enabling intervention.

(a) Immediate intervention

The immediate intervention category implied that immediate, focussed interventions were required by necessary role players owing to the relative importance of the identified themes of sustainable city development along with the relative potential impact that those identified financing tools and instruments might result in with respect to scale and magnitude.

Proposed financing tools and instruments contained within the immediate interventionist category included:

i. Location (social grants, housing assistance programmes, social facilities)
ii. Water (existing developments)
iii. Compact cities (municipal bonds)
iv. Energy (revaluation of land assigned to solar, wind and biomass energy generation)
v. Food supply (provision for urban agricultural schemes within city's town planning scheme)
vi. Public health (low-income settings)
vii. Child-centred development (levy per child at public schools)

Those financing tools and instruments listed from (i) to (vii) all required initial action ranging from national to local government. Once the appropriate steps had been initiated by either national or local government the financing instruments and tools of (ii), (iii), (iv) and (vii) might be taken up by either the private sector or private individuals. Those financing tools and instruments of (i), (v) and (vi) required both initiation by national or local government as well as the implementation thereof.

(b) Facilitative intervention

The facilitative focus category implied that custodians of utilities, land or services undertake actions would facilitate further sustainable development. Identified financing tools and instruments contained within the facilitative focus category included:

i. Energy (PPPs, on-bill financing and crowd funding)
ii. Food supply (tax increment financing targeted towards major retailers)
iii. Green buildings (continual revision of building codes, voluntary programmes)
iv. Public health (social impact bonds)
v. Biodiversity (management grants, inverse auctions)
vi. Child-centred development (social impact bonds)

Those financing tools and instruments listed from (i) to (iv) and (vi) all resulted from funding sourced from the private sector or individuals associated with some form of return on investment. National or local government facilitated the investment thereof

through the offering of utility provision, land or services. Financing tools and instruments related to (v) results from payments made to the private sector for services undertaken within the sphere of biodiversity management. The mechanisms employed were still facilitative in nature as they sought to facilitate response behaviour and ownership of the environment through the tools utilised.

(c) Gradual intervention

The gradual intervention category accepted that those financing tools and instruments that were proposed were processes that must be managed over time. Identified financing tools and instruments contained within the gradual intervention category included:

i. Water (new developments)
ii. Compact cities (centralised infrastructure investment coordination)
iii. Solid waste (polluter pays principle, micro-financing to extend loans to waste scavengers)
iv. Air pollution (tax rebates and subsidised public transportation)

Financing tools and instruments (i), (iii) and (iv) eventually resulted in the private sector funding the eventual interventions but only after national or local government had undertaken gradual interventions to allow for those financing interventions. Financing tool (ii) was purely government-related, however, the coordination required across varying government sectors to ensure coordinated infrastructure delivery in support of sustainable city development was a long and laborious task.

(d) Enabling intervention

The enabling intervention category contained those financing tools and instruments that national or local government did not necessarily have direct control over but rather installed programmes, mostly voluntary, that the private sector could take up. Identified financing tools and instruments contained within the enabling intervention category included:

i. Public transport (Universal transit passes and parking cash-out)
ii. Food supply (tax exemptions)

iii. Green buildings (financial institutions adopt leadership role, programmes developed between financial institutions and GBCSA)
iv. Biodiversity (offsetting)

Financing tools (i) to (iv) relied largely on the private sector to take the lead in implementing such interventions.

7.4.3 Component 3: Financing Type

Component 3 related to financing decisions. The third component of the model, with respect to financing type, detailed the financing tool and instrument type in terms of incentive, opportunity, punitive and mandatory interventions.

(a) Incentive category

The incentive category related to those financing tools and instruments that were employed to motivate predominantly the private sector or individuals, relative to the identified themes of sustainable city development, to perform certain actions or services in support of sustainable development. The motivation to provide goods or services stems from the potential remunerative or financial incentive that existed for the private sector in providing a particular good or service. Proposed financing tools and instruments contained within the incentive category included:

i. Food supply (provision for urban agricultural schemes within city's town planning scheme)
ii. Energy (PPPs, on-bill financing and crowd funding)
iii. Biodiversity (management grants, inverse auctions)
iv. Air pollution (tax rebates and subsidised public transportation)
v. Public transport (Universal transit passes and parking cash-out)
vi. Green buildings (financial institutions adopt leadership role, programmes developed between financial institutions and GBCSA)

Financing tools contained within (i), (iii) and (vi) were reflective of the notion to motivate the private sector or individuals, relative to the identified themes of sustainable city development, to perform certain actions or services in support of sustainable development. Financing tools contained within (i), (iv) and (v) contained financial

incentives for the private sector, however, that motivation was combined with a moral along with intrinsic incentive in undertaking such actions. Government was central to initiating processes relative to the themes of sustainable city development in order that the private sector might participate in such incentive schemes as listed.

(b) Opportunity category

The opportunity category related to those financing tools and instruments that were employed that were marginally different to those contained within the incentive quadrant. Opportunity-related financing tools and instruments sought to install measures that typically facilitated the selling of a business opportunity. Identified financing tools and instruments contained within the opportunity category included:

i. Compact cities (municipal bonds)
ii. Energy (revaluation of land assigned to solar, wind and biomass energy generation)
iii. Food supply (tax increment financing targeted towards major retailers)
iv. Public health (social impact bonds)
v. Child-centred development (social impact bonds)
vi. Solid waste (micro-financing to extend loans to waste scavengers)
vii. Green buildings (voluntary programmes)
viii. Food supply (tax exemptions)
ix. Biodiversity (offsetting)

As with financing tools contained within (i), (iv) and (v), the private sector or individuals had an opportunity to invest in the stipulated bond markets. Financing tools and instruments contained within (ii), (iii), (vi), (vii), (viii) and (ix) related to opportunities that might be availed, both to the betterment of sustainable cities, government and the private sector, should government initiate certain key processes to facilitate such opportunity.

(c) Punitive category

The punitive category related to those financing tools and instruments that were employed that sought to ensure an imposition on groupings or individuals, implemented by government, to either deter unsustainable development or actions in

contrast to sustainable city development or to ensure a collectable subsidy from privileged sectors of society in order to aid the less-privileged. Identified financing tools and instruments contained within the punitive category included:

i. Water (existing developments)
ii. Child-centered development (levy per child at public schools)
iii. Water (new developments)
iv. Solid waste (polluter pays principle)

The punitive measures employed by government in (i) to (iv) resulted in the availability of funds to be further applied.

(d) Mandatory category

The mandatory category related to those financing tools and instruments that were employed to seek a binding obligation to the administrative function within all sectors of government. The mandatory quadrant sought to propose non-negotiable interventions that were key to future sustainable city development. Identified financing tools and instruments contained within the mandatory category included:

i. Location (social grants, housing assistance programmes, social facilities)
ii. Public health (low income settings)
iii. Green buildings (continual revision of building codes)
iv. Compact cities (centralised infrastructure investment coordination)

Deviation from these identified themes, along with the financing tools and instruments in support of them, would detract from sustainable city development.

7.4.4 Component 4: Scale of Application

Component 4 related to investment decisions. The fourth component of the model detailed the of financing tools and instruments with respect to scale in terms of city-wide application, sector-wide application, urban application or suburban application.

(a) City-wide application

The city-wide category related to those financing tools and instruments that were employed that possessed city-wide implications. Proposed financing tools and instruments contained within the city-wide category included:

i. Compact cities (municipal bonds)
ii. Energy (PPPs, on-bill financing and crowd funding)
iii. Green buildings (continual revision of building codes, voluntary programmes)
iv. Compact cities (centralised infrastructure investment coordination)
v. Location (social grants, housing assistance programmes, social facilities)
vi. Green buildings (financial institutions adopt leadership role, programmes developed between financial institutions and GBCSA)

In terms of scale, the financing tools and instruments associated with the respective themes arguably possessed the most significant impact with respect to sustainable city development.

(b) Sector-wide application

The sector-wide category related to those financing tools and instruments that were employed relative to specific sectors within the city context. In essence, they were stand-alone interventions that could be employed in a one-dimensional aspect relative to the specific sector. Identified financing tools and instruments contained within the sector-wide category included:

i. Energy (revaluation of land assigned to solar, wind and biomass energy generation)
ii. Child-centered development (levy per child at public schools)
iii. Food supply (tax increment financing targeted towards major retailers)
iv. Public health (social impact bonds)
v. Child-centred development (social impact bonds)
vi. Biodiversity (offsetting)

The financing tools and instruments associated with the respective themes related specifically to the sectors of energy, education, agriculture and the environment.

(c) Urban application

The urban category related to those financing tools and instruments that were more relevant to areas within the city of a higher population density along with the associated infrastructure. Identified financing tools and instruments contained within the urban context category included:

i. Food supply (provision for urban agricultural schemes within city's town planning scheme)
ii. Air pollution (tax rebates and subsidised public transportation)
iii. Public transport (Universal transit passes and parking cash-out)
iv. Food supply (tax exemptions)

Higher population densities within the urban centre dictated the application of the financing tools and instruments relevant to these themes.

(d) Suburban application

The suburban category related to those financing tools and instruments that were more relevant to areas within the city of a lower population density along with the associated infrastructure. Identified financing tools and instruments contained within the suburban context category included:

i. Water (existing developments)
ii. Public health (low-income settings)
iii. Biodiversity (management grants, inverse auctions)
iv. Water (new developments)
v. Solid waste (polluter pays principle, micro-financing to extend loans to waste scavengers)

City expansion within the context of city development dictated the application of the financing tools and instruments relevant to these themes.

7.5 SUSTAINABLE CITIES AND THEIR RELATION TO POVERTY ALLEVIATION

The occurrence of poverty in South Africa is largely due to the engineering policies of the past wherein large-scale land dispossession, the establishment of overcrowded and poorly-resourced homelands and the migratory labour system was established

(Aliber, 2002). As such, the geographical, racial and gender dimensions of poverty are largely a result of the historical experience (Aliber, 2002). Aliber (2002) identifies three primary aspects of poverty, namely:

- Income poverty
- Quality of life with respect to the experience of well-being not necessarily related to personal income
- Inequality in relation to access to services and health status

The promotion of poverty eradication through sustainable development has predominantly occurred through five types of government initiatives (Aliber, 2002). These initiatives include the following:

- National economic and development policy frameworks such as the Reconstruction and Development Programme, the National Growth and Development Strategy and the Growth, Employment and Redistribution Strategy
- Anti-poverty strategies that seeks a general move towards developmental welfare
- Public works programmes that seek to promote environmental conservation and job creation
- Major infrastructure programmes
- Second-generation grand integration strategies such as the Rural Development Programme and the Urban Renewal Strategy

Although extensive progress has been made with respect to these interventions, certain anti-poverty strategies remained dislocated to the principles of sustainable development. Cities and towns are and will continue to be the primary human living space as cities can provide many socio-economic benefits (United Nations, 2012). Through the concentration of people, investment and resources cities increase the possibilities for economic development, innovation and social interaction (United Nations, 2012).

Godfrey and Zhao (2016) state that compact, connected urban growth can contribute to the creation of cities that are more productive, socially-inclusive, resilient, cleaner and safer. Matching the scale and type of infrastructure required can underpin future

economic prosperity along with poverty reduction (Godfrey & Zhao, 2016). Therefore, investment in better urban infrastructure in cities is fundamental to reducing poverty. According to Godfrey and Zhao (2016), the economic, social and environmental case for investing in better, more sustainable urban infrastructure is convincing. Investment decisions that cities make within the next five to fifteen years surrounding key urban infrastructure will be critical for capturing the economic, social and environmental benefits. Furthermore, the financing of this urban transition is imperative to sustainable city development (Godfrey & Zhao, 2016). Godfrey and Zhao (2016) advocate the following recommendations to facilitate the urban transition:

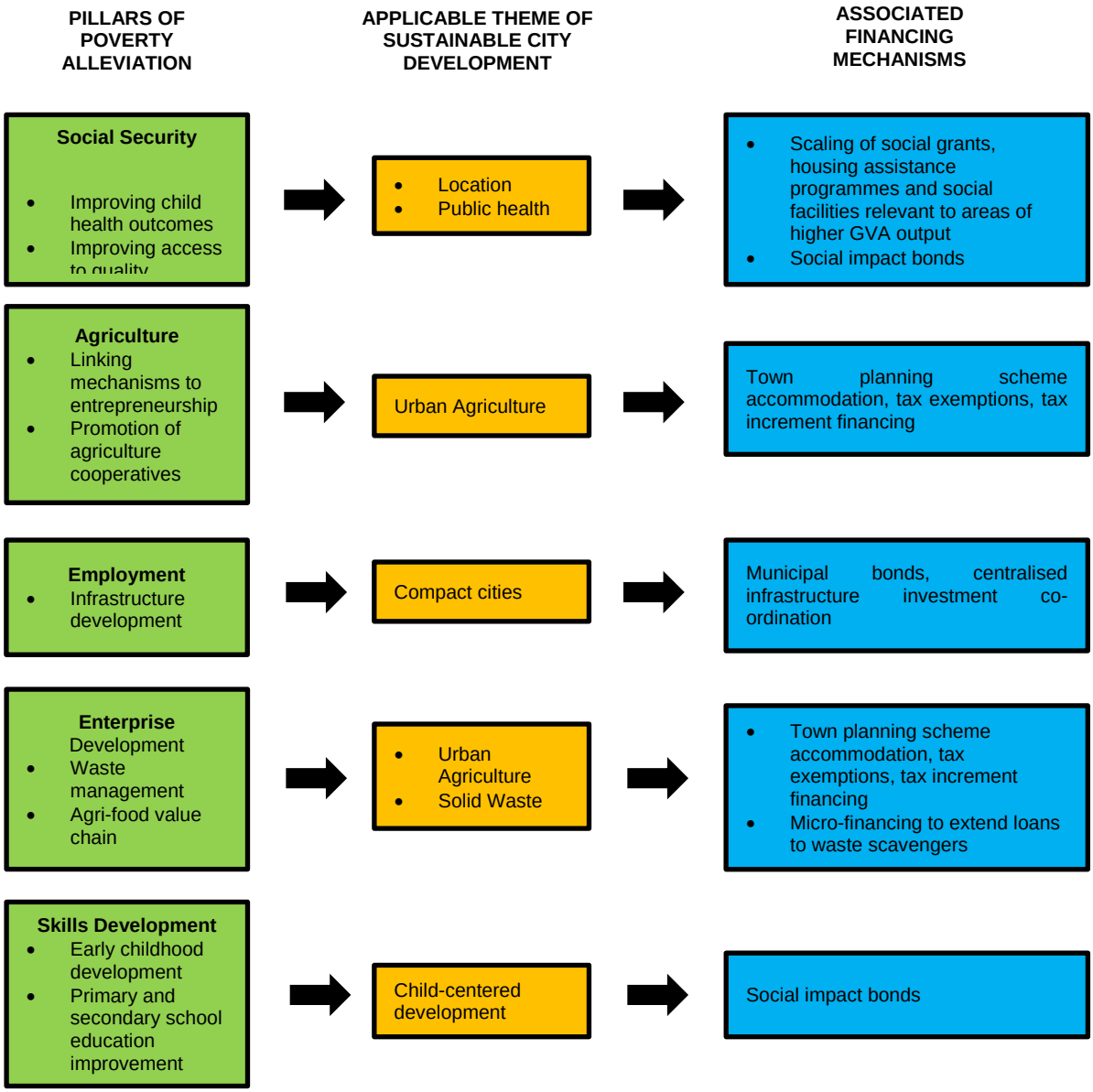
- All countries should:
  - Develop national urbanisation strategies in conjunction with city governments inclusive of creating financial and legal infrastructure that favours sustainable infrastructure.
- All cities should:
  - Commit to prioritising policies and investments in sustainable urban infrastructure.
- National and city-level decision makers should:
  - Consider establishing special purpose financing vehicles to support urban areas to become more compact and connected with appropriate private-sector participation.
  - Redirect existing infrastructure funding towards more compact and connected urban infrastructure.
  - Reform fuel subsidies and consider charges on land conversion and displaced development.
  - Introduce new mechanisms to finance upfront investments.

Poverty is a multi-faceted occurrence that requires varying strategies to address its complexities. Systematic poverty results in sustained inequality in social power relations along with associated vulnerability to external events (KwaZulu-Natal Province, 2014). Although this study sought to propose of model for the financing of sustainable cities, context needed to be provided as to how those proposed financing interventions and actions could be viewed as a measure to raise people out of poverty. Kwazulu-Natal Province (2014) identifies five pillars as game changers to poverty

eradication. These include social security, agriculture, employment, enterprise development and skills development. In defining the financing tools and instruments for sustainable cities, key to note is how those identified themes of sustainable city development and their associated financing mechanisms can contribute to the poverty alleviation game changers of social security, agriculture, employment, enterprise development and skills development.

Figure 7.3 depicts the relation between this study's identified themes of sustainable city development and their associated financing mechanisms to the stated pillars of poverty alleviation.

Figure 7.3: Relation between pillars of poverty alleviation and the financing of sustainable city development



Source: Author's own compilation

As depicted in Figure 7.3, the sustainable city development themes of location, public health, urban agriculture, compact cities, solid waste and child-centred development had a direct bearing on the respective pillars of poverty alleviation. As such, the associated financing mechanisms thereof were potential game changers should the financing of sustainable cities be viewed within the context of an overall poverty alleviation programme. The challenge in future would be to involve the private sector

in ways to finance these. As business was striving to maximise its shared values, creative applications in this regard would be possible.

7.6 SUMMARY

In Chapter 7, a model for the financing of sustainable cities within the context of the following was proposed. Firstly, the model included an application of financing tools and instruments relevant to the identified themes of sustainable city development. Secondly, the model included the application of financing tools and instruments with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention and an enabling intervention. Thirdly, the model included financing tool and instrument types in terms of incentive, opportunity, punitive and mandatory interventions. Fourthly, the model included the application of financing tools and instruments with respect to scale in terms of city-wide application, sector-wide application, urban application or suburban application. Finally, the model included the application of financing tools and instruments and their relation to addressing poverty within the city context.

The resultant model for the financing of sustainable cities sought to direct the nature and scale of financing intervention relevant to a particular theme of sustainable city development. By implication, the stated nature and scale of financing intervention should, therefore, provide direction as to what themes of sustainable city development to focus on along with their associated interventions. Given the occurrence of poverty in South Africa, the relation between poverty alleviation and the financing of sustainable cities was discussed.

In Chapter 8 conclusions, recommendations and possible further research are discussed.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

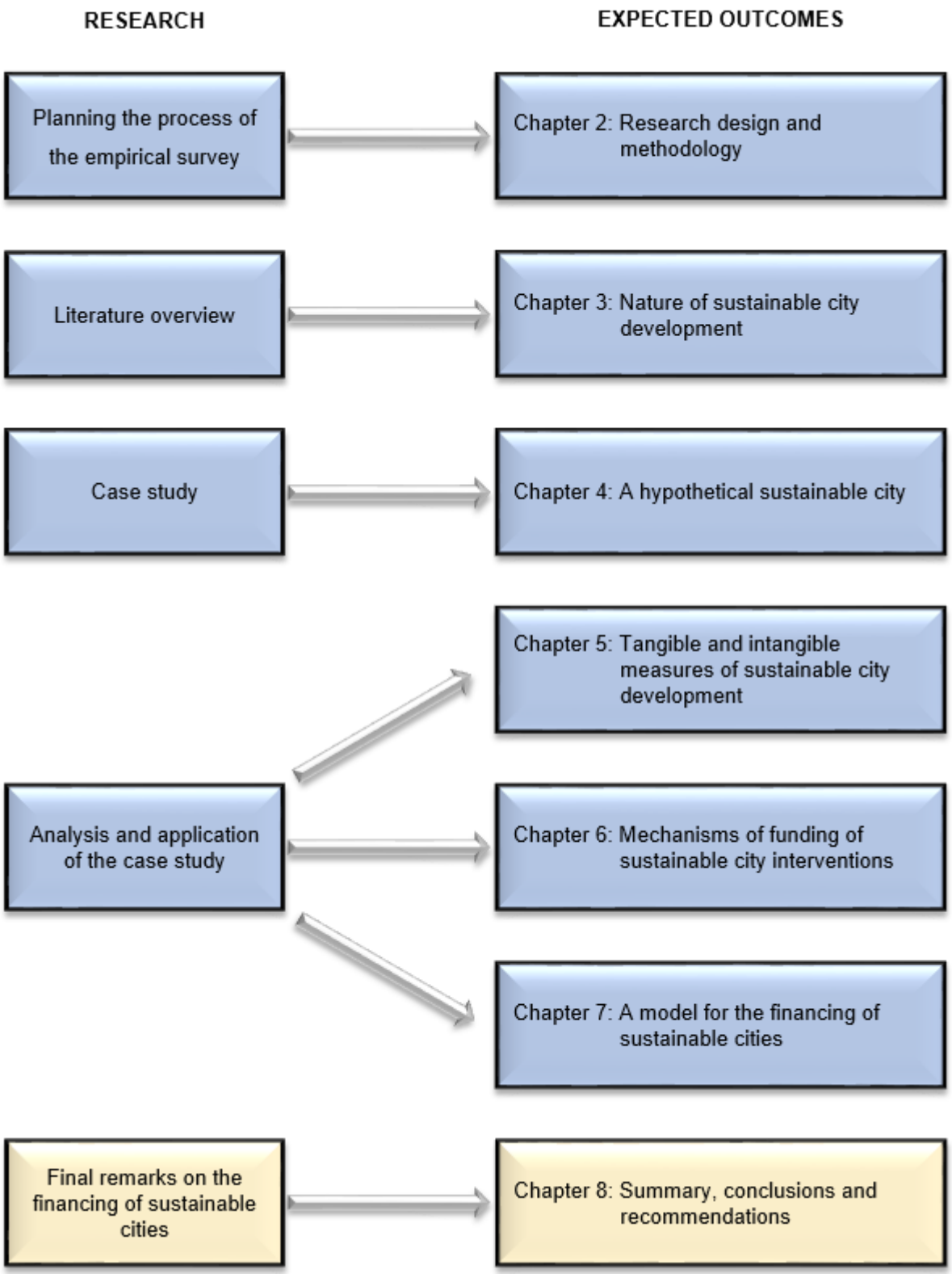
In this study, a model for the financing of sustainable cities within the context of four applications was proposed. The first application related to how financing tools and instruments were applied across the varying stated themes and associated interventions of sustainable city development. The second application related to how financing tools and instruments were applied with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention or and enabling intervention. The third application related to how financing tools and instruments were applied with respect to application type in terms of either incentive, opportunity, punitive or mandatory interventions. The last application related to how financing tools and instruments were applied with respect to scale in terms of city-wide, sector-wide, urban or suburban application. In addition to the four applications, an evaluation of how the application of financing tools and instruments related to the addressing of poverty within the city context was discussed.

Chapter 8 summarises the study by addressing the problem statement, research objectives, research design and methodology employed in the study. A synopsis of the literature overview results is also provided. The main purpose of Chapter 8 is to make recommendations regarding the possible utilisation of the model in the financing of sustainable cities within the context of South Africa. The limitations of the study and possible future research areas are provided. To conclude, the chapter and the study, some final remarks are made regarding the study.

8.2 STUDY FRAMEWORK

The process that formed the basis of this study is depicted in Figure 8.1.

Figure 8.1: The framework for the study



Source: Author's own compilation

As depicted in Figure 8.1, this study is comprised of eight chapters. Chapter 8 relates to the summary, conclusions and recommendations for the study.

8.3 SUMMARY OF CHAPTERS

A brief summary of the Chapters are presented in the following sections.

8.3.1 Summary of Chapter 1

Chapter 1 discussed the background to the study, the problem statement and the primary and secondary objectives of the study. Furthermore, this chapter provided an overview of the research design and methodology which was used to obtain the empirical data for the study. Concluding this chapter was an outline of the forthcoming chapters.

The primary research objective of this study was to investigate various funding mechanisms for sustainable city development thereby resulting in the design of a model for the financing of sustainable cities. To give effect to the primary objective of this study, various secondary objectives and research questions were formulated.

The research process undertaken in this study included seven steps, namely:

a) Step 1: Define the nature of sustainable development within a sustainable city. This was undertaken by means of a literature review.
b) Step 2: Determine the themes and associated interventions that should be addressed for a city to be defined as sustainable. This was undertaken by means of a literature review.
c) Step 3: Define the acceptance of the themes and associated interventions of sustainable city development. This was undertaken by means of a literature review.
d) Step 4: Develop a hypothetical case of a sustainable city. Using a hypothetical city size, both tangible and intangible perspectives of the acceptance of projects were determined. A hypothetical case was assessed based on the application of tangible and intangible perspectives against one intervention of sustainable city development. The applied tangible and intangible measures were then appraised by means of interviews with sector specific specialists.

e) Step 5: Complete the hypothetical case by populating all interventions resulting in an investment scenario. This was undertaken by means of an interpretive study.
f) Step 6: Utilise investment scenarios to determine the financing thereof. This was undertaken by means of an interpretive study.
g) Step 7: Develop a model for the financing of sustainable cities.

A brief literature overview was also provided and a proposed framework for the study developed.

8.3.2 Summary of Chapter 2

Chapter 2 identified and described the processes followed during the research process. The nature of research and the various research classifications were described. The different research paradigms were discussed, and the specific paradigm, namely, a qualitative research design was chosen and motivated. As this research was based on a case study, a case study as a research design was outlined. The hypothetical case was developed and experts interviewed to confirm the parameters used in the hypothetical case. Figure 2.3 outlined the research design process of this research and showed that the research was conducted in two phases. Phase one involved a literature analysis to determine the theoretical components of sustainable city interventions. Phase two was to first apply one intervention of a theme and then have it reviewed by city development experts. Thereafter, all themes and associated interventions were populated. Investment acceptability decisions could be made and appropriate financing instruments and tools selected. A model to finance a sustainable city was proposed

8.3.3 Summary of Chapter 3

In Chapter 3, the nature of a sustainable city was defined along with the stated themes and associated interventions thereof.

The respective themes of sustainable city development included location, water, sanitation, compact cities, public transport, energy, urban agriculture, solid waste, green buildings, air pollution, public health, biodiversity, child-centred development. Table 3.9 depicted, for the purposes of this study, the components of sustainable city development along with the associated sub-components. Proposed funding

mechanisms and instruments per the varying components would need to take cognisance of the stated influencing factors as highlighted in Table 3.9.

8.3.4 Summary of Chapter 4

In Chapter 4, a hypothetical city with set population parameters and growth trajectories was developed. This included a hypothetical city size and tangible as well as intangible criteria for acceptance of interventions. Within the hypothetical city, the structuring elements of the city was described inclusive of the themes and associated interventions of sustainable city development. From thereon, tools and instruments were proposed to determine the acceptability of the varying themes and associated interventions of sustainable city development. A case study was prepared demonstrating the outcome of the tangible and intangible tools and instruments utilised. The tools and instruments along with the associated outcomes were confirmed through interviews with city development experts.

8.3.5 Summary of Chapter 5

In Chapter 5, tangible and intangible criteria for sustainable city development were applied across all the identified themes and interventions of sustainable city development. The demonstration of the tangible and intangible assessment criteria to the varying themes and associated interventions confirmed that, in principle, the application of stated interventions was acceptable. This, in turn, would guide the financing tools and instruments that could potentially be applied to the relevant interventions.

Table 5.7 illustrated the consolidated assessment of the tangible and intangible criteria as relevant to the varying identified themes of sustainable city development. It further demonstrated the tangible and intangible assessment criteria applied to each identified theme of sustainable city development along with the associated outcomes of those respective assessments.

8.3.6 Summary of Chapter 6

Chapter 6 outlined the tools and instruments of sustainable cities. Besides conventional funding by government, the IDCF (2014) proposed a list of financial

approaches such as capital through leverage of land assets, land asset based financing, bond instruments, green funds, development banks, special purpose vehicles and concessions. The WWF (2015) suggested instruments that would have a medium to high impact, including land assets, Public Private Partnerships, taxes, user charges fees, grants and subsidies and the usage of building rights. The European Commission (2013) suggested four types of financing, namely, innovative solutions using grants, project financing, smart bonds, spread shareholding and crowd financing. Other types of financing included green bonds, green equities, management grants, inverse auctions, offsetting and visitor payback schemes.

Although most of the financing of sustainable cities revolved around public sector finance, the private sector also played an important role in the financing of sustainable cities. Table 6.5 outlined a summary for the themes where the private sector played a role in the financing of sustainable cities.

8.3.7 Summary of Chapter 7

In Chapter 7, a model for the financing of sustainable cities within the context of the following was proposed. Firstly, the model included an application of financing tools and instruments relevant to the identified themes of sustainable city development. Secondly, the model included the application of financing tools and instruments with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention and an enabling intervention. Thirdly, the model included financing tool and instrument types in terms of incentive, opportunity, punitive and mandatory interventions. Fourthly, the model included the application of financing tools and instruments with respect to scale in terms of city-wide application, sector-wide application, urban application or suburban application. Finally, the model included the application of financing tools and instruments and their relation to addressing poverty within the city context.

The resultant model for the financing of sustainable cities sought to direct the nature and scale of financing intervention relevant to a particular theme of sustainable city development. By implication, the stated nature and scale of financing intervention should, therefore, provide direction as to what themes of sustainable city development to focus on along with their associated interventions.

Figure 7.2 illustrates the proposed inclusive model wherein the application of financing tools and instruments relevant to the themes of sustainable city development, application type, financing type and scale of application was portrayed.

Although extensive progress has been made with respect to interventions to alleviate poverty, certain anti-poverty strategies remained dislocated to the principles of sustainable development. Cities and towns were and would continue to be the primary human living space as cities could provide many socio-economic benefits. The sustainable city development themes of location, public health, urban agriculture, compact cities, solid waste and child-centred development had a direct bearing on the respective pillars of poverty alleviation. As such, the associated financing mechanisms thereof were potential game changers should the financing of sustainable cities be viewed within the context of an overall poverty alleviation programme. The challenge in future would involve the private sector in ways to finance these. As business was striving to maximise its shared values, creative applications in this regard would be possible.

8.4 ACHIEVEMENT OF RESEARCH OBJECTIVES

The main question that was asked during the study was whether a model could be developed to propose a model to finance sustainable cities. The context of the question recognised that although the public sector would always remain the key initiator behind infrastructure development, various mechanisms of financing, along with applicable financing partners and the basis of investment, would be required to address future sustainable cities.

8.4.1 Achievement of primary and secondary objectives

The attainment of the primary objective was supported by several secondary objectives.

The primary objective of this study was to determine the infrastructure investment basis of a sustainable city to investigate various funding mechanisms resulting in the design of a model for the financing of sustainable cities.

Table 8.1 summarises the attainment of the various secondary objectives to achieve the primary objective as presented in Chapter 1.

Table 8.1: Attainment of Research Objectives

SECONDARY OBJECTIVES	CHAPTER ADDRESSING THE OBJECTIVE
To define the nature of sustainable development within a sustainable city	Chapter 3
To determine the themes and associated interventions that should be addressed for a city to be defined as sustainable	Chapter 3
To define the acceptance of the themes and associated interventions of sustainable city development	Chapter 4
To formulate tools and instruments to determine the sustainability of the themes and associated interventions of sustainable city development	Chapter 4
To present the acceptance for the themes and associated interventions of sustainable city development utilising tools and instruments	Chapter 5
To determine whether the themes and associated interventions were indeed acceptable thereby confirming their inclusion in sustainable city development	Chapter 5
To investigate tools and instruments to finance investment of sustainable city	Chapter 6
To match the tools and instruments with the themes and associated interventions of sustainable city development to propose potential funding mechanisms	Chapter 6
To develop a model to finance sustainable cities	Chapter 7

Source: Author's own compilation

8.4.2 Addressing the research questions

Six research questions were formulated in this study. The answers provided to these questions are discussed in the following sections.

- What is the nature of sustainable development within a sustainable city and what themes and associated interventions should be addressed for a city to be defined as sustainable?

In Chapter 3 (see Table 3.9), the nature of a sustainable city was defined along with the stated themes and associated interventions thereof. Thirteen themes were identified, namely, location, water, sanitation, compact cities, public transport, energy, urban agriculture, solid waste, green buildings, air pollution, health care, biodiversity and child-centred development. Each of the identified themes, incorporated interventions in support of the relevant theme.

- How is the acceptance of the themes and associated interventions of sustainable city development defined?

The acceptance of the themes and associated interventions of sustainable city development were defined in terms of stated tangible and intangible perspectives as set out in Chapter 4. Various tangible criteria were discussed which included the average return method, discounted payback period method, net present value method, internal rate of return method, and profitability index method. Defined intangible perspectives included how identified themes contributed to building the middle class, integrating communities, leveraging public resources, linking the city to the regional economy, building leadership and partnerships and fostering policy reform.

- How can one determine whether the themes and associated interventions are indeed acceptable thereby confirming their inclusion in sustainable city development?

A case was developed based on a hypothetical sustainable city in Chapter 4. Only one of the components were populated to determine whether this could be extrapolated to all themes and related interventions. The tangible perspective along with the intangible perspective satisfied the respective measurements of sustainable city development.

The appraisal of tangible and intangible measures as a basis of determining acceptability occurred via the means of reviewer input. City development expert reviewers were used as independent reviewers to evaluate the tangible and intangible measures (as part of the hypothetical case). The tools and instruments along with the associated outcomes were confirmed through interviews with city development experts

- How is the acceptance of the themes and associated interventions of sustainable city development determined?

In Chapter 4, one theme and associated related intervention were populated to confirm its inclusion in contributing to sustainable city development. The identified theme was that of energy with the associated intervention being that of photovoltaic power.

In Chapter 5, all components and related interventions were populated. The tangible criteria applied for the themes included gross value addition (GVA?) for location, discounted payback period for water, discounted lifetime costs for sanitation, a direct comparison of recurrent and capital costs for compact cities, net present value for public transport, energy, urban agriculture, solid waste, green buildings and air pollution, cost effectiveness ratios for public health, consolidated ecosystem value for biodiversity and internal rate of return for child-centred development.

The intangible criteria to be applied were described in Table 5.6. The extent to which the themes of sustainable city development satisfied the stated intangible criteria ranged from limited to extensive contribution to the intangible assessment. The following themes extensively contributed to the intangible criteria, namely, location, compact cities, public transport and energy.

- What tools and instruments can be utilised to finance the investment in a sustainable city?

The application of the tangible and intangible assessment criteria to the varying themes and associated interventions confirmed that, in principle, the application of stated interventions were acceptable. This, in turn, guided the financing tools and instruments that could potentially be applied to the relevant interventions. Table 6.2 indicated the implication for funding instrument and tools per theme.

Besides conventional funding by government, a list of financial approaches such as capital through leverage of land assets, land asset based financing, bond instruments, green funds, development banks, special purpose vehicles and concessions might be utilised. The WWF (2015) suggested that various instruments would have a medium to high impact including land assets, Public Private Partnerships, taxes, user charges fees, grants and subsidies and the usage of building rights. The European Commission (2013) suggested four types of financing, namely, innovative solutions using grants, project financing, smart bonds, spread shareholding and crowd financing. Other types of financing included green bonds, green equities, management grants, inverse auctions, offsetting and visitor payback schemes.

Although most of the financing of sustainable cities revolved around public sector finance, the private sector also played an important role in the financing of sustainable cities. Table 6.5 outlined a summary for those themes where the private sector might play a role in the financing of sustainable cities.

- What model can be developed to finance sustainable cities?

In Chapter 7, a model was proposed for the financing of sustainable cities within the context of four applications. The first application related to how financing tools and instruments were applied across the varying stated themes and associated interventions of sustainable city development. The second application related to how financing tools and instruments were applied with respect to an immediate interventionist focus, a facilitative focus, a gradual intervention or and enabling intervention. The third application related to how financing tools and instruments were applied with respect to application type in terms of either incentive, opportunity, punitive or mandatory interventions. The last application related to how financing tools and instruments were applied with respect to scale in terms of city-wide, sector-wide, urban or suburban application.

8.5 MAJOR FINDINGS

Thirteen themes and associated interventions to be included in a sustainable city were identified. These included location, water, sanitation, compact cities, public transport,

energy, urban agriculture, solid waste, green buildings, air pollution, public health, biodiversity and child-centred development.

A hypothetical city with set pollution parameters and growth trajectories was determined. Tools and instruments were proposed to determine the sustainability of the varying themes and associated interventions of sustainable city development. A case study was prepared demonstrating the outcome of the tangible and intangible tools as well as the instruments utilised in an acceptability assessment. The tools and instruments along with the associated outcomes were confirmed through interviews with city development experts.

Tangible and intangible assessment criteria were applied to the remainder of the identified themes of sustainable city development to demonstrate their acceptability to sustainable city development.

Applicable financing tools and instruments were applied against the relevant themes and associated interventions of sustainable city development based on the collective assessment of each.

The proposed model for the financing of sustainable cities sought to direct the nature and scale of financing intervention relevant to a particular theme of sustainable city development. By implication, the stated nature and scale of financing intervention should, therefore, provide direction as to what themes of sustainable city development to focus on along with their associated interventions.

8.6 RECOMMENDATIONS AND PRACTICAL IMPLICATIONS OF THIS STUDY

Based on the content of the study, along with the proposed model for the financing of sustainable cities, four key components were included in the model. The following recommendations were made:

- Certain financing tools and instruments were more appropriate than others and, therefore, possessed a higher potential to support investment in sustainable cities. The recommended list of financing tools and instruments contained within this study were not exhaustive. Key to the study was demonstrating how

sustainable cities were defined and then how appropriate financing tools and instruments were applied to those identified interventions of sustainable city development. Existing cities could follow a similar approach by, firstly, defining what sustainable cities meant to them, confirming the acceptability thereof and applying the most appropriate form of financing tools and instruments to gain the potential to support investment.

- City planning practitioners must be cognisant of the detailing of sustainable city development along with the economics thereof with respect to tangible assessment criteria. Often trajectories are proposed with very little consideration to the economic acceptance thereof. The successful financing of interventions can only be based on the initial economic acceptance thereof. City planning practitioners in many instances need to broaden their planning perspectives to incorporate the economic acceptance of identified city interventions.
- Unlocking investment requires collaboration. As a result, local government, the private sector and the community each have a role to play in unlocking investment potential. Key to this aspect is realising when to drive such processes directly and when only to facilitate such processes.

Given the outcomes of the model, the proposed model could be utilised to:

- Assist with the financing of urban infrastructure and services which result in a productive investment, which could possibly unlock growth potential.
- Enable and empower cities to utilise their unfulfilled potential whilst simultaneously increasing and diversifying their source of revenues by way of innovative mechanisms.
- Encourage local government to expand and harness private-sector participation whilst leveraging local assets.

By considering these outcomes, it is important to recognise that investment within urban development could leverage enormous benefits which outweigh costs in the long-term. As a result, cities would continue to grow and expand. The linkage of financing, planning, economic activity and value capture could contribute to compact, connected and integrated cities.

8.7 CONTRIBUTION OF THE STUDY

This study contributes to the body of knowledge with respect to the application of financing tools and instruments relevant to the identified themes and associated interventions of sustainable city development. This study could also prove useful on a practical level wherein city management practitioners are able explore the possibility of utilising stated financing tools and instruments relevant to the stated interventions of sustainable city development.

Given the increasing importance of sustainability, particularly within the realm of sustainable city development and the financing thereof, educators could utilise the findings of this study to inform students of identified themes and associated interventions of sustainable city development, the tangible and intangible perspectives in ascertaining the acceptability of those interventions along with the matching of financing tools and instruments relevant to the themes and associated interventions of sustainable city development. The findings of this study could also be used to ensure that future city practitioners realise opportunities that might be available when financing sustainable city along with what elements define what a sustainable city is. Key to the proposed model is the recognition that the financing of sustainable cities does not fall within the ambit of local government or the private sector alone. The financing of sustainable cities is a combination of efforts, actions and activities initiated both local government, communities and the private sector. Local government is, however, key to the facilitation of such participation.

Researchers interested in the financing of sustainable cities could potentially utilise the findings of this study to develop and improve models for the financing of sustainable cities dependent on the context thereof.

Through the findings in this study, policy-makers may also gain insights on tools and instruments within the span of government control to encourage communities and the private sector to become involved in the financing of sustainable cities relevant to the stated themes and associated interventions of sustainable city development. The findings may also be useful to identify whether any further incentives, infrastructure, or resources are required to motivate the private sector in playing a role within the financing of sustainable cities. The focus on poverty alleviation through sustainable cities is also a fresh approach to policy-makers and the private sector.

8.8 LIMITATIONS OF THE STUDY

This study sought to propose a model for the financing of sustainable cities within the South African context. The limitations of the study are as follows:

- Although rationale has been provided for the selection of themes and the associated interventions of sustainable city development, different themes and interventions, not included in this study, could contribute to sustainable city development.
- Applied tangible and intangible criteria to determine themes or interventions' acceptability in relation to their contribution to sustainable city development are not exhaustive. Additional tangible and intangible criteria could be applied.
- Sustainability and equality, as opposed to equity, are often not interchangeable. A sustainability focus with respect to city financing may influence potential equality directives.

8.9 FURTHER RESEARCH

Although this study has partly made reference to how stated financing tools and instruments could address poverty alleviation, further research on the poverty dimension within the scope of sustainable cities and the financing thereof, are proposed. This study stated that local government, communities and the private sector were key role-players in actioning and facilitating the financing of sustainable cities. However, it also needs to be considered what influence the poor possess in the actioning and facilitative process? If the poor are able to gain influence in the process, how much more of a sustainable impact would the poor have on sustainable cities? In addition, it needs to be considered whether mechanisms such as participatory budgeting have a place within the financing of sustainable cities, and, if so, what form would they take to be tangibly-inclusive of the poor?

Lastly, it is suggested that the proposed model in this study be empirically tested to provide an empirically-tested model for financing sustainable cities.

8.10 CONCLUDING REMARKS

Although directives exist with respect to promoting sustainable development, financial strategies to cater for collective sustainable development, along with an increasing

population, need to be formulated relevant to metropolitan and urban areas. As urban economic output and energy needs increase, urban areas will increasingly need to invest in infrastructure to ensure sustainable and eco-friendly solutions. Key to the required investment in infrastructure is who will assume the costs and direction thereof? Although the public sector will always remain the key initiator behind infrastructure development, various mechanisms of financing, along with applicable financing partners and the basis of investment, will be required to address future sustainable cities. This study may potentially form the basis of that platform.

REFERENCE LIST

Abolhosseini, S., Heshmati, A. & Altmann, J. (2014). *A Review of Renewable Energy Supply and Energy Efficiency Technologies.* IZA Discussion Paper Series, IZA DP No.8145.

Abolhosseini, S. & Heshmatic, A. (2014). *The Main Support Mechanisms for Finance Renewable Energy Development.* IZA Discussion Paper Series, IZA DP No. 8182.

AECOM. (2016). *Africa Property and Construction Cost Guide 2016.* Johannesburg: AECOM.

Agenda 21, United Nations Sustainable Development. (1992). *Agenda 21, United Nations Conference on Environment and Development.* United Nations Sustainable Development, Rio de Janerio, Brazil, 3 to 14 June 1992.

Aliber, M. (2002). *Poverty-Eradication and Sustainable Development.* Integrated Rural and Regional Development Research Programme, Occasional Paper 1, Pretoria: HSRC.

Allen, A. (2009). *Sustainable Cities or Sustainable Urbanisation*. London: Publication of University College of London.

American Public Transportation Association (APTA). (2014). *Economic Impact of Public Transportation Investment.* Washington DC: American Public Transportation Association.

Ayalon, O., Flicstein, B. & Shtibelman, A. (2013). Benefits of Reducing Air Emissions: Replacing Conventional with Electric Passenger Vehicles. *Journal of Environmental Protection,* 4 pp. 1035-1043.

Baker, S. H. (2014). *Project Finance and Sustainable Development in the Global South.* Technical Paper. San Francisco: University of San Francisco School of Law.

Bammeke, P. O. (2013). *Sustainable Regional Development Planning to Green the Spatial Impact of Urbanisation in Sub-Saharan Africa.* Technical paper Centre for Studies in Technology and Sustainable Development (CSTM). Enschede, Netherlands: University of Twente.

Belluomini, D. (2016). *Environmental Safeguard and Sustainable Development: An Insight into Payments for Ecosystem Services.* CEsA, Working Paper CEsA CSG 140.

Berrisford, S. (2012). *Economic and Fiscal Costs of Inefficient Land Use Patterns.* Submission for the 2012/13 Division of Revenue- Technical Report. Cape Town: Finance and Fiscal Commission.

Boeing, G. (2016). *How Our Neighbourhoods Lost Food and How They Can Get it Back.* New York: Cornell University, Progressive Planning.

Bouton, S., Cis, D., Mendonca, L., Pohl, H., Remes, J., Ritchie, H. & Woetzel, J. (2013). *How to Make a City Great: A Review of the Steps City Leaders Around the World Take to Transform Their Cities Into Great Places to Live and Work.* New York: McKinsey & Company.

Bradshaw, W., Connelly, E. F., Cook, M. F., Goldstein, J. & Pauly, J. (2005). *The Costs and Benefits of Green Affordable Housing.* Boston: New Ecology and The Green CDCs Initiative.

Bryman, A. & Bell, E. (2007). *The Nature of Qualitative Research.* Business Research Methods. Oxford: Oxford University Press.

Burnett, N. (2010). *Strategies for Financing of Education: A Global View.* Paris, France: United Nations Educational, Scientific and Cultural Organisation (UNESCO).

Callahan, R. F. & Pisano, M. (2014). *Aligning Fiscal and Environmental Sustainability.* San Francisco: The University of San Francisco.

Capello, R. & Camagni, R. (2000). Beyond Optimal City Size: An Evaluation of Alternative Urban Growth Patterns. *Urban Studies,* 37(9) pp. 1479-1496.

Carraro, C., Pandey, S. & Stone, S. (2015). *Why Fiscal Policy Matters for a Green Economy Transition.* Review of Environment, Energy and Economics. Italy, Milan: Fondazione Eni Enrico Mattei.

Carter, R. C., Tyrrel, S.F. & Howsam, P. (1999). Impact and Sustainability of Community Water Supply and Sanitation Programmes in Developing Countries. *Journal of the Chartered Institution of Water and Environmental Management,* 13 pp. 292-296.

Chalones-Browne, R.W. (2011). Sustainable Cities: New Avenues for Financing. *Environmental Leader* [online] available at: www.environmentalleader.com/2011/05/24/sustainable-cities-new-avenues-for-financing/ [Accessed May 2014].

Choon, S., Siwar, C., Pereira, J.J., Jemain, A.A., Hashim, H.S. & Hadi, A.S. (2011). A Sustainable City Index for Malaysia. *International Journal of Sustainable Development & World Ecology,* 18(1) pp. 28-35.

City of Victoria. (2013). *Downtown Core Area Plan.* Victoria, Australia*:* City of Victoria.

Cohen, B. (2006). Urbanisation in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society,* 28 pp. 63-80.

Cohen, J. T., Neumann, P. J. & Weinstein, C. (2008). Does Preventive Care Save Money? Health Economics and the Presidential Candidates. *The New England Journal of Medicine,* 3857 pp. 661-663.

Collis, J. & Hussey, R. (2003). *Business Research: A Practical Guide for Undergraduate and Postgraduate Students.* 2nd edition. Basingstoke, Hampshire, England: Palgrave Macmillan.

Community Based Sanitation. (2015). BORDA Germany. Bremen Overseas Research and Development Association. [online]. Available at: http://www.borda-net.org/basic-needs-services/community-based-sanitation.html [Accessed September 2015].

Constantinescu, C. (2013). Green Economy: An Opportunity during the Global Crisis. *Social Economic Debates*, 2(2) pp. 23-35.

Cooper, D.R. & Schindler, P.S. (2008). *Business Research Methods*. 10th edition. London, England: McGraw-Hill.

Coyle, D. & Rosewell, B. (2014). *Investing in City Regions: How Does London Interact with the UK System of Cities and what are the Implications of this Relationship?* Manchester, United Kingdom: Enlightenment Economics.

Cresswell, J.W. (2014). *Research Design.* 4th edition. London, England: SAGE.

CSIR. (2009). Geo Spatial Analysis Platform. [online] available at: http:// www.gap.csir.co.za/ [Accessed March 2014].

Dahlen, L. & Lagerkvist, A. (2010). Evaluation of Recycling Programmes in Household Waste Collection Systems. *Waste Management and Research,* 28 pp. 577-586.

De Beer, T. (2013). *Sustainable Waste Management: A Decision Support Framework.* Masters Dissertation in Engineering. Stellenbosch: University of Stellenbosch.

Deb, A. (2010). Sustainable Cities in Developing Countries. *Building and Research Information,* 26(1) pp. 29-38.

Department of Basic Education. (2012). *Guidelines Relating to Planning for Public School Infrastructure.* Pretoria, South Africa: Department of Basic Education.

Department of Education. (2009). *The National Minimum Norms and Standards for School Infrastructure.* Pretoria, South Africa: Department of Education.

Department of Energy. (2015). *State of Renewable Energy in South Africa.* Pretoria, South Africa: Department of Energy.

Department of Environmental Affairs and Tourism. (2005). *Working with Waste: Guideline on Recycling of Solid Waste.* Pretoria, South Africa: Department of Environmental Affairs and Tourism.

Department of Environmental Affairs and Tourism. (2008). *National Framework for Sustainable Development in South Africa.* Pretoria, South Africa: Department of Environmental Affairs and Tourism.

Department of Environmental Affairs. (2011). *National Legacy Report for the Greening of the 2010 FIFA World Cup.* Pretoria, South Africa: Department of Environmental Affairs.

Department of Health. (2000). *The Primary Health Care Package for South Africa: A Set of Norms and Standards.* Pretoria, South Africa: Department of Health.

Department of Science and Technology. (2014a). *A National Waste Research, Development (R&D) and Innovation Roadmap for South Africa: Phase 2 Waste RDI Roadmap.* Pretoria, South Africa: Department of Science and Technology.

Department of Science and Technology. (2014b). *The State of Green Technologies in South Africa.* Pretoria, South Africa: Department of Science and Technology.

Doddington, C. & Hilton, M. (2007). *Child-Centred Education.* Thousand Oakes, California: SAGE Publications.

Du Plessis, D. J. & Boonzaaier, I. (2014). The Evolving Spatial Structure of South African Cities: A Reflection of the Influence of Spatial Planning Policies. *International Planning Studies,* 20(1-2) pp. 87-111.

du Toit, E., Erasmus, P., Kotze, L., Ngwenya, S., Thomas, K. & Viviers, S. (2010). *Corporate Finance: A South African Perspective.* Oxford: Oxford University Press.

DuVivier, K.K. (2014). *Rural Wind Windfalls*. University of Denver Sturm College of Law. Legal Research Paper Series, Working Paper No. 14-40.

Easterby-Smith, M., Thorpe, R. & Lowe, A. (2006). *Management Research: An Introduction.* 2nd edition. Thousand Oakes, California: Sage Publications

Economic Policy Forum. (2014). *Promoting Sustainable and Inclusive Growth in Emerging Economies: Green Buildings.* Berlin, Germany: Economic Policy Forum.

Elagroudy, S., Warith, M. A. & El Zayat, M. (2016). *Municipal Solid Waste Management and Green Economy.* Berlin, Germany: Global Young Academy.

Electric Vehicle Initiative. (2013). *Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020.* Electric Vehicle Initiative.

Engineering Advice and Services (EAS). (2010). *District Roads Hierarchy Prioritisation.* Port Elizabeth, South Africa: Cacadu District Municipality.

England, P. (2009). Managing Urban Water in Australia: The Planned and the Unplanned. *Management of Environmental Quality: An International Journal,* 20(5) pp. 592–608.

EScience Associates, Urban-Econ Development Economists & Ahlfeldt, C. (2013). *The Localisation Potential of Photovoltaics (PV) and a Strategy to Support Large Scale Roll-out in South Africa.* Pretoria, South Africa: Department of Trade and Industry.

Eskom. (2015). *Eskom Factsheet.* Sandton South Africa: Eskom.

European Commission. (2013). *Financing Models for Smart Cities.* Brussels, Belgium: European Commission Smart Cities Stakeholder Platform.

European Union. (2011). *Cities of Tomorrow: Challenges, Visions, Ways Forward.* Brussels, Belgium: European Union Regional Policy.

FAO. (2007). *Profitability and Sustainability of Urban and Peri-Urban Agriculture.* FOA, Agricultural Management, Marketing and Finance Occasional Paper, 19.

Fourie, J. (2006). *Some Policy Proposals for Future Infrastructure Investment in South Africa.* University of Stellenbosch, Stellenbosch Economic Working Papers: 05/06.

Freire, M. (2016). Arrival Cities and the Great Migration. *Perspectives: A Publication of the International Development Programme [online]* available at: http://www.saisperspectives.com/#idevblog-home [Accessed 19 March 2016]

Ganguly, S., Kujac, P., Leonard, M., Wagner, J. & Worthington, Z. (2011). *Lively'Hood Farm Financial Analysis: A Feasibility Study of Commercial Urban Agriculture in the City of San Francisco.* San Francisco, United States: Team Lively'Hood.

Gauteng City Region Observatory (GCRO). (2013). *State of Green Infrastructure in the Gauteng City Region.* Johannesburg, South Africa: Gauteng City Region Observatory.

Gauteng Department of Economic Development. (2010*). Strategy for a Developmental Green Economy for Gauteng.* Report prepared for the Gauteng Province Department of Economic Development. Johannesburg, South Africa: Gauteng Department of Economic Development.

Gisclon, A., McCarley, S. & McNally, K. (2002). *The Durban Water Recycling Project: The Vision Becomes Reality.* Paper Presented at the Biennial Conference of the Water Institute of South Africa (WISA).

Godfrey, N. & Zhao, X. (2016). *Financing the Urban Transition for Sustainable Development: Better Finance for Better Cities.* Contributing paper for The Sustainable Infrastructure Imperative: Financing for Better Growth and Development. New Climate Economy, London and Washington, DC. Available at: http://newclimateeconomy.report/misc/working-papers/ [Accessed 24 April 2016].

Golden, S. (2013). *Urban Agriculture Impacts: Social, Health and Economic: A Literature Review.* UC Sustainable Agriculture Research and Education Programme. Davis, University of California: Agricultural Sustainability Institute at UC Davis.

Green Building Council of South Africa. (2012a). What is a Green Building? *Green Building Council SA.* [online] available at: <http://www.gbcsa.org.za/home.php> [Accessed 20 February 2014].

Green Building Council of South Africa. (2012b). *The Rands and Sense of Green Building.* Cape Town, South Africa: Green Building Council of South Africa.

GroundUp. (2017). Everything You Need to Know About Social Grants. *GroundUp.* [online] available at: http://www.groundup.org.za/article/everything-you-need-know-about-social-grants_820/ [Accessed March 2017].

Gunningham, N. (2014). *Regulatory Institutions Network.* CEGNet Working Paper, No. 29.

Haering, K. C., Evanylo, G. K., Benham, B. & Goatley, M. (2009). *Water Reuse: Using Reclaimed Water for Irrigation.* Virginia, United States: Virginia Cooperative Extension.

Handy, S. (2002). *Accessibility vs Mobility Enhancing Strategies for Addressing Automobile Dependence in the U.S.* Technical Report. Davis, California: University of California at Davis.

Hanna, V. M. (2014). *Stop, Think, Build, Repeat: Using Behavioural Economics to Better Design Energy Efficiency Policies for our Cities' Buildings*. Technical Report. Miami, United States: University of Miami Law Review, 2014.

Hofman, Y., Phylipsen, G. J. M., Janzic, R. & Ellenbroek, R. (2004). *Small Scale Project Design Document, Biomass Rajasthan.* Technical Report. Mumbai, India: Kalpataru Power Transmission Limited.

Horn, S. J. (2003). *The Municipal Credit Market in South Africa.* Masters Dissertation in Commerce (Risk Management). Potchefstroom: Potchefstroom University for Christian Higher Education.

Human Settlements. (2010). *National Housing Policy and Subsidy Programmes.* Pretoria, South Africa: Department of Human Settlements.

Hutton, G. & Haller, L. (2004). *Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level.* Technical Paper. Geneva, Switzerland: World Health Organisation.

International Development Finance Club (IDFC). (2014). *Investing in Sustainable Cities: Challenges and Opportunities.* Mumbai, India: IDFC.

Lossa, E., Spagnolo, G. & Velleze, M. (2013). *The Risks and Tricks in Public-Private Partnerships.* The Center for Research on Energy and Environmental Economics and Policy, Working Paper n. 64. The Center for Research on Energy and Environmental Economics and Policy, Bocconi University, Milan.

Jenks, M. & Burgess, R. (2000). *Compact Cities: Sustainable Urban Forms for Developing Countries.* London, United Kingdom: SPON Press.

Jimenez, B. S. (2014). *Separate, Unequal and Ignored? Inter-Jurisdictional Competition and the Budgetary Choices of Poor and Affluent Municipalities.* Technical Paper. Boston, United States: North Eastern University.

Kaiser, G. N. (2013). *Improved Decision Making Through Analysing the Economic Impact of Budget Allocation at the City of Cape Town.* PhD Thesis in Construction Management. Port Elizabeth, South Africa: Nelson Mandela Metropolitan University.

Koont, S. (2008). A Cuban Success Story: Urban Agriculture. *Review of Radical Political Economics,* 40(3) pp. 285-291.

Krugell, W. F. (2011). *Putting the Economy in its Place: Geographical Economics in South Africa.* North-West University, Scientific Contribution, Series H: Inaugural Address Nr. 242.

Kwazulu-Natal Province. (2014). *Kwazulu-Natal Poverty Eradication Master Plan*. Durban, South Africa: Kwazulu-Natal Province.

Labouret, A. & Villoz, M. (2010). *Solar Photovoltaic Energy.* London, United Kingdom: The Institution of Engineering and Technology, Renewable Energy Series 9.

Lindenberg, N. (2014). *Public Instruments to Leverage Private Capital for Green Investments in Developing Countries.* German Development Institute, Discussion Paper 4. German Development Institute, Bonn.

Lumby, S. & Jones, C. (2011). *Corporate Finance, Theory and Practice,* 8th edition. Independence, United States: South Western Cengage Learning.

Luzadis, V., Alkire, C., Mater, C., Romm, J., Stewart, W., Will, L. & Vaagen, D. (2001). Investing in Ecosystems and Communities. *Journal of Sustainable Forestry,* 12(3-4) pp. 169-194.

Macomber, J. (2011). The Role of Finance and Private Investment in Developing Sustainable Cities. *Journal of Applied Corporate Finance,* 23 pp. 64-74.

Marr, B. (2007). Measuring and Managing Intangible Value Drivers. *Business Strategy Series,* 8(3) pp. 172-178.

Masters, G. M. (2004). *Renewable and Efficient Electric Power Systems.* New Jersey, United States: Wiley-Interscience, A John Wiley & Sons Inc. Publication.

Maylath, L. R. (2014). *Progressive Cities: Models for Using Public Land for Community Gardens.* Technical Report. San Francisco, United States: Golden Gate University School of Law.

McGuigan, J. R., Moyer, R. C., Rao, R. & Kretlow, W.J. (2008). *Contemporary Corporate Finance,* 12th edition. Independence, United States: South Western Cengage Learning.

McIntyre, D., Bloom, G., Doherty, J. & Brijlal, P (1995). *Health Expenditure and Finance in South Africa.* Technical Paper. Durban, South Africa: Health System Trust and the World Bank.

Meghani, A., Abdulwahab, A., Privor-Dumm, L. & Wonodi, C. (2015). *Basket Funds: A Pooled Arrangement to Finance Primary Health Care Delivery and Address the Funding Flow in Nigeria.* Technical Report. Baltimore, United States: International Vaccine Access Centre (IVAC).

Meltzer, J. P. (2016). *Financing Low Carbon, Climate Resilient Infrastructure: The Role of Climate Finance and Green Financial Systems.* Global Economy and Development at Brookings, Global Economy & Development Working Paper 96.

Menzies, G. (2010). *An Economic Evaluation of a Wind Power Electricity Generating Farm in South Africa.* Technical Report. Port Elizabeth South Africa: Nelson Mandela Metropolitan University.

Migendt, M., Schock, F., Taube, F., von Flotow, P. & Polzin, F. (2014). *Private Equity in Clean Technology: An Exploratory Study of the Finance-Innovation-Policy-Nexus.* Technical Paper. Germany: EBS University.

Miller, S. R. (2016). *Financing Local Food Factories*. Technical Paper. New York, United States: Fordham University, School of Law, Fordham Urban Law Journal.

Minde, G. P., Magdum, S. S. & Kalyanraman, V. (2013). Biogas as a Sustainable Alternative for Current Energy Need of India. *Journal of Sustainable Energy and Environment,* 4 pp. 121-132.

Moon, J., Song, J. & Seojin, L. (2016). *Catalyzing Investment for Renewable Energy in Developing Countries.* Technical Paper. Korea: Korea Institute for International Economic Policy.

Mudavanhu, S., Blignaut, J., Nkambule, N., Morokong, T. & Vundla, T. (2016). A Cost-Benefit Analysis of Using Rooikrans as Biomass Feedstock for Electricity Generation: A Case Study of the De Hoop Nature Reserve, South Africa. *SAJEMS Asset Research,* 19(50) pp. 788-813.

Murphy, L. M., Ondechek Jr, R., Bracho, R. & McKenna, J. (2014). *Clean Energy-Bridging to Commercialisation: The Key Potential Role of Large Strategic Industry Partners.* Italy, Milan: Nota Di Lavoro, Fondazione Eni Enrico Mattei.

National Development Plan 2030. (2012). *National Development Plan 2030, Our Future- Make it Work.* Pretoria, South Africa: National Planning Commission.

National Treasury. (2013). *Guidelines for the Implementation of the Integrated City Development Grant in 2013/14.* Pretoria, South Africa: National Treasury.

National Treasury. (2016). *Municipal Borrowing Bulletin.* Pretoria, South Africa: Department of National Treasury.

Nelson Mandela Bay Municipality. (2016). Document Library- Tariffs. *Nelson Mandela Bay Municipality.* [online] available at: http://www.nelsonmandelabay.gov.za/Documents.aspx?catID=37&pageID=224 [Accessed March 2016].

NMMU. (2015). PV Farm Feasibility Assessment. Port Elizabeth, South Africa: Nelson Mandela Metropolitan University (NMMU).

NSW Government. (2008). *NSW Guidelines for Greywater Reuse in Sewered, Single Household Residential Premises*. Australia: NSW Government.

Oates, B.J. (2006). *Researching Information Systems and Computing*. London, England: SAGE.

OECD. (2009). *Alternative Ways of Providing Water: Emerging Options and Their Policy Implications.* OECD, Advance Copy for 5th World Water Forum.

Ottinger, R. L. & Bowie, J. (2014). *Innovative Financing for Renewable Energy.* Baltimore, United States: IUCN Academy of Environmental Law Colloquium.

Pacific Institute. (2010). *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management.* Oakland, United States: Pacific Institute.

Perdiguero, J. & Jimenez, J. L. (2012). *Policy Options for the Promotion of Electric Vehicles: A Review.* IREA, Research Institute of Applied Economics. Working Paper 2012/08.

Perkins, P. (2011). *The Role of Economic Infrastructure in Economic Growth: Building on Experience.* Technical Paper. Pretoria, South Africa: Statistics South Africa.

Phillips, J. F. & Stricklan, P.J. (2015). Local Government Sustainable Development: A Theoretical Paradigm or a Plan for Action? *Journal of Accounting, Ethics & Public Policy* 16(1) pp 1-37.

Phimphanthavong, H. (2014). The Determinants of Sustainable Development in Laos. *International Journal of Academic Research in Management*, 3(1) pp. 51-75.

Polese, M. (2013). Five Principles of Urban Economics. *Economy, Finance and Budgets: Cities.* [online] available at: https://www.city-journal.org/html/five-principles-urban-economics-13531.html [Accessed May 2016].

Portney, K.E. (2001). *Taking Sustainable Cities Seriously: A Comparative Analysis of Twenty-Three US Cities.* Paper presented at the 2001 meetings of American Political Science Association.

PriceWaterhouseCoopers. (2008). *New Thinking on Infrastructure Funding: Tax Increment Financing to Fund Public Urban Infrastructure in Australia.* Australia: PriceWaterhouseCoopers.

PriceWaterhouseCoopers. (2014). *Trends, Challenges and Future Outlook: Capital Projects and Infrastructure in East Africa, Southern Africa and West Africa.* South Africa: PWC.

Rai, V., Funkhouser, E., Udwin, T. & Livingston, D. (2015). *Venture Capital in Clean Energy Innovation Finance: Insights From the U.S. Market During 2005-2014.* University of Texas at Austin, Working Paper.

Ratas, J. & Maeltsemess, S. (2013). *Role of Environment in Strengthening Competitiveness of Cities by Example of European Green Capitals and Tallin.* Technical Paper. Estonia: Tallinn University of Technology.

Rode, P. & Floater, G. (2014). *Accessibility in Cities: Transport and Urban Form.* The New Climate Economy, NCE Cities, Paper 3.

Ross, M. M. D. (2014). *Diversification of Energy Supply: Prospects for Emerging Energy Sources.* ADB Economics, Working Paper Series, No. 403.

Rutovitz, J. (2010). *South African Energy Sector Jobs to 2030: How the Energy [R]evolution will Create Sustainable Green Jobs.* Johannesburg, South Africa: Greenpeace.

Savard, J. L., Clergeau, P. & Mennechez, G. (2000). Biodiversity Concepts and Urban Ecosystems. *Landscape and Urban Planning,* 48 pp. 131-142.

Sharif, S. (2014). *Municipal Finance: A Short Note.* Pakistan: State Bank of Pakistan.

Siemens White Paper on Sustainable Cities. (2010). *Trends, Investment Challenges & Financing Solutions.* A Research Report from Siemens Financial Service. Germany: Siemens Financial Services

South African Cities Network. (2013). *State of City Finances, Towards Sustainable Municipal Finances.* Johannesburg, South Africa: South African Cities Network.

Spencer, L. (2014). *Farming the City: Urban Agriculture, Planning Law and Food Consumption Choices.* Technical Paper. Australia: University of Western Sydney.

Stake. R. E. (2005). *Qualitative Case Studies.* Thousand Oaks, California: Sage.

Statistics South Africa. (2005). *South African Statistics, 2004/05.* Pretoria, South Africa: Statistics South Africa.

Statistics South Africa. (2014). *South African Statistics.* Pretoria, South Africa: Statistics South Africa.

Steg, L. (2003). Can Public Transport Compete with the Private Car? *IATSS Research,* 27(20) pp. 27-35.

Stilwell, F. (2000) Towards Sustainable Cities. *Urban Policy and Research,* 18(2) pp. 205-217.

Sundic, M. & Leitner, K. (2013). Capability for Infrastructure Asset Capacity Management. *Digiworld Economic Journal,* 89(55) pp. 55-89.

Surrey Wildlife Trust (2014). *Living Landscapes Strategy.* Woking, United Kingdom: Surrey Wildlife Trust.

Svara, J. H. (2014). *Local Governments, Social Equity and Sustainable Communities: Advancing Social Equity Goals to Achieve Sustainability.* United States: ICMA.

Swilling, M. (2005). *Rethinking the sustainability of the South African City.* Technical Paper. Sustainability Institute, Development Update, 2005.

Swilling, M. (2013). Economic Crises, Long Waves and the Sustainability Transition: An African Perspective. *Environmental Innovation and Societal Transitions*, 6 pp. 96-115.

The Presidency. (2006). *National Spatial Development Perspective.* Pretoria, South Africa: The Presidency, Republic of South Africa.

Too, E. G. (2011). Crowdsourcing as an Innovation Strategy. *International Journal of Strategic Property Management,* 15(2) pp. 139-151.

Troy, P. (2004). *The Structure and Form of the Australian City: Prospects for Improved Urban Planning.* Technical Paper. Australia: Griffith University.

Tsinda, A. & Abbott, P. (2017). *Between the Market and the State: Financing and Servicing Self-Sustaining Sanitation Chains in Informal Settlements in East African Cities.* Centre for Global Development, University of Aberdeen, Working Paper 1.

Tumlin, J. (2012). *Sustainable Transportation Planning Tools for Creating Vibrant, Healthy and Resilient Communities.* New Jersey, United States: John Wiley & Sons Inc.

Turok, I. (2012). *Urbanisation and Development in South Africa: Economic Imperatives, Spatial Distortions and Strategic Responses.* International Institute for Environment and Development, United Nations Population Fund, Urbanisation and Emerging Population Issues, Working Paper 8.

US Department of Energy & US Department of Transport. (2016). *Guide to Federal Funding, Financing and Technical Assistance for Plug-in Electric Vehicles and Charging Stations.* United States: US Department of Energy & US Department of Transport.

US Department of Housing and Urban Development. (2013). *Building Resiliency: The Role of Anchor Institutions in Sustaining Community Economic Development.* US United States: Department of Housing and Urban Development, Office of University Partnerships.

UNDP. (2002). *Child-centred Development: The Basis for Sustainable Human Development.* New York, United States: UNDP.

UNEP. (2003). *Energy and Cities: Sustainable Building and Construction.* New York, United States: UNEP, International Environmental Technology Center.

UNEP. (2005). *Water and Wastewater Reuse: An Environmentally Sound Approach for Sustainable Urban Water Management.* Nairobi, Kenya: UNEP.

UNEP. (2007). *Rainwater Harvesting and Utilisation: An Environmentally Sound Approach for Sustainable Urban Water Management- An Introductory Guide for Decision Makers.* Nairobi, Kenya, UNEP.

UNEP. (2010). *Green Buildings and the Finance Sector: An Overview of Financial Institution Involvement in Green Buildings in North America.* United States: North American Task Force, UNEP Finance Initiative.

UNEP. (2012). *Sustainable, Resource Efficient Cities.* Nairobi, Kenya: UNEP.

UNEP. (2013). *Green Economy Modelling Report of South Africa.* Pretoria, South Africa: Department of Environmental Affairs.

UNESCO. (2016). *Culture, Urban, Future: Global Report on Culture for Sustainable Urban Development.* Paris, France: UNESCO.

UN-Habitat. (2009). *Rainwater Harvesting and Utilisation: Book 2- Beneficiaries and Capacity Builders.* Tanzania: UN-Habitat.

UN-Habitat. (2014a). *A New Strategy of Sustainable Neighbourhood Planning: Five Principles.* UN-Habitat, Discussion Note 3, Urban Planning.

UN-Habitat. (2014b). *State of African Cities, Re-imagining Sustainable Urban Transitions.* Tanzania: UN-Habitat.

UN-Habitat. (2014c). *Urban Equity in Development- Cities for Life*. Concept Paper. Tanzania: UN Habitat.

UNICEF. (2009). *Manual: Child Friendly Schools.* New York, United States: UNICEF.

United Nations General Assembly. (2012). *The Future We Want.* Resolution adopted by the General Assembly on 27 July 2012. 66/288.

United Nations. (2012). *Guidebook to the Green Economy.* Division for Sustainable Development. New York, United States: United Nations, UNDESA.

United Nations. (2013). *World Economic and Social Survey*. Report published by the United Nations. New York, United States: United Nations.

University of Michigan. (2009). *Building a Community-Based Sustainable Food System.* Michigan, United States: University of Michigan, Urban and Regional Planning.

Urban Catalyst Associates. (2005). *Building Green for the Future: Case Studies of Sustainable Development in Michigan.* Michigan, United States: University of Michigan.

Urban Econ Development Economists. (2015). *The Wind Energy Industry: Localisation roadmap in Support of Large Scale Rollout in South Africa.* Pretoria, South Africa: Department of Trade and Industry.

Urbed. (2014). *Uxcester Garden City.* Urbed, Second Stage Submission for the 2014 Woltson Economics Prize.

Van der Heijden, J. (2014). *Voluntary Programmes for Building Retrofits: Opportunities, Performance and Challenges.* Australian National University, Regnet Research Paper No. 48.

van Huyssteen, E., Biermann, S., Naude, A. & le Roux, A. (2009). Advances in Spatial Analysis to Support a More Nuanced Reading of the South African Space Economy. *Urban Form,* 20 pp.195-214.

Victoria Transport Policy Institute. (2017a). *Evaluating Public Transit Benefits and Costs.* Australia: Victoria Transport Policy Institute.

Victoria Transport Policy Institute. (2017b). *Local Funding Options for Public Transportation.* Australia: Victoria Transport Policy Institute.

Welman, C., Kruger, F. & Mitchell, B. (2010). *Research Methodology*. 3rd edition. Cape Town, South Africa: Oxford

Western Cape Government. (2013). *Development Parameters: A Quick Reference for the Provision of Facilities within Settlements of the Western Cape.* Cape Town, South Africa: Western Cape Government, Environmental Affairs and Development Planning.

Williams, K. (2010). Sustainable Cities: Research and Practice Challenges. *International Journal of Urban Sustainable Development,* 1(1-2) pp.128-132.

Wojewnik-Filipkowska, A. (2017). Rationalisation of Investment Decisions in the Sustainable Management of Urban Development: Is a New Paradigm Needed. *Problems of Sustainable Development,* 12(1) pp.79-90.

World Bank. (2012). *Inclusive Green Growth: The Pathway to Sustainable Development.* Washington D.C., United States: The World Bank.

World Health Organisation. (2004). *What are the Advantages and Disadvantages of Restructuring a Health Care System to be More Focused on Primary Care Services?* Geneva, Switzerland: World Health Organisation: Europe.

World Summit. (2005). The 2005 World Summit Outcomes. [online] Available at: http://www.who.int/hiv/universalaccess201/worldsummit.pdf [Accessed 7 July 2014].

World Wildlife Fund (WWF). (2015). *Financing the Transition: Sustainable Infrastructure in Cities.* Switzerland: World Wildlife Fund (WWF).

Xue, Y., You, J. & Shao, L. (2014). Understanding Socio-technical barriers to sustainable mobility: Insights from Demonstration Program of EV's in China. *Problems of Sustainable Development,* 9(1) pp.29-36.

Yin, R.K. & Davis, D. (2007). *Adding New Dimensions to Case Study Evaluations.* Thousand Oak, California: Sage.

Yin, R.K. (2009). *Case Study Research: Design and Methods.* Thousand Oak, California: Sage.

Yin, R.K. (2011). *Qualitative Research from Start to Finish.* New York, United States: The Guildford Press.

Zeynalov, A. (2013). *Do Sufficient Institutions Alter the Relationship Between Natural Resources and Economic Growth?* Munich Personal RePEc Archive (MPRA), MPRA Paper No. 46850.

Zhu, D., Patella, D. P., Steinmetz, R. & Peamsilpakulchorn, P. (2016). *The Bhutan Electric Vehicle Initiative: Scenarios, Implications and Economic Impact.* Geneva, Switzerland: The World Bank.

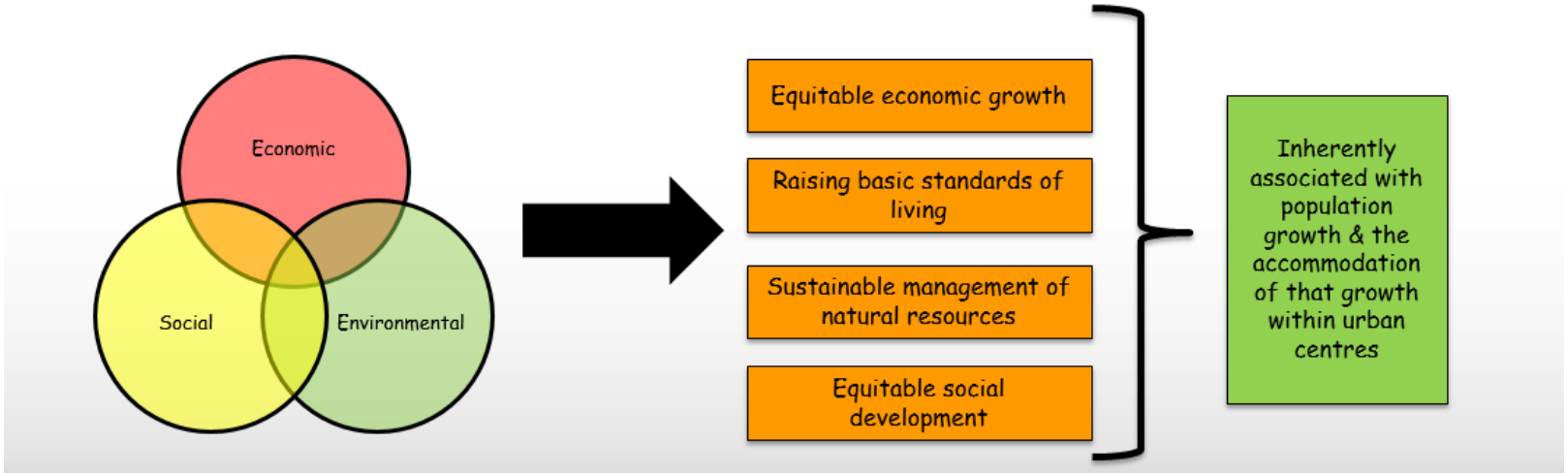
Zikmund, W.G., Babin, B.J., Carr, J.C. & Griffen, M. (2010). *Business Research Methods*. 8th edition. Mason, Ohio: South-Western, Cengage Learning.

APPENDIX A: INTERVIEW SCHEDULE

INTRODUCTION AND BACKGROUND

Nelson Mandela Metropolitan University for tomorrow

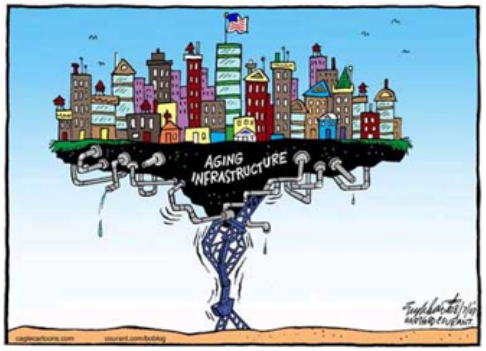
- The United Nations General Assembly's (2012) resolution stipulates a common vision for the future wherein economic, social and environmental aspects are mainstreamed at all levels so as to achieve sustainable development.
- This resolution recognises that the need to achieve sustainable development is obtained by promoting sustained, inclusive and equitable economic growth, raising basic standards of living, promoting the integrated and sustainable management of natural resources and ecosystems and fostering equitable social development (United Nations General Assembly 2012).
- These factors are inherently associated with population growth along with the subsequent accommodation of that growth within urban centres.



INTRODUCTION AND BACKGROUND (CONT.)

Nelson Mandela Metropolitan University
for tomorrow

- Although directives exist with respect to promoting sustainable development, financial strategies to cater for collective sustainable development, along with an increasing population, need to be formulated relevant to metropolitan and urban areas.



- As urban economic output and energy needs increase, urban areas will increasingly need to invest in infrastructure to ensure sustainable and eco-friendly solutions (Siemens White Paper on Sustainable Cities, 2010).

- Key to the required investment in infrastructure is who will assume the costs and direction thereof?

INTRODUCTION AND BACKGROUND (CONT.)

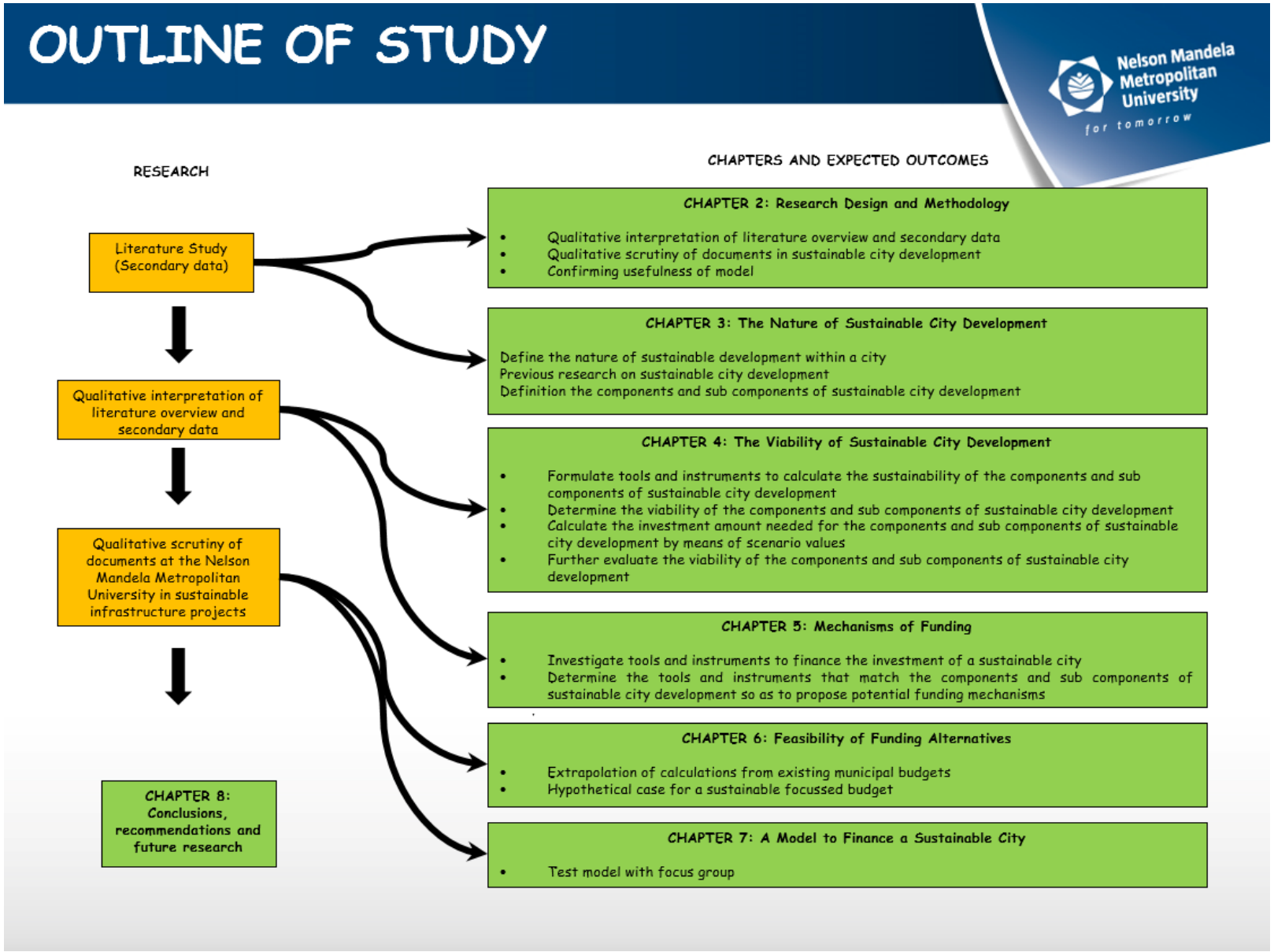
Nelson Mandela Metropolitan University
for tomorrow

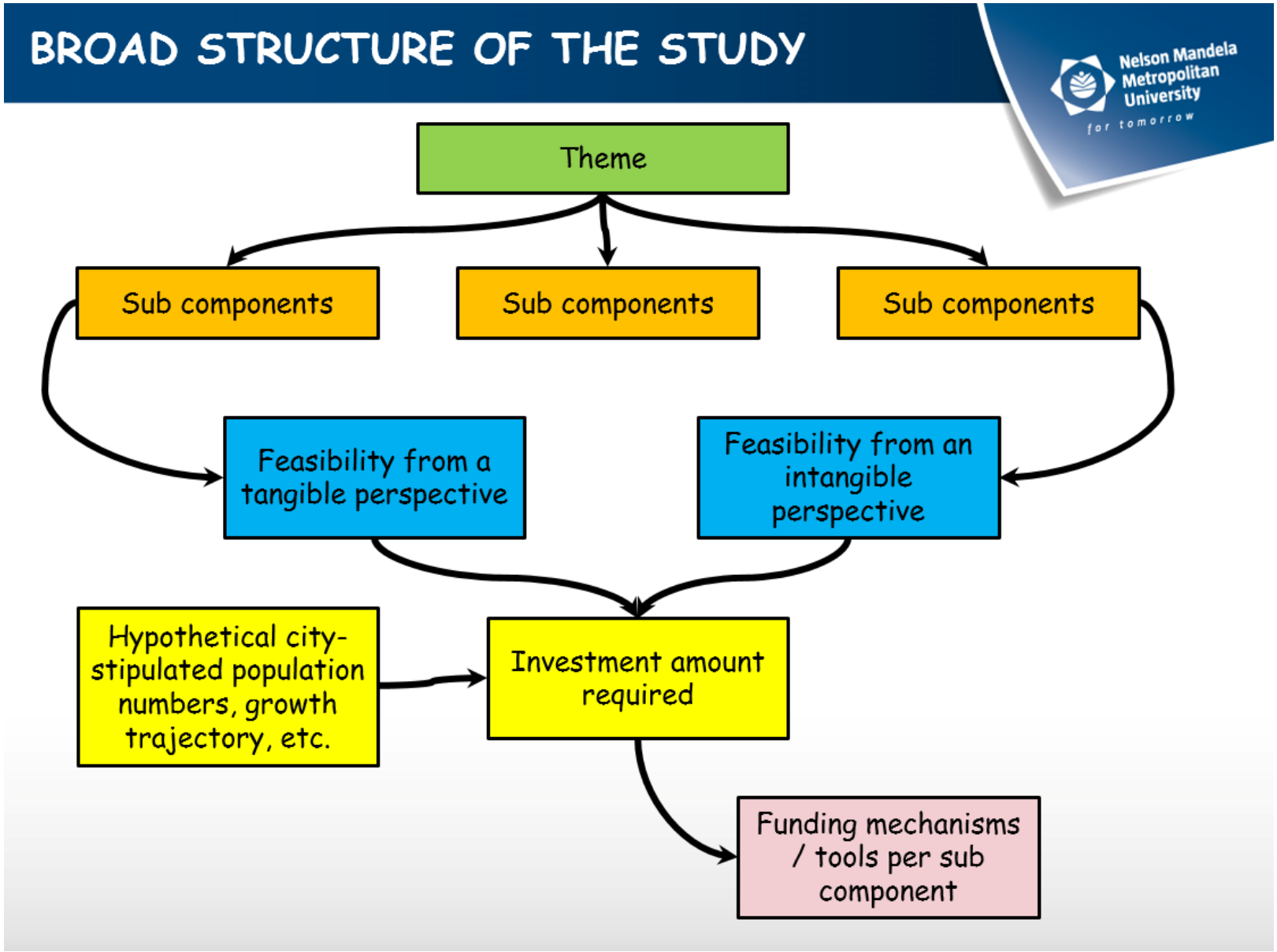
- This study seeks to initially quantify the basis of infrastructure investment with respect to the development of a sustainable city.
- Thereafter a determination on the various financing methods of funding sustainable cities will be undertaken resulting in the design of a model to finance sustainable cities. Such a model will provid- guidance to the public and priv sector in the development of future sustainable communities cities.

PROBLEM STATEMENT

Nelson Mandela Metropolitan University
for tomorrow

- Although directives exist with respect to promoting sustainable city development, financial strategies so as to cater for collective sustainable development, along with an increasing population, need to be formulated relevant to metropolitan and urban areas. As urban economic output and energy needs increase, urban areas will increasingly need to invest in infrastructure so as to ensure sustainable and eco-friendly solutions (Siemens White Paper on Sustainable Cities, 2010). Key to the required investment in infrastructure is who will assume the costs and direction thereof?


OUTLINE OF STUDY
Nelson Mandela Metropolitan University
for tomorrow
RESEARCH
CHAPTERS AND EXPECTED OUTCOMES
Literature Study (Secondary data)
Qualitative interpretation of literature overview and secondary data
Qualitative scrutiny of documents at the Nelson Mandela Metropolitan University in sustainable infrastructure projects
CHAPTER 8: Conclusions, recommendations and future research
CHAPTER 2: Research Design and Methodology
Qualitative interpretation of literature overview and secondary data
Qualitative scrutiny of documents in sustainable city development
Confirming usefulness of model
CHAPTER 3: The Nature of Sustainable City Development
Define the nature of sustainable development within a city
Previous research on sustainable city development
Definition the components and sub components of sustainable city development
CHAPTER 4: The Viability of Sustainable City Development
Formulate tools and instruments to calculate the sustainability of the components and sub components of sustainable city development
Determine the viability of the components and sub components of sustainable city development
Calculate the investment amount needed for the components and sub components of sustainable city development by means of scenario values
Further evaluate the viability of the components and sub components of sustainable city development
CHAPTER 5: Mechanisms of Funding
Investigate tools and instruments to finance the investment of a sustainable city
Determine the tools and instruments that match the components and sub components of sustainable city development so as to propose potential funding mechanisms
CHAPTER 6: Feasibility of Funding Alternatives
Extrapolation of calculations from existing municipal budgets
Hypothetical case for a sustainable focussed budget
CHAPTER 7: A Model to Finance a Sustainable City
Test model with focus group


BROAD STRUCTURE OF THE STUDY
Nelson Mandela Metropolitan University
for tomorrow
Theme
Sub components
Sub components
Sub components
Feasibility from a tangible perspective
Feasibility from an intangible perspective
Hypothetical city-stipulated population numbers, growth trajectory, etc.
Investment amount required
Funding mechanisms / tools per sub component

THEMES OF SUSTAINABLE CITY DEVELOPMENT

Nelson Mandela Metropolitan University
for tomorrow

- Reducing the total consumption of water along with the dependence on large scale water capture systems;
- Encouraging a community based sanitation system for all income groups where sewerage is treated and re-used;
- Promoting densification, mixed land use and mixed income residential areas;
- Reducing the use of private vehicles whilst simultaneously increasing the use of public transport;
- Reducing the use of fossil fuel based energy leading to a transition of energy provision that utilises a combination of solar, wind, micro-hydro and hydrogen power couples with increased efficiencies;
- Increasing food supplies from urban farms along with building local food retail markets;
- The separation at source of solid waste couples with collection and recycling systems;
- Ensuring that building materials and design are based on the assessment of the environmental and social impact;
- A reduction in air pollution and CO^2 emissions from vehicles, utilities and homes;
- A public health system that focuses on the provision of basic services;
- Increased biodiversity and recreational space; and
- Enhancing child centred development and learning.

COMPONENTS WITHIN THE THEMES

Nelson Mandela Metropolitan University
for tomorrow

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Location	• Regional • Local area	• Tangible determination: o Gross Value Addition • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Linking the city to the regional and national economy o Building and sustaining leadership and partnerships	• Given that gross value addition can measure the value of goods and services produced within a particular locality, it is an appropriate tool in assessing the applicability of location. • The theme of location plays a critical role in contributing to the development of mixed income districts, the development and utilisation of public transportation, equal education amongst mixed income groups along with equity of access with respect to opportunity and services. • The theme of location influences city development and regional performance. • The theme of location influences integrating environmental considerations along with promoting opportunities for all residents.

COMPONENTS WITHIN THE THEMES (cont.)

Nelson Mandela Metropolitan University
for tomorrow

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Water	• Rainwater harvesting • Utilisation of grey water • Utilisation of reclaimed water	• Tangible determination: o Discounted payback period o NPV • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Fostering state level policy reform	• Cost of capital is considered in conjunction with discounted values of expected future cash inflows • Assess cash flows of the project along in conjunction with associated discounts. • Ensure equity of access with respect to opportunity and services. • Water related interventions can to contribute to creating the demand for green innovation.
Sanitation	• Low diameter sewerage systems collect and discharge household wastewater from residences into low maintenance wastewater treatment plants. • Shared septic tank system where a number of residents connect into one septic tank. • Community sanitation centres.	• Tangible determination: o Discounted payback period o NPV • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Fostering state level policy reform	• Cost of capital is considered in conjunction with discounted values of expected future cash inflows • Assess cash flows of the project along with associated discounts. • Ensure equity of access with respect to opportunity and services. • Water related interventions can to contribute to creating the demand for green innovation.

COMPONENTS WITHIN THE THEMES (cont.)

Nelson Mandela Metropolitan University

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Promoting densification, mixed land use and mixed income residential areas	• Bulk infrastructure (water, sanitation and electricity) cost provisions.	• Tangible determination: o Average return method o IRR • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Leveraging public resources and assets for private investment o Building and sustaining leadership and partnerships	• Will be utilised in comparing investments wherein the project lifespans are more or less the same. • The measure can be utilised for simple acceptance / rejection problems. • The theme of promoting densification plays a critical role in contributing to the development of mixed income districts, the development and utilisation of public transportation, equal education amongst mixed income groups along with equity of access with respect to opportunity and services. • The theme of densification and mixed land use development involves a range of stakeholders that will require collaborative efforts and quality standards. • Increased densification and mixed use development can contribute to smart growth and improved service delivery at a reduced cost.
Public transport	• Creating universal transit passes. • Parking cash-out. • Bicycle facilities. • Car sharing. • Transportation resources centres.	• Tangible determination: o Profitability index • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Leveraging public resources and assets for private investment o Fostering state level policy reform	• The acceptance or rejection of public transportation interventions may be measured due to the individualistic nature of the interventions. • Assessing how each component of public transportation theme contributes to the development and utilisation of an overall public transportation system • The theme of public transportation involves a range of stakeholders that will require collaborative efforts and quality standards • Public transportation interventions can contribute to creating the demand for green innovation.

COMPONENTS WITHIN THE THEMES (cont.)

Nelson Mandela Metropolitan University for tomorrow

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Energy	• Biomass. • Wind power. • Solar power.	• Tangible determination: o NPV • Intangible determination: o Building the middle class; o Building and sustaining leadership and partnerships o Fostering state level policy reform	o Enables one to assess cash flows of each project along with associated discounts. o Ensuring that each job within the identified intervention promotes sufficient wages and benefits, the scale to which employment within each component of the respective themes is outsourced or not. o How interventions within the respective themes will achieve smart growth and how interventions are able to contribute to improved service delivery at reduced cost. o How interventions within the respective themes are able to contribute to creating the demand for green innovation.
Food supply	• Urban agriculture scheme modelled on Cuban 'organoponicos' scheme.	• Tangible determination: o Profitability index • Intangible determination: o Building the middle class	• The acceptance or rejection of urban agriculture schemes may be measured due to the individualistic nature of the interventions. • Ensuring that each job within the identified intervention promotes sufficient wages and benefits. • The scale to which employment within each component of the respective themes is outsourced or not. Limiting outsourced employees will be viewed as contributing to building the middle class. • The scale to which the workplace within each component of the respective themes is pro-family. Increased pro-family orientation will be viewed as contributing to building the middle class.

COMPONENTS WITHIN THE THEMES (cont.)

Nelson Mandela Metropolitan University
for tomorrow

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Solid waste	• Property close systems. • Drop off systems. • Mandatory versus voluntary programmes.	• Tangible determination: o Discounted payback period o NPV • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Fostering state level policy reform	• Cost of capital is considered in conjunction with discounted values of expected future cash inflows • Assess cash flows of the project along with associated discounts. • Ensure equity of access with respect to opportunity and services. • Solid waste related interventions can to contribute to creating the demand for green innovation.
Building materials	• GBCSA's material assessment component.	• Tangible determination: o Discounted payback period • Intangible determination: o Integrating newly arriving communities and addressing racial disparities o Fostering state level policy reform	• Cost of capital is considered in conjunction with discounted values of expected future cash inflows • Ensure equity of access with respect to opportunity and services. • Building material related interventions can to contribute to creating the demand for green innovation.

COMPONENTS WITHIN THE THEMES (cont.)

Nelson Mandela Metropolitan University for tomorrow

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Air pollution	• Electric vehicles.	• Tangible determination: o Profitability index • Intangible determination: o Leveraging public resources and assets for private investment o Fostering state level policy reform	• The acceptance or rejection of electric vehicle interventions may be measured due to the individualistic nature of the intervention. • The theme of electric vehicles involves a range of stakeholders that will require collaborative efforts and quality standards • Electric vehicle interventions can contribute to creating the demand for green innovation.
Health care	• Responsive clinics. • Access to clinic based on proportion of people with a certain radius of the clinic.	• Tangible determination: o Average return method o IRR • Intangible determination: o Integrating newly arriving communities and addressing racial disparities	• Will be utilised in comparing investments wherein the project lifespans are more or less the same. • The measure can be utilised for simple acceptance / rejection problems. • The theme of health care plays a critical role in contributing to the development of mixed income districts and equity of access with respect to opportunity and services.

COMPONENTS WITHIN THE THEMES (cont.)

Nelson Mandela Metropolitan University

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASSUREMENT CRITERIA
Biodiversity	• Adjacent landscapes interventions. • City interventions. • City sector interventions. • Individual lot interventions.	• Tangible determination: o Average return method o IRR • Intangible determination: o Leveraging public resources and assets for private investment o Building and sustaining leadership and partnerships	• Will be utilised in comparing investments wherein the project lifespans are more or less the same. • The measure can be utilised for simple acceptance / rejection problems. • Involves a range of stakeholders that will require collaborative efforts and quality standards. • Biodiversity can contribute to smart growth and improved service delivery at a reduced cost.
Child centred development	• Shared formal learning facilities. • Informal learning facilities.	• Tangible determination: o Average return method o IRR • Intangible determination: o Integrating newly arriving communities and addressing racial disparities	• Will be utilised in comparing investments wherein the project lifespans are more or less the same. • The measure can be utilised for simple acceptance / rejection problems. • The theme of child centred development plays a critical role in contributing to the development of mixed income districts and equity of access with respect to opportunity and services.

EXAMPLES OF POSSIBLE EVENTUAL FINANCING MECHANISMS / TOOLS

Nelson Mandela Metropolitan University for tomorrow

Examples of funding mechanisms and tools:

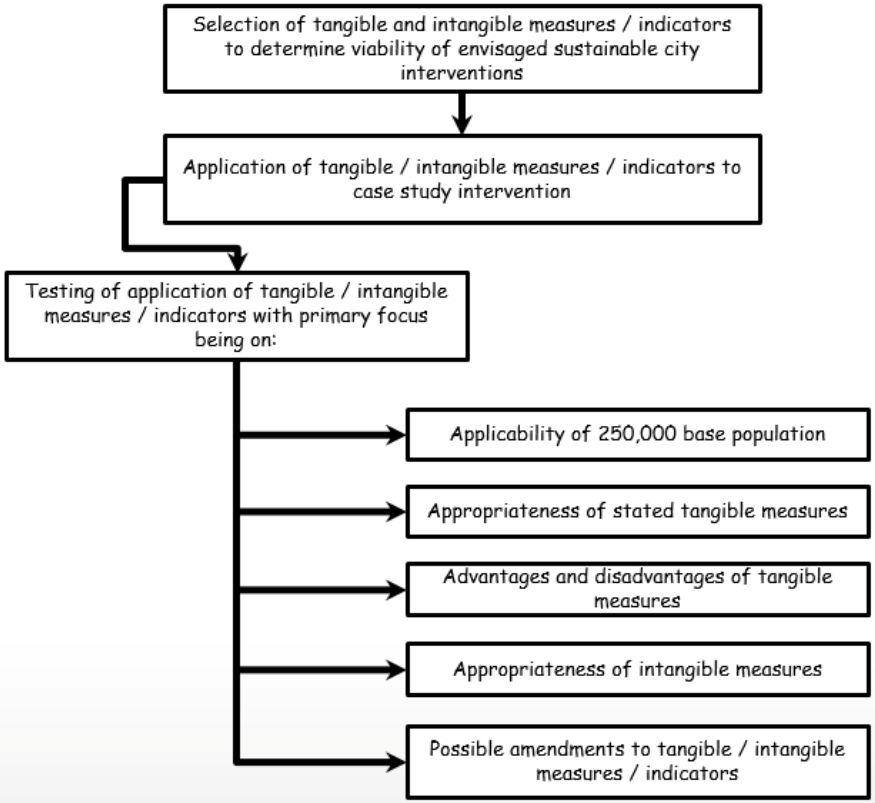
- Management grants
- Inverse auctions
- Land acquisition
- Offsetting
- Crowd funding
- Rates and taxes- slant to sustainability
- PPP
- Bonds
- Visitor payback
- Trading schemes
- Infrastructure reserve
- Bulk contributions- increased density
- Social entrpreneurship
- Etc.

NB:

- Schemes within schemes!!!!!!
- Key- organisation and participation

TESTING OF TANGIBLE / INTANGIBLE APPROACH

Nelson Mandela Metropolitan University
for tomorrow



TESTING OF TANGIBLE / INTANGIBLE APPROACH- PV POWER

Nelson Mandela Metropolitan University for tomorrow

THEME	INTERVENTION IN RELATION TO THE COMPONENTS OF SUSTAINABLE CITY DEVELOPMENT	TANGIBLE AND INTANGIBLE ASSESSMENT CRITERIA	RATIONALE FOR MEASUREMENT CRITERIA
Energy	• Photovoltaic power	• Tangible determination: o NPV	o Enables one to assess cash flows of each project along with associated discounts.
		• Intangible determination: o Building the middle class;	o Ensuring that each job within the identified intervention promotes sufficient wages and benefits, the scale to which employment within each component of the respective themes is outsourced or not.
		o Building and sustaining leadership and partnerships	o How interventions within the respective themes will achieve smart growth and how interventions are able to contribute to improved service delivery at reduced cost.
		o Fostering state level policy reform	o How interventions within the respective themes are able to contribute to creating the demand for green innovation.

RESULTS

Nelson Mandela Metropolitan University
for tomorrow

TANGIBLE:

Energy Costs NMBM vs SSP Year 1-10												
Year		PPA	NMBM Increase		NMBM		NMBM - PPA		Cumulative Saving (Break-even Analyses)		Annual Savings NPV
1	R	274,992,000	0%	R	161,760,000	R	-113,232,000	R	-113,232,000	R	-113,232,000
2	R	291,168,000	15%	R	186,024,000	R	-105,144,000	R	-218,376,000	R	-98,726,761
3	R	308,961,600	15%	R	213,927,600	R	-95,034,000	R	-313,410,000	R	-83,787,608
4	R	326,755,200	15%	R	246,016,740	R	-80,738,460	R	-394,148,460	R	-66,839,261
5	R	347,784,000	15%	R	282,919,251	R	-64,864,749	R	-459,013,209	R	-50,420,867
6	R	367,195,200	14%	R	322,527,946	R	-44,667,254	R	-503,680,463	R	-32,601,773
7	R	389,841,600	13%	R	364,456,579	R	-25,385,021	R	-529,065,484	R	-17,397,221
8	R	414,105,600	12%	R	408,191,369	R	-5,914,231	R	-534,979,715	R	-3,805,845
9	R	438,369,600	11%	R	453,092,419	R	14,722,819	R	-520,256,896	R	8,895,987
10	R	464,251,200	10%	R	498,401,661	R	34,150,461	R	-486,106,435	R	19,375,374
Energy Costs NMBM vs SSP Year 11-20												
11	R	-	10%	R	548,241,827	R	548,241,827	R	62,135,392	R	292,062,695
12	R	-	10%	R	603,066,010	R	603,066,010	R	665,201,402	R	301,661,000
13	R	-	10%	R	663,372,611	R	663,372,611	R	1,328,574,013	R	311,574,741
14	R	-	10%	R	729,709,872	R	729,709,872	R	2,058,283,885	R	321,814,287
15	R	-	10%	R	802,680,859	R	802,680,859	R	2,860,964,745	R	332,390,343
16	R	-	10%	R	882,948,945	R	882,948,945	R	3,743,913,690	R	343,313,970
17	R	-	10%	R	971,243,840	R	971,243,840	R	4,715,157,529	R	354,596,588
18	R	-	10%	R	1,068,368,224	R	1,068,368,224	R	5,783,525,753	R	366,249,997
19	R	-	10%	R	1,175,205,046	R	1,175,205,046	R	6,958,730,799	R	378,286,382
20	R	-	10%	R	1,292,725,551	R	1,292,725,551	R	8,251,456,350	R	390,718,329
Totals	R	3,623,424,000		R	11,874,880,350	R	8,251,456,350		-	R	2,954,128,359

RESULTS

Nelson Mandela Metropolitan University
for tomorrow

INTANGIBLE:

	BUILDING THE MIDDLE CLASS			BUILDING LEADERSHIP AND PARTNERSHIPS		FOSTERING POLICY REFORM
	Equity of wages	Scale of outsourcing	Pro-family orientation	Achievement of smart growth	Improved service delivery at reduced cost	Create demand for green innovation
Photovoltaic energy	Yes	Yes	n/a	Yes	Yes	Yes

QUESTIONS

Nelson Mandela Metropolitan University
for tomorrow

- The interviewee's comment on the selection of stated tangible and intangible measures / indicators as a determining factor in assessing the viability of sustainable city development.
- The interviewee's comment on the application of the stated tangible and intangible measures / indicators to the varying themes and sub components of sustainable city development.
- The interviewee's comment on the applicability of a 250,000 base population as a foundation from which to assess sustainable city development.
- The interviewee's comment on the case study outcome of stated tangible measures of sustainable city development.
- The interviewee's perceived advantages and disadvantages of the stated tangible measures of sustainable city development.
- The interviewee's comment on the case study outcome of stated intangible measures of sustainable city development.
- The interviewee's comment on possible amendments to the stated tangible and intangible measures / indicators to sustainable city development.

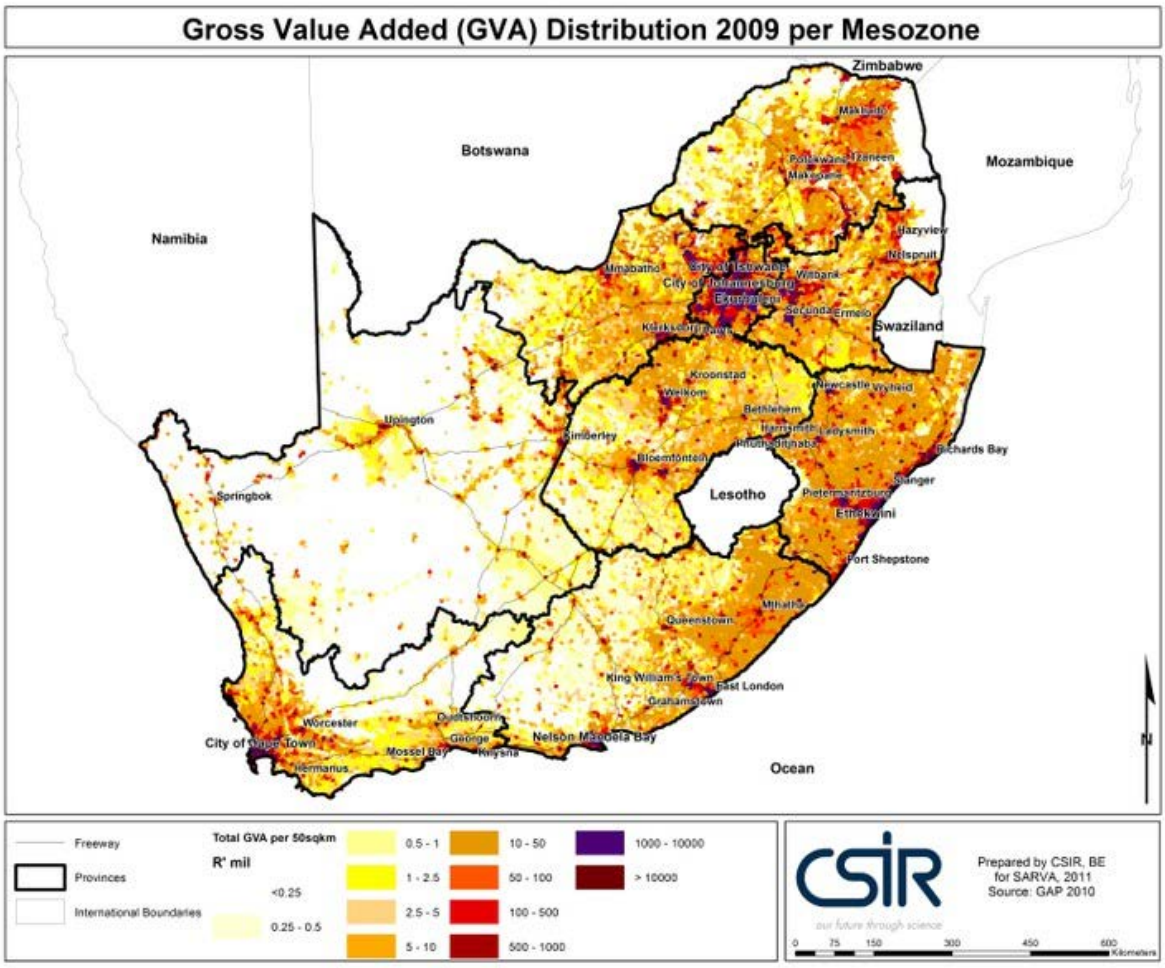
THANK YOU

APPENDIX B: CALCULATIONS AND INFORMATION IN SUPPORT OF TANGIBLE ASSESSMENT OF THE THEMES OF SUSTAINABLE CITY DEVELOPMENT

(i) LOCATION

Gross value addition (GVA) represents the value of goods and services produced within a particular region, industry or sector. Figure B.1 represents the spatial distribution of overall economic activity within South Africa as produced by the CSIR.

Figure B.1: Spatial distribution of economic activity in South Africa, 2004



Source: CSIR (2009)

As depicted in Figure B.1, volume of overall economic activity can be gauged relevant to varying locations across South Africa. As illustrated in Figure B.1, predominant economic activity within South Africa is concentrated amongst those areas shaded

from orange to brown. By implication demands on infrastructure services and ecosystem services will be higher in those areas given the existing economic base along with the future developmental potential. For the purposes of this study, the envisaged hypothetical city of 250,000 inhabitants should ideally be located within the periphery of those areas shaded orange to brown given the current and future economic development potential to support such growth. As such the assessment of the tangible measure of appropriate location is pre-determined given the existing economic activity within a given area.

(ii) WATER: RAINWATER HARVESTING

A rainwater harvesting system typically consists of a collection system, a conveyance system and a storage system. Collection systems range from simple household systems to systems that form part of larger water treatment plants. For the purposes of this study a simple household roof water collection system will apply. According to UN-Habitat (2009), determining the performance of rainwater catchment systems stems from the use of a runoff coefficient wherein catchment is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface. Calculating the runoff coefficient assists in determining the collection efficiency of the rainwater harvesting system. UN-Habitat (2009) depicts the following runoff coefficients for various catchment surfaces as illustrated in Table B.1.

Table B.1: Water catchment coefficients

Type of Catchment	Coefficient
Roof catchments:	
Tiles	0.8 – 0.9
Corrugated metal sheets	0.7 – 0.9
Ground surface coverings:	
Concrete	0.6 – 0.8
Brick pavement	0.5 – 0.6
Untreated ground catchments:	
Soil on slopes less than 10%	0.0 – 0.3
Rocky natural catchments	0.2 – 0.5
Green area	0.05 – 0.10

Source: UN-Habitat (2009)

Given that for the purposes of this study, a household roof water collection would apply the category of catchment applicable, and associated coefficient, would relate to roof catchments as contained within Table B.1. Furthermore, a conservative coefficient of 0.7 would be applied.

For the purposes of this study, the average catchment area per dwelling, within a base population of 250,000, was 100m². Utilising the city of Port Elizabeth within South Africa as a point of reference, average annual rainfall equates to 510,2mm per annum (Statistics South Africa, 2005). The potential for annual rainwater harvesting from a 100m² catchment area on an individual dwelling is depicted through the following calculation.

100 x 0.5102 = 51.02

= 51,020 litres

Potential volume of water harvested= 51,020 litres x 0.7 = 35,714 litres per annum

As such, a catchment area of 100m² on an individual dwelling within the Port Elizabeth area, has the potential of harvesting 35,714 litres per annum based on a catchment coefficient of 0.7.

Current (2017) water supply rates within the municipal jurisdiction are depicted in Table B.2.

Table B.2: Water supply rates within the municipal jurisdiction of Port Elizabeth (per kl)

Water Supply	Rate
1. Treated water for residential premises: • Up to 1 kl/d • Next 1 kl/d • Additional Consumption (per kl)	 • R 5.43 • R 6.81 • R 8.16
2. Treated water for commercial and institutional premises, including municipal and government departments (per kl)	• R 4.76
3. Treated water for industrial premises (per kl)	• R 4.76
4. Treated water for multiple dwelling units per dwelling unit: • Up to 1 kl/d • Next 1 kl/d • Additional Consumption (per kl)	 • R4.76 • R5.97 • R7.16
5. Treated water for irrigation of sports grounds, where reclaimed effluent is not available	• R 4.76
6. Treated water drawn trough standpipes (per kl)	• R 7.16
7. Raw water for residential premises (per kl) • Up to 1 kl/d • Next 1 kl/d • Additional Consumption	 • R 3.83 • R 4.76 • R 5.72
8. Raw water for commercial premises (per kl)	• R 3.83
9. Raw water for industrial premises (per kl)	• R 3.83

Source: Nelson Mandela Bay Municipality (2016)

As depicted in Table B.2 the current (2016) supply rate for treated water to residential premises equates to R5.43 per kilo litre.

A typical 5000 litre above ground rainwater harvesting system wherein water is harvested from a 150m² roof to be utilised for the purposes of general washing, flushing of toilets and other general non-potable water applications would cost between R15,000 and R20,000 to install. The applicable system would be a pressurised system wherein a pump switches on and off dependent on the relevant water demand at the time.

Given the stated application of use, the following parameters would apply to an envisaged rainwater harvesting system relevant to an individual household. Table B.3 illustrates the assumptions and variables that shall apply to an envisaged individual household rainwater harvesting system.

Table B.3: Assumptions and variables to an envisaged individual household rainwater harvesting system

Assumptions and Variables	
Annual water harvested	35,714 litres per annum
Municipality water supply rate	R5.43 per kilo litre
Initial investment	R15,000.00
Annual cashflow	R195.00
Increase per annum	8%
Discount rate	10%

Source: Author's own compilation

As depicted in Table B.3, it is assumed that 35,714 litres per annum would be harvested from a household's individual rainwater harvesting system. This equates to a R195.00 saving in potable municipal water supply in year 1.

Table B.4 depicts the payback period utilising the assumptions as contained within Table B.3.

Table B.4: Discounted payback period- individual household rainwater harvesting system

YEAR	CASH FLOW	NET CASH FLOW	DISCOUNTED CASH FLOW	NET DISCOUNTED CASH FLOW
Year 0	-R15,000.00	-R15,000.00	-R15,000.00	-R15,000.00
Year 1	R195.00	-R14,805.00	R177.27	-R14,822.73
Year 2	R210.60	-R14,594.40	R174.05	-R14,648.68
Year 3	R227.45	-R14,366.95	R170.89	-R14,477.79
Year 4	R245.64	-R14,121.31	R167.78	-R14,310.01
Year 5	R265.30	-R13,856.01	R164.73	-R14,145.29
Year 6	R286.52	-R13,569.49	R161.73	-R13,983.55
Year 7	R309.44	-R13,260.05	R158.79	-R13,824.76
Year 8	R334.20	-R12,925.86	R155.90	-R13,668.86
Year 9	R360.93	-R12,564.93	R153.07	-R13,515.79
Year 10	R389.81	-R12,175.12	R150.29	-R13,365.50
Year 11	R420.99	-R11,754.13	R147.55	-R13,217.95
Year 12	R454.67	-R11,299.46	R144.87	-R13,073.07
Year 13	R491.04	-R10,808.42	R142.24	-R12,930.84
Year 14	R530.33	-R10,278.098	R139.65	-R12,791.19
Year 15	R572.75	-R9,705.34	R137.11	-R12,654.07
Year 16	R618.57	-R9,086.76	R134.62	-R12,519.45
Year 17	R668.06	-R8,418.71	R132.17	-R12,387.28
Year 18	R721.50	-R7,697.20	R129.77	-R12,257.51
Year 19	R779.22	-R6,917.98	R127.41	-R12,130.10
Year 20	R841.56	-R6,076.42	R125.09	-R12,005.01

Source: Author's own compilation

(iii) WATER: GREY WATER

According to NSW (2008), an average sewered single household, of three occupants per household, utilises 825 litres of water each day or approximately 300,000 litres per year. This would equate to approximately 339 litres of grey water per house per day. The reuse of grey water within a household has the potential to save between 50,000 and 100,000 litres of drinking water per year.

Given the stated application of use, the following parameters would apply to an envisaged grey water system relevant to an individual household. Table B.5 illustrates the assumptions and variables that shall apply to an envisaged individual household grey water harvesting system.

Table B.5: Assumptions and variables to an envisaged individual household grey water system

Assumptions and Variables	
Annual drinking water saved	100,000 litres per annum
Municipality water supply rate	R5.43 per kilo litre
Initial investment	R11,800.00
Annual cashflow	R1,629.00
Increase per annum	8%
Discount rate	10%

Source: Author's own compilation

As depicted in Table B.5, it is assumed that 100,000 litres of drinking water per annum would be saved from a household's individual grey water system. This equates to a R1,629.00 saving in potable municipal water supply in year 1.

Table B.6 depicts the discounted payback period utilising the assumptions as contained within Table B.5.

Table B.6: Discounted payback period- individual household grey water system

YEAR	CASH FLOW	NET CASH FLOW	DISCOUNTED CASH FLOW	NET DISCOUNTED CASH FLOW
Year 0	-R11,800.00	-R11,800.00	-R11,800.00	-R11,800.00
Year 1	R1,629.00	-R10,171.00	R1,480.91	-R10,319.09
Year 2	R1,759.32	-R8,411.68	R1,453.98	-R8,865.11
Year 3	R1,900.07	-R6,511.61	R1,427.55	-R7,437.56
Year 4	R2,052.07	-R4,459.54	R1,401.59	-R6,035.97
Year 5	R2,216.24	-R2,243.31	R1,376.11	-R4,659.86
Year 6	R2,393.54	R150.23	R1,351.09	-R3,308.77
Year 7	R2,585.02	R2,735.25	R1,326.52	-R1,982.25
Year 8	R2,791.82	R5,527.07	R1,302.40	-R679.84
Year 9	R3,015.17	R8,542.23	R1,278.72	R598.88
Year 10	R3,256.38	R11,798.61	R1,255.47	R1,854.36
Year 11	R3,516.89	R15,315.50	R1,232.65	R3,087.00
Year 12	R3,798.24	R19,113.74	R1,210.24	R4,297.24
Year 13	R4,102.10	R23,215.84	R1,188.23	R5,485.47
Year 14	R4,430.27	R27,646.11	R1,166.63	R6,652.10
Year 15	R4,784.69	R32,430.79	R1,145.42	R7,797.52
Year 16	R5,167.46	R37,598.26	R1,124.59	R8,922.11
Year 17	R5,580.86	R43,179.12	R1,104.14	R10,026.25
Year 18	R6,027.33	R49,206.45	R1,084.07	R11,110.32
Year 19	R6,509.52	R55,715.96	R1,064.36	R12,174.68
Year 20	R7,030.28	R62,746.24	R1,045.01	R13,219.68

Source: Author's own compilation

(iv) WATER: RECLAIMED WATER

In terms of the Durban water recycling project, a water recycling plant was commissioned in 2001 that was designed to treat 47.5 Ml/d of domestic and industrial wastewater to a near potable standard for sale to industrial consumers (Gisclon, McCarthy & McNally, 2002). The cost of the project, funded by the private sector equated to R74 million in 2001.

Given the stated application of use, the following parameters would apply to an envisaged reclaimed water system relevant to the parameters as contained within the Durban water recycling project. Table B.7 illustrates the assumptions and variables that shall apply to an envisaged reclaimed water system. The cost of the system was extrapolated to 2016 figures utilising a cumulative inflation rate of six percent per year.

Table B.7: Assumptions and variables to an envisaged municipal reclaimed water project

Assumptions and Variables	
Annual potable water saved	17,337.50 mega litres per annum based on estimates from the Durban water recycling project, Gisclon *et al.,* 2002)
Municipality water supply rate	R5.43 per kilo litre
Initial investment	R177 million (based on a cumulative inflation rate of six percent per year from the base year of 2001 at R74 million)
Annual cashflow	R37,657,050
Increase per annum	8%
Discount rate	10%

Source: Author's own compilation

As depicted in Table B.7, it is assumed that 17,337.50 mega litres of drinking water per annum would be saved from a potential reclaimed water project system based on the parameters of Durban's water recycling project implemented in 2001. This equates to a R37,657,050 saving in potable municipal water supply in year 1.

Table B.8 depicts the discounted payback period utilising the assumptions as contained within Table B.7.

Table B.8: Discounted payback period- municipal reclaimed water project

YEAR	CASH FLOW	NET CASH FLOW	DISCOUNTED CASH FLOW	NET DISCOUNTED CASH FLOW
Year 0	-R177,000,000.00	-R177,000,000.00	-R177,000,000.00	-R177,000,000.00
Year 1	R37,657,050.00	-R139,342,950.00	R34,233,681.82	-R142,766,318.18
Year 2	R40,669,614.00	-R98,673,336.00	R33,611,251.24	-R109,155,066.94
Year 3	R43,923,183.12	-R54,750,152.88	R33,000,137.58	-R76,154,929.36
Year 4	R47,437,037.77	-R7,313,115.11	R32,400,135.08	-R43,754,794.28
Year 5	R51,232,000.79	R43,918,885.68	R31,811,041.71	-R11,943,752.57
Year 6	R55,330,560.85	R99,249,446.54	R31,232,659.14	R19,288,906.57
Year 7	R59,757,005.72	R159,006,452.26	R30,664,792.61	R49,953,699.18
Year 8	R64,537,566.18	R223,544,018.44	R30,107,250.92	R80,060,950.10
Year 9	R69,700,571.48	R293,244,589.91	R29,559,846.36	R109,620,796.46
Year 10	R75,276,617.19	R368,521,207.11	R29,022,394.61	R138,643,191.07
Year 11	R81,298,746.57	R449,819,953.68	R28,494,714.71	R167,137,905.78
Year 12	R87,802,646.29	R537,622,599.97	R27,976,628.99	R195,114,534.77
Year 13	R94,826,858.00	R632,449,457.97	R27,467,963.00	R222,582,497.77
Year 14	R102,413,006.64	R734,862,464.60	R26,968,545.50	R249,551,043.27
Year 15	R110,606,047.17	R845,468,511.77	R26,478,208.30	R276,029,251.57
Year 16	R119,454,530.94	R964,923,042.71	R25,996,786.34	R302,026,037.91
Year 17	R129,010,893.42	R1,093,933,936.13	R25,524,117.49	R327,550,155.40

YEAR	CASH FLOW	NET CASH FLOW	DISCOUNTED CASH FLOW	NET DISCOUNTED CASH FLOW
Year 18	R139,331,764.89	R1,233,265,701.02	R25,060,042.63	R352,610,198.03
Year 19	R150,478,306.08	R1,383,744,007.10	R24,604,405.49	R377,214,603.52
Year 20	R162,516,570.57	R1,546,260,577.67	R24,157,052.66	R401,371,656.18

Source: Author's own compilation

(v) SANITATION

Table B.9: Discounted lifetime costs of centralised and decentralised sanitation systems (€)

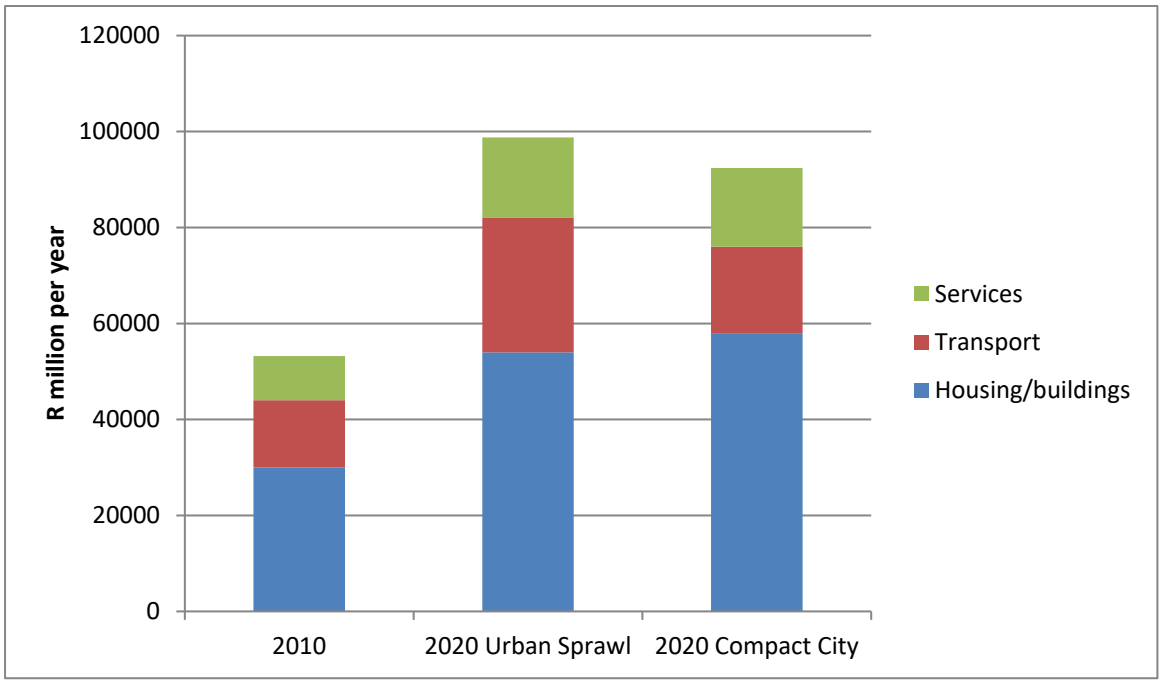
			Conventional (Centralised)			Source Separated			Hybrid		
Expenses	**Scale**		**CAPEX**	**OPEX**	**Share**	**CAPEX**	**OPEX**	**Share**	**CAPEX**	**OPEX**	**Share**
Sewer	Neighbourhood	Neighbourhood connection and public sewer	22,289,000	226,000	45%	27,248,000	1,926,000	49%	44,404,000	432,000	50%
		Private sewer	18,826,000	210,000	38%	23,940,000	1,957,000	44%	37,653,000	402,000	43%
	District	District backbone	1,793,000	18,000	4%	2,189,000	155,000	4%	1,790,000	17,000	2%
		Pumping station	1,331,000	392,000	3%	1,353,000	298,000	3%	773,000	376,000	1%
	City	Inter district pipe	2,311,000	23,000	5%	-	-	0%	1,387,000	111,000	2%
		District connection	25,000	5,000	0%	-	-	0%	25,000	5,000	0%
		Area backbone	2,382,000	123,000	5%	-	-	0%	1,678,000	118,000	2%
	Sub-total sewers		48,957,000	997,000		54,730,000	4,336,000		87,710,000	1,461,000	
	Total		49,953,000		59%	59,065,000		69%	89,170,000		62%
Treatment			12,240,000	22,216,000		16,131,000	10,754,000		22,283,589	31,799,663	
	Total		34,456,000		41%	26,885,000		31%	54,083,000		38%
Total overall			84,410,000		100%	85,950,000		100%	143,254,000		100%

Source: Hutton and Haller (2004)

(vi) COMPACT CITIES

The graphical depiction of total recurrent costs for a hypothetical city is illustrated in Figure B.2.

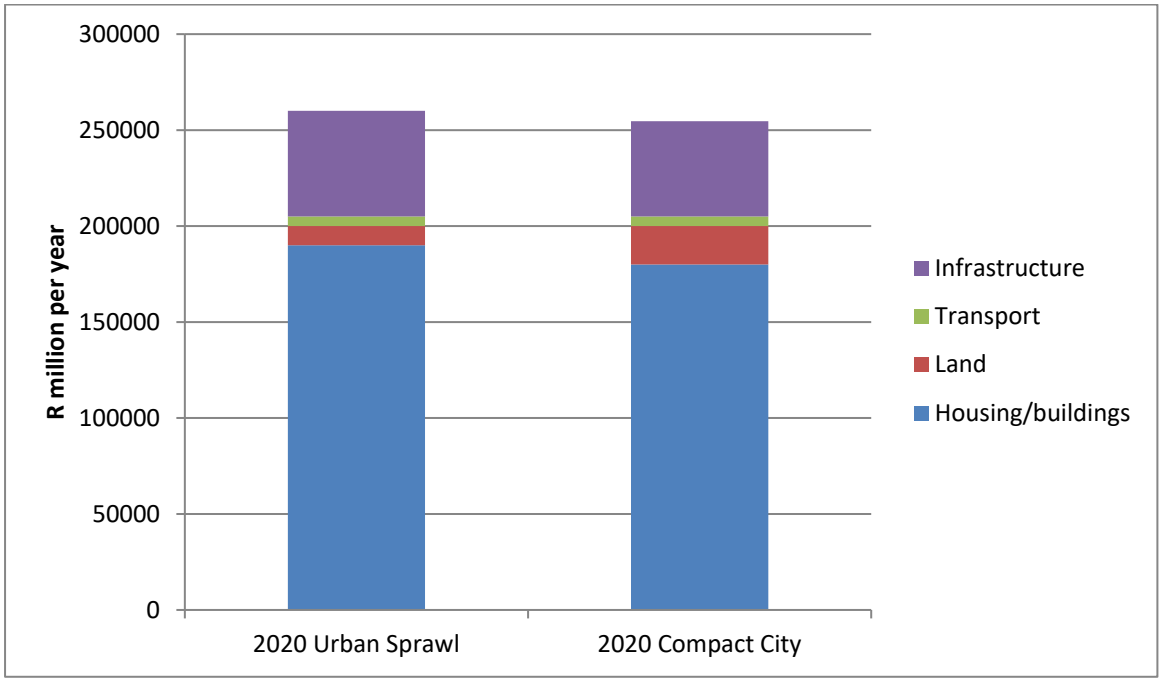
Figure B.2: Total recurrent cost for the hypothetical city (R million)



Source: Berrisford (2012)

The graphical depiction of total capital costs for a hypothetical city is illustrated in Figure B.3.

Figure B.3: Total capital cost over a ten year period for an urban sprawl city versus a compact city (R million)



Source: Berrisford (2012)

(vii) PUBLIC TRANSPORT

Table B.10: Net present value of public transportation capital investment and vehicle operating cost savings for selected scenarios

SCENARIO AND GROWTH RATE OF RIDERSHIP	NPV OVER 2010-2050, IN $BILLIONS	
	PUBLIC TRANSPORTATION CAPITAL INVESTMENT	SAVINGS IN VEHICLE OPERATING AND FUEL COSTS
Current trend scenario: 2.45% growth / year	$255	$136
Doubling ridership scenario: 3.53% growth / year	$503	$282
High growth scenario: 4.67% growth / year	$1,197	$612

Source: American Public Transport Association (2014)

(viii) ENERGY: BIOMASS

Table B.11: Cumulative NPV for bio-electricity using Rooikrans woody biomass

YEAR	DEA DH (ZAR/year)	DEA DH+ (ZAR/year)	Baseline Case: Do nothing (ZAR/year)
2008	0	0	0
2009	0	0	-6,370,788
2010	0	0	-20,033,358
2011	0	0	-28,273,592
2012	0	0	-34,212,656
2013	0	0	-39,010,304
2014	0	0	-49,860,064
2015	0	0	-53,067,416
2016	0	0	-57,588,208
2017	0	0	-61,853,108
2018	4,763,531	6,108,945	-61,853,108
2019	9,257,428	11,872,110	-61,853,108
2020	13,496,954	17,309,054	-61,853,108
2021	17,496,508	22,438,246	-61,853,108
2022	21,269,672	27,277,108	-61,853,108
2023	24,829,260	31,842,072	-61,853,108
2024	28,187,362	36,148,640	-61,853,108
2025	31,355,384	40,211,440	-61,853,108
2026	34,344,084	44,044,272	-61,853,108
2027	37,163,612	47,660,152	-61,853,108
2028	39,823,544	51,071,360	-61,853,108
2029	42,332,916	54,289,480	-61,853,108
2030	44,700,248	57,325,444	-61,853,108

Source: Mudavanhu *et al.* (2016)

(ix) ENERGY: WIND POWER

The overall parameters of the wind farm at Jeffreys Bay is depicted in Table B.12

Table B.12: Parameters of Jeffreys Bay wind farm

CHARACTERISTIC	VALUE
Name	Kouga Wind Energy Project
Location	Sunnyside Dairy Farm, Jeffreys Bay
Installed capacity	15MW
Project life	25 years
No. of turbines (turbine capacity)	8(2MW) to 30(500kW)
Area required	20ha
Turbine height	75m
Blade length	45m
Annual capacity factor	30%
Electricity production	21462MWh
CO2 off-set	545000 tonnes

Source: Menzies (2010)

As illustrated in Table B.12, the wind farm occupies 20ha with an energy production capacity of 15MW.

Table B.13 illustrates the net present value of the project. A 3% discount rate was applied over a project lifespan of twenty-five years.

Table B.13: Summary of cost benefit analysis decision criteria

Proposed Kouga Wind Energy Project: Jeffreys Bay	CBA criteria (at social discount rate of 3%)		
	NPV	IRR	BCR
	R108,273,903.67	11%	1.512

Source: Menzies (2010)

(x) URBAN AGRICULTURE

Table B.14: Net present value and total value at each horizon year

Year	NPV Cashflows	PV Horizon Value	Total Value
5	$(15,085)	$148,522	$133,436
10	$50,175	$91,465	$141,640
15	$87,778	$60,687	$148,465
20	$115,333	$36,525	$151,858

Source: Ganguly *et al.* (2011)

(xi) SOLID WASTE

Table B.15: Net present value ranking of solid waste recycling options

Option	NPV Ranking %
2	36
3	17
5	25
6	11
8	7
10	4

Source: De Beer (2013)

(xii) GREEN BUILDINGS

Table B.16: Net present values of the varying categories of green buildings

CATEGORY	20 YEAR NPV / SQ. FT.
Reduced energy consumption	$5.79
Emissions reduction	$1.18
Water consumption savings	$0.51
Reduced waste	$0.03
Operations and maintenance savings	$8.47
Productivity and health gains	$36.89 to $55.33
Cost premium for green buildings (2%)	($4.00)
Total 20 year NPV	$48.87 to $67.31

Source: University of Michigan (2005)

Table B.17: Net present value of varying residential housing developments

UNIT NAME	NUMBER OF UNITS	RESIDENT / HOMEOWNER NPV	REBATES / GRANTS FOR GREENING	DEVELOPER / OWNER NPV AFTER REBATES	COMBINED NPV
20th Street	34	$6,460	$1,100	-$507	$5,954
Arroyo Chico	17	$7,820	$0	$0	$7,782
Betty Ann	76	$6,919	$592	$789	$7,709
Brick Capital	5	-$140	$0	$0	-$140
CAST	42	$1,962	$1,382	$1,027	$2,990
Colorado Court	44	$0	$12,626	$5,673	$5,673
Erie Ellington	50	$23,451	$1,326	$34,764	$58,215
Emeryville	3	$11,506	$7,202	$0	$11,506
Johnson Creek	15	$9,953	$1,013	-$1,842	$8,110

UNIT NAME	NUMBER OF UNITS	RESIDENT / HOMEOWNER NPV	REBATES / GRANTS FOR GREENING	DEVELOPER / OWNER NPV AFTER REBATES	COMBINED NPV
Linden	42	$59,861	$1,200	$8,031	$67,892
Melrose	90	$36,721	$0	-$306	$36,415
New Homes	25	$13,702	$10,640	-$4,012	$9,690
Positive Match	7	$1,497	$0	-$9,730	-$8,233
Riverwalk	52	$15,213	$3,692	$3,904	$19,117
Traugott	50	$1,211	$1,405	$7,829	$9,040
Woodlawn	10	$6,064	$2,900	-$2,015	$4,049
Mean		$12,637	$2,817	$2,725	$15,363
Median		$7,370	$1,263	$0	$7,965
Benefits outweigh costs		14		7	14
Costs outweigh benefits		1		6	2
Benefits equal costs		1		3	0

Source: Bradshaw *at al.* (2005)

(xiii) AIR POLLUTION

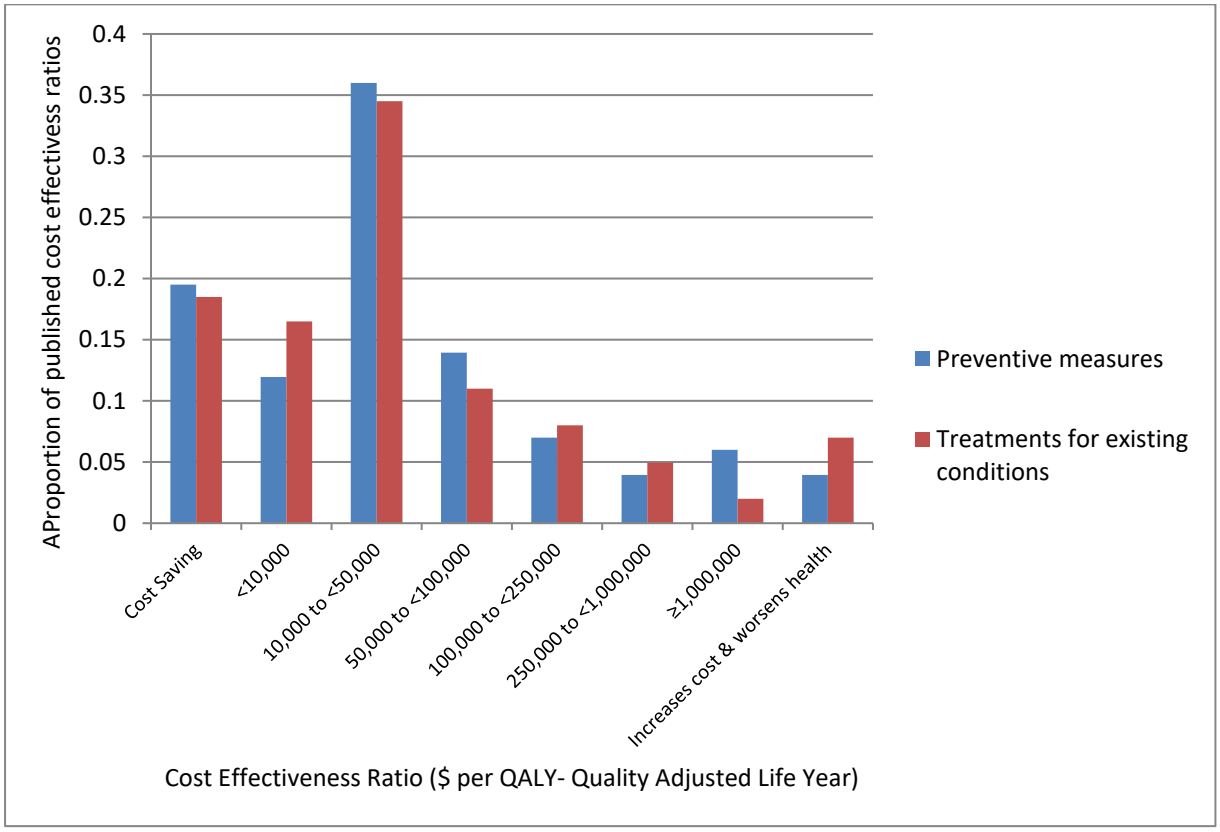
Table B.18: Net present value of electric vehicle with associated government interventions

SCENARIO	BASELINE		FREE ELECTRICITY		BUY-BACK SCHEME		CONCESSIONAL LOAN	
Discount	5%	7%	5%	7%	5%	7%	5%	7%
NPV	80850	49829	140057	104856	319385	288211	306048	286496

Source: Zhu *et al.* (2016)

(xiv) HEALTH CARE

Figure B.4: Distribution of cost effectiveness ratios for preventive measures and treatments for existing conditions



Source: Cohen *et al.* (2008)

(xv) BIODIVERSITY

Table B.19: Recreational value from green open spaces

	CONTINGENT VALUATION (Rand/ha)		HEDONIC PRICING (Rand/ha)
	METRO S	METRO SE	METRO SE
Parks	5,220	4,100	134,365
Sports fields	26,288	47,139	25,217
Natural vegetation	9,128	1,501	
Vacant land	1,316	408	-7,840
Agricultural fields	74,355	1,207	

Source: Gauteng City Region Observatory (2013)

Table B.20: Indicative values per hectare per year for open space type in the City of Johannesburg

	2013 VALUE IN R/HA/YR		
	Low Estimate	Medium Estimate	High Estimate
Parks	R3,926	R4,462	R4,999
Sports fields	R25,173	R35,156	R45,139
Natural vegetation	R1,438	R5,089	R8,741
Vacant lands	R390	R825	R1,260
Wetlands	R3,127	R5,166	R7,203
Bird sanctuary	R4,776	R7,164	R9,552
Cemetery	R914	R1,371	R1,828
Deport	R390	R586	R781
Flagship road island	R914	R1,371	R1,828
Environmental conservation development	R4,508	R6,762	R9,015
In estate	R3,926	R5,889	R7,852
Informal settlement	R825	R1,238	R1,651

	2013 VALUE IN R/HA/YR		
	Low Estimate	**Medium Estimate**	**High Estimate**
Main arterial	R914	R1,371	R1,828
Main road	R914	R1,371	R1,828
Nature reserve	R4,462	R6,694	R8,925
Nursery	R2,957	R4,436	R5,914
Park- developed smaller parks	R4,462	R6,694	R8,925
Park- flagship	R4,462	R6,694	R8,925
Park- as yet undeveloped	R2,957	R4,436	R5,914
Park- as yet undeveloped (not actively managed)	R1,132	R1,697	R2,263
River	R3,302	R4,953	R6,604
Road island	R2,957	R4,436	R5,914
Sidewalk	R2,957	R4,436	R5,914
Sidewalk (not actively managed)	R390	R586	R781
Sport	R35,156	R52,734	R70,312
Town entrance	R2,957	R4,436	R5,914
Water body	R5,128	R7,692	R10,255
Zoo	R4,462	R6,694	R8,925

Source: Gauteng City Region Observatory (2013)

(xvi) CHILD-CENTRED DEVELOPMENT

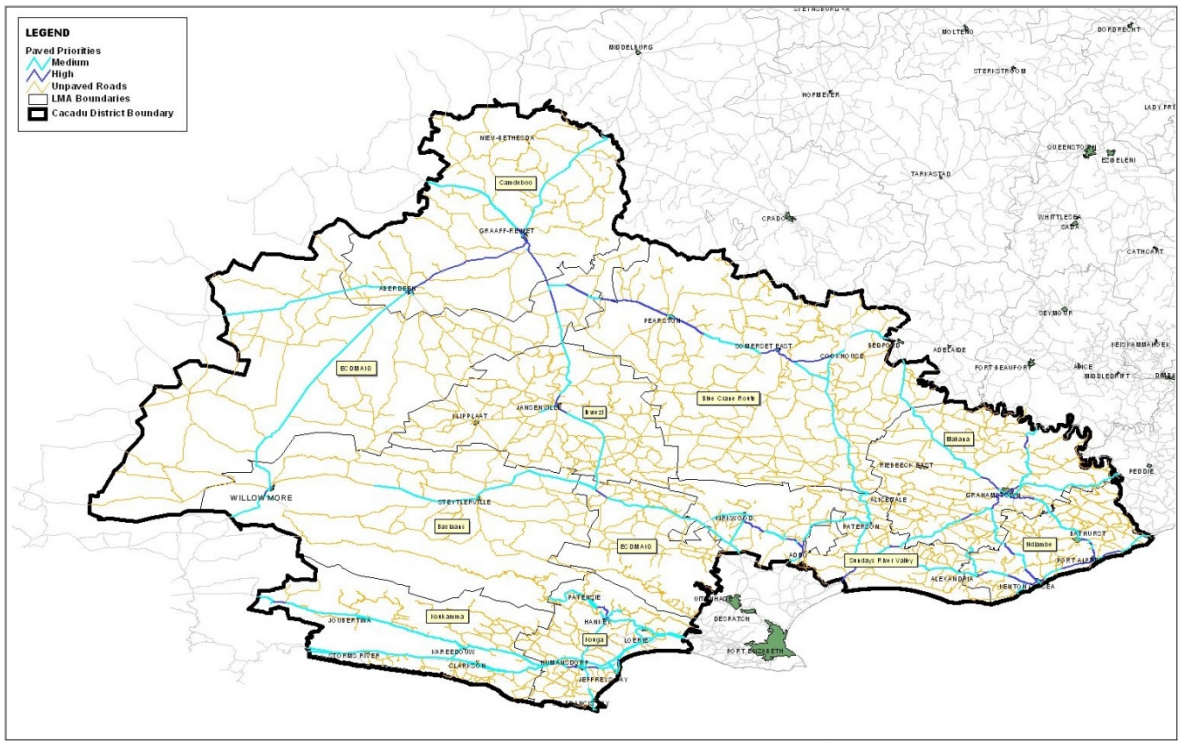
Table B.21: Comparison of South African estimates of the output elasticities and rates of return on infrastructure / public capital

YEAR	INFRASTRUCTURE MEASURE ON ECONOMIC GROWTH	ECONOMETRIC TECHNIQUE	OUTPUT ELASTICITY	RATE OF RETURN
(1995)	Public authorities capital stock	OLS	0.33	0.23
	Public sector capital stock	OLS	0.17	0.20
(1998)	Public sector infrastructure stock	OLS	0.30	0.24
(1998)	Public authorities capital stock	OLS	0.25	0.28
		Co-integration	0.30	0.33
	Public sector capital stock	OLS	0.15	0.9
		Co-integration	0.28	0.17
	Public sector infrastructure stock	OLS	0.17	0.11
		Co-integration	0.25	0.17
(2005)	Electricity generation	VECM	0.10-0.20 but rising to 0.5 when institutions are controlled for	
(2005)	Infrastructure measures on labour productivity	VECM	Mostly between 0.20-0.40 with some higher outliers	
	Infrastructure measures on Total Factor Productivity	VECM	Very strong negative elasticities (-0.60) with no significant positive elasticities	
(2006)	Electricity generation	VECM	0.20	
	Electricity generation on a measure of equity performance	VECM	0.38	

Source: Fourie (2006)

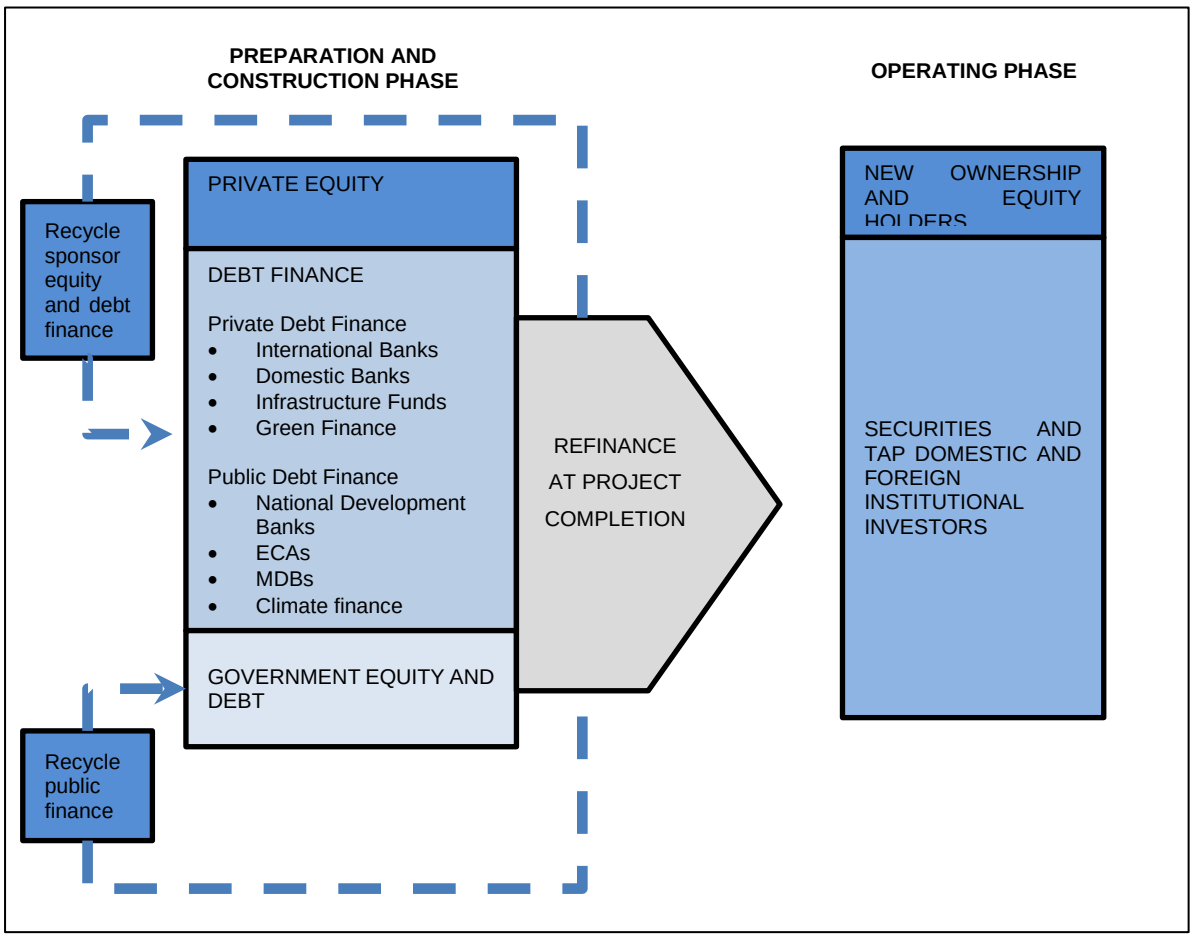
APPENDIX C: INFORMATION AND DATA IN SUPPORT OF PROPOSED FINANCING TOOLS AND INSTRUMENTS

Figure C.1: District road prioritisation based on contribution to GVA and technical engineering criteria



Source: Engineering Advice and Services (2010)

Figure C.2: Infrastructure financing requirements for emerging markets and developing countries



Source: Meltzer (2016)

Table C.1: Possible water compliance programmes

Activity / facility	Restriction
Gardens and lawns	Town water may be used on established gardens using buckets (20 litre maximum capacity) or watering cans that are filled directly from a tap. Sprinklers, hand-held hoses and unattended water devices connected to the town supply cannot be used (some exemptions / concessions apply). Newly-established gardens and lawns may only be watered for one hour on the day of establishment and for one hour each day thereafter for fourteen days. Watering should be carried out with a hand-held hose attached to a trigger or twist nozzle and should take place between 04:00 and 07:00 or between 16:00 and 19:00.
Pools and spas	New pools and spas must not be filled with town water. Owners should use water sourced from rainwater. Existing pool and spa owners will only be able to top up with town water as a last resort, and only when they have used all available water from a rainwater tank or from a downpipe rainwater diverter. Pool and spa owners are also required to have three of the following four water saving devices on the premises: • Swimming pool and / or spa cover • Three-star water efficient showerheads and taps • Dual flush toilets • Four-star water efficient washing machine If the premises do not have a rainwater tank or a downpipe rainwater diverter, then town water is not permitted for topping up pools or spas.
Vehicle washing	Vehicle mirrors, lights, glass surfaces and number plates must only be washed with a bucket filed directly from a tap. Vehicles can also be spot cleaned to remove paint damaging marks. Town water can still be used to flush an inboard or outboard motor or the brakes on a vehicle.

Source: England (2009)

Table C.2: Potential public transport funding options

SCHEME	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Fare increases	Increase fares or change fare structure to increase revenues	Widely applied. Is a user fee (considered equitable).	Discourages transit use. Is regressive.
Discounted bulk passes	Discounted passes sold to groups based on their ridership.	Increases revenue and transit ridership.	Increases transit service costs and so may provide little net revenue.
Property taxes	Increase local property taxes.	Widely applied. Distributes burden widely.	Supports no other objectives. Is considered regressive.
Sales taxes	A special local sales tax.	Distributes burden widely.	Supports no other objectives. Is considered regressive.
Income tax	Special income tax for transit or transportation.	Progressive with respect to income. Relatively stable.	May be difficult to implement.
Fuel taxes	An additional fuel tax in the region.	Widely applied. Reduces vehicle traffic and fuel use.	Is considered regressive.
Vehicle fees	An additional fee for vehicles registered in the region.	Applied in some jurisdictions. Charges motorists for costs.	Does not affect vehicle use.
Utility levy	A levy to all utility account in the region.	Easy to apply. Distributes burden widely.	Is small, regressive and supports no other objectives.
Employee levy	A levy on each employee within a designated area or jurisdiction.	Chargers for commuters.	Requires administration. Encourages sprawl if in city centres.
Road tolls	Tolls on some roads or bridges.	Reduces traffic congestion.	Costly to implement. Can encourage sprawl if only applied in city centres.
Vehicle-km tax	A distance-based fee on vehicles registered in the region.	Reduces vehicle traffic.	Costly to implement.
Parking taxes	Special tax on commercial parking transactions	Is applied in other cities.	Discourages parking pricing and downtown development.

SCHEME	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Parking levy	Special property tax on parking spaces throughout the region	Large potential. Distributes burden widely. Support strategic goals.	Costly to implement. Opposed by suburban property owners.
Expanded parking pricing	Increases when and where public parking facilities (e.g. on-street parking) are priced	Moderate to large potential. Distributes burden widely. Reduces parking and traffic problems.	Requires parking meters and enforcement and imposes transaction costs.
Development or transport impact fees	A fee on new development to help finance infrastructure, including transit improvements	Charges beneficiaries.	Limited potential.
Land value capture	Special taxes on property that benefit from the transit service	Large potential. Charges beneficiaries.	May be costly to implement.
Station rents	Collect revenues from public-private development at stations	Charges beneficiaries.	Limited potential.
Station air rights	Sell the rights to build over transit stations	Charges beneficiaries.	Limited potential.
Advertising	Additional advertising on vehicles and stations	Already used.	Limited potential. Sometimes unattractive.

Source: Victoria Transport Policy Institute (2017a)

Table C.3: Financing options to finance primary health care

FINANCING OPTION	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Basket funds	• Pooled funding arrangement for shared PHC priorities • Aims to improve PHC funding flow from LGAs, the state government and interested stakeholders	• Acts on improving disbursement and financing management mechanisms. • Introduces financial controls (auditing, direct disbursements) to create transparency and efficiency.	• Significant political will from state and Local Government Authorities (LGAs) required to establish fund. • Difficult to find champion(s) to liaise between partners and facilitate establishment processes.
Community-based health insurance programme	• Common fund created by pooling low insurance premiums from community members.	• Community participation increases ownership and demand for health services. • Protects against catastrophic health spending.	• Transfers funding responsibility from government to citizens. • Might require external funding to subsidise the start-up and sustain coverage costs.
Results based financing	• Provides incentives to achieve desired goals. • Rewards high performers with monetary or non-monetary incentives.	• May be applied to address any programme or priority, including, those tailored to improving programme performance, health system efficiency and health outcomes. • Enhances positive accountability.	• Requires strategic programme design to appropriately match incentives with decision making ability. • Strong data management needed to track and measure performance.
Public private partnership	• Programme that is funded or delivered through a partnership between government and private sector to address a common goal.	• Ability to leverage the technical expertise of the private sector on specific work areas. • Minimises the public sector's borrowing and financial risk.	• Added administrative responsibility of managing and implementing the partnership. • Requires equal commitment by government and partners.

Source: Meghani, Abdulwahab, Privor-Dumm and Wonodi (2015)

APPENDIX D: LANGUAGE EDITORS LETTER

memo

Department of Applied Languages

NELSON MANDELA UNIVERSITY

• PO Box 77000 • Nelson Mandela University
• Port Elizabeth • 6031 · South Africa • www.mandela.ac.za

To: **TO WHOM IT MAY CONCERN**
From: Dr Marcelle Harran
Date: 26 July 2017
Re: **LANGUAGE PRACTITIONER DECLARATION**

This is to confirm that Dr Marcelle Harran completed a linguistic edit of Mr Greg Ducie's PhD thesis in July 2017. The thesis was entitled:

FINANCING SUSTAINABLE CITIES IN SOUTH AFRICA

Regards

Dr Marcelle Harran
Research Associate
Faculty of Arts
Nelson Mandela University
+971 528818195
mailto:marcelle.harran@nmmu.ac.za