Sustainable Urban Infrastructure: the Prospects and Relevance for Middle-income Cities of the Global South

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Declaration

I hereby declare by submitting this thesis electronically, that the entirety of it is my own unaided work, both in concept and execution, and that apart from the normal guidance from my supervisor, I have received no assistance. Neither the substance nor any part of the thesis has been submitted in the past, or is being, or is to be submitted for any other degree at this University or at any other university.

Katherine Hyman

15th August 2015

Abstract

In this thesis, I contribute to the emerging theoretical knowledge of and policy discourse on sustainable urban infrastructure, as a potential solution to the myriad of ecological and socio-economic developmental challenges, for middle-income contexts of the global south. To understand this under-studied theme better, this dissertation uses three emblematic case studies of utility departments in the City of Cape Town (CCT) – an in-depth study of the Solid Waste Management Department and supporting studies of the Electricity Services Department, and the Water and Sanitation Department – to determine the prospects and relevance of sustainable infrastructure in such contexts. Through an analysis of urban networked infrastructure, I provide novel insight into the underpinning institutional dynamics that reproduce the service delivery model, and highlight how innovative activities that reflect the principles of sustainable urban infrastructure become embedded within institutional practice.

Two conceptual frameworks, developed from the literature, have guided the empirical research and the analysis. The first is a heuristic device that enhances our understanding of sustainable urban infrastructure knowledge and discourse. The second offers a way to understand how it is institutionally mediated. Specifically, these conceptual frameworks are applied to the cases to reveal how the CCT's utility departments respond to an emergent crisis within a sector and how they pursue purposive interventions that reflect the sustainable urban infrastructure theory and discourse. The research was carried out over a period of two years and six months, during which I conducted semi-structured and informal interviews, and extensive document analysis.

Empirically, this thesis finds that, in Cape Town, the notion of sustainable urban infrastructure is relevant, considering the socio-economic and ecological conditions of the context. However, sustainable urban infrastructure literature is currently only partly included in dominant policy discourse of the CCT and is largely absent in the routine decision-making and operations. The CCT does not possess the variables that are necessary to support the institutional uptake and embedding of alternative infrastructure configurations, and therefore the prospects of sustainable urban infrastructure are relatively poor. Theoretically, findings grounded in the empirical research enhance understanding of sustainable urban infrastructure in two ways. The first is the identification of the variables necessary for the institutional uptake of alternative modalities of service delivery, in the endeavour to shift the urban

development trajectory onto a more sustainable pathway. The second is the specificity of external, disruptive pressure to coax intransient institutions to recognise the inadequacy of current practice as an important component of transition processes. Importantly, this thesis argues that without foregrounding the power relations and institutional mediation of sustainable infrastructure policy choices, the reconfiguration of socio-technical processes in the endeavour to achieve sustainable urban development may be overcome by institutional inertia.

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Dedication

For my loving parents, Wallace Hyman (1947-2011) and Rosemary Hyman (1943-2011), whose tireless commitment secured for my sister and me the privilege of a tertiary education, which their own circumstances did not allow. Your beloved memory has been a constant motivation.

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Acronyms, Abbreviations and Symbols

AMP	Asset Management Plan
ANC	African National Congress
AWRMS	Atlantis Water Resource Management Scheme
BLA	Black Local Authorities
Bt/yr	Billion tonnes per year
CCT	City of Cape Town
CH_4	Methane
CO_2	Carbon Dioxide
CSP	Concentrated Solar Power
CSSC	Clean and Safe Sanitation Campaign
DA	Democratic Alliance
DANIDA	Danish Government Development Agency
DoE	Department of Energy
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DEAPD	Department of Environmental Affairs and Development Planning
DoRA	Division of Revenue Act
DSM	Demand side management
DWAF	Department of Water Affairs and Forestry
DWF	Darling Wind Farm
DWA	Department of Water Affairs
ED	Executive Director
EE	Energy Efficiency
EEDSM	Energy Efficiency Demand Side Management
EIA	Environmental Impact Assessment
EMT	Executive Management Team
ERM	Environmental Resource Management
ESKOM	Electric Supply Commision of South Africa
EU	European Union
ES	Electricity Services
EJ	Exajoule
FBE	Free Basic Electricity
CGEC	Global Commission on the Economy and Climate

GIS	Geographic Information System
GDP	Gross Domestic Product
GEAR	Growth, Employment and Redistribution
GHG	Green House Gases
IDP	Integrated Development Plan
IMEP	Integrated Environmental Management Plan
IWM	Integrated Waste Management
ISWM	Integrated Solid Waste Management
ISWMP	Integrated Solid Waste Management Plan
IWRM	Integrated Water Resource Management
IPP	Independent Power Producer
IPCC	Intergovernmental Panel on Climate Change
IRP	International Resource Panel
KPI	Key Performance Indicator
kWh	Kilo Watt Hours
kV	Kilo Volt
LTS	Large technological systems
MFA	Material Flow Analysis
MRF	Material Recovery Facility
MW	MegaWatt
MVA	Mega Volt Ampres
MEC	Member of the Executive Council
Mg	Milligram
MLP	Multi-levelled Perspective
MFMA	Municipal Finance Management Act
MSA	Municipal Systems Act
N_2O	Nitrous Oxide
NERSA	National Energy Regulator of South Africa
NEMWA	National Environmental Managment: Waste Act
NSFWUS	National Science Foundation Workshop on Urban Sustainability
NWA	National Water Act
NWRS	National Water Resource Strategy
OECD	Organisation for Economic Cooperation and Development
PDG	Palmer Development Group

PV	Photovoltaic
PBDM	Planning and Building Development and Managment
PPM	Pre-payment Metres
PFMA	Public Finance Management Act
RDP	Reconstruction and Development Programme
RTS	Refuse Transfer Station
RE	Renewable Energy
RSA	Republic of South Africa
SDBIP	Service Delivery Budget Implementation Plan
SJC	Social Justice Coalition
SW	Solid Waste
SWM	Solid Waste Management
SWMP	Solid Waste Management Plan
SWH	Solar Water Heater
StatsSA	Statistics South Africa
TMG	Table Mount Group
TWh	Terawatt-hour
UAW	Unaccounted for Water
UNFPA	United Nations Population Fund
UNDESA	United Nation Department of Economic and Social Affairs
UN-Habitat	United Nation Human Settlement Programme
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environmental Programme
UNDP	United National Development Programme
USAID	United States Trade and Development Agency
USD	United States Dollar
WWT	Waste Water Treatment
WWTW	Waste Water Treatment Works
W&S	Water and Sanitation
WC/WDM	Water Conservation and Water Demand Management Strategy
WDM	Water Demand Management
WCWSS	Western Cape Water Supply System
WCWRSS	Western Cape Water Reconciliation Strategy Study
WLA	White Local Authorities

WMF	Waste Management Facility
WSDP	Water Services Development Plan
WWF	World Wildlife Fund
WBCSD	World Business Council for Sustainable Development
WCED	World Commission on Environment and Development

1. Introduction

Cities have a co-dependent and intertwined relationship with their networked infrastructure. Infrastructure networks, which convey goods, services, data and capital, support the economic system, anchored in urban territories. The particular configuration of these networks has, however, separated social systems from those ecological systems that supply materials and resources necessary for urban functioning. Despite David Harvey's (1993: 34) now famous dictum that "it is, in practise, hard to see where 'society' begins and 'nature' ends", nature is often *hidden* from plain sight in the urban setting. The consequences of this disconnection are becoming increasingly apparent.

Urbanism[1] is, in part, shaped by a particular configuration of infrastructure, which were historically constructed on a set of modern values that extended infrastructure as a universal right. Infrastructure is directly associated with urban living in world cities[2], but, by design, infrastructure networks are generally hidden from view, and their presence taken for granted. However, the absence of networked infrastructure in many cities of the global south has increased in notoriety, bringing to attention the vital role that infrastructure plays in ensuring access to sufficient natural resource flows, a critical component to realising socio-economic and human development. Closer analysis has demonstrated the unsustainable and disproportionate allocation of natural resources and materials, conveyed by infrastructure, consumed throughout cities across the globe (UNEP, 2013). The modern principles that dictate decision-making for infrastructure configurations have contributed to an unsustainable development pathway. For that reason, urban systems as they manifest in infrastructure networks are an important part of the bigger debate around urban sustainability.

The growing recognition within Development Studies and Urban Studies of the interrelated challenges of global environmental change and urban development processes have brought networked urban infrastructure systems of the world into sharp focus. Sustainable urban

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[1]Urbanism refers to "the 'ways of life' associated with built forms, infrastructure and flows – they shape through design how these infrastructures and flows evolve, and they are conditioned by the infrastructure and flows on which everyday life depends" (Swilling & Annecke 2012: 121).

[2] Following Hodson and Marvin's (2010a) understanding,'world cities' is defined as cities which are critical nodes within the global economy, and are both politically and economically primed to ensure economic reproduction and the status quo, through the securing of strategic but vulnerable infrastructures.

infrastructure has been identified as a potential solution for the multiple socio-economic developmental challenges associated with climate change, resource scarcity and ecosystem service deterioration facing cities. This thesis critically explores the emergent discourse of sustainable infrastructure with an eye on its prospects and relevance for Cape Town, South Africa, where global environmental change, coupled with urbanisation and informality, remains a significant constraint for sustainable urban development.

This chapter begins with a concise overview of the trends that affect and influence urban development, with the intention of surfacing the research questions and the focus of this thesis. The background to the research topic is offered as means to contextualise and locate the set of arguments made with a central focus on the nature of the responses to what are considered here as unsustainable development trends that have emerged during the last century. This chapter concludes with a breakdown of the structure of this thesis.

1.1 Setting the scene

This section introduces the confluence of mega trends that profoundly influence emerging development agendas. The presence of both the urban transition underway and global environmental change must necessarily fundamentally alter how urban socio-economic development is understood and enabled. Shifts in social, economic and environmental systems during the 20th century have had an overwhelming impact on urban development pathways. Morin (1999:73) refers to these trends as a set of mutually reinforcing, globally interacting phenomena that has resulted in a "polycrisis". The polycrisis cannot be reduced to a single cause and requires unique and previously unimagined solutions (Swilling, 2013). If cities have emerged as the scale for tackling the global polycrisis, then networked urban infrastructure systems are key intervention points. The following section reveals the role the infrastructure plays in the two trends introduced.

1.1.1 Urbanisation and informality

Urbanisation is a defining megatrend of the 21st century (Pieterse, 2008). In 2008 the scales tipped, and global population is now categorically an urban one (UN-Habitat, 2008; UNFPA, 2007). During the second urbanisation wave[3], currently underway, urban areas will absorb an additional 3 billion people over four decades, predominantly in developing cities of the global

[3] The second urbanisation wave refers to the urbanisation that is currently underway, having its origins in 1950, and its likely conclusion by 2030 (Swilling and Annecke, 2012).

south (UN-Habitat, 2013). This shift is indicative of the importance of cities within the sustainability debate (Bulkeley & Betsill, 2003; Simon, 2010; UNEP, 2013). The second urbanisation wave is unique to and differentiated from the first[4] not only because of its unprecedented scale and pace, but also because low-income and middle-income countries are now home to the bulk of the global population. The second urbanisation wave is characterised by poverty and inequality (Satterthwaite, 2007). Economic growth, development and prosperity are not associated with this trend and therefore it represents an entirely different set of circumstances. As the locality of this transition, cities[5] of the global south will face a number of major challenges over the next century; nowhere more so than in Africa. Africa's development trajectory shows that the population will double from 1 billion in 2010 to 2.2 billion by 2050, and that it will be the last to shift into a predominantly urban demographic in 2030 (Cilliers et al., 2011). This will be the largest increase from a regional perspective, globally.

The nature of urban growth in cities of the global south has created a different type of urban dweller. Rapid urbanisation in inadequately resourced cities juxtaposed to decades of public sector disinvestment in infrastructure has resulted in the expansion of informality and the resultant mushrooming of slums. Recognition of growing urban informality was articulated in a report entitled *Challenge of Slums* as early as 2003 (UN-Habitat, 2003); however, there has been little success in efforts to curb this trend. Considering that "the absence of basic infrastructure … inhibits urban development" (IPCC 2014:35), it is sobering that 62 percent of Africa's urban population survives without access to basic infrastructure services (UN-Habitat, 2010a). Access to basic infrastructure services is only one of the many competing demands required for human development. While this is only an illustration of slum prevalence in the context of Africa, as urbanisation plays out, the absolute number of people that need to be connected to basic services will increase dramatically. Without decisive and effective intervention, it can be assumed the total proportion of people living in informal conditions will remain the same, if not worsen.

4 This is differentiated from the first urbanisation wave, which took place between 1750 and 1950 (largely) in the global North where the number of urban dwellers increased by 15 million to 423 million people (Swilling & Annecke, 2012).
5 This thesis has adopted the UN definition of cities (see UNDESA, 2014: 54-55): small urban centres have a population of less or equal to 500,000 people; medium urban centres, a population between 1 million and 5 million people; large urban centres, a population of 5 million and more; mega urban centres, a population of 10 million and more.

Providing networked infrastructure to ensure the flow of resources and services is a central component of meeting basic human rights requirements: from clean drinking water to sophisticated fibre optic networks that connect individuals at an international level (Graham & Marvin, 2001). Even though infrastructures "can be conceptualised as a series of interconnecting life support systems" (Gandy 2005: 28), Graham (2009: 6) suggests that the average consumer remains blissfully unaware of the "huge and geographically stretched infrastructural complexes" that sustain urban living. Table 1.1 depicts the crisis that surrounds the infrastructure deficit in the global south, "where both acute financing and infrastructure deficits predominate" (Pieterse & Hyman 2014: 194). The massive annual investment gap of approximately 45 percent (World Bank, 2012) demonstrates how big a challenge the provision of networked urban infrastructure is for cities of the global south, while the absence of these systems "has left many urban dwellers, particularly the urban poor with limited, disrupted or no access to [essential] services, reinforcing the conditions of poverty and inequality" (Silver, 2013: 14).

As Africa and the rest of the global south reaches the so-called urban tipping point, the aspiration of the population to connect to a bundle of modern infrastructure services, as was the case during the first urbanisation wave, is interrupted at a particular moment when global environmental change and ecological degradation have emerged as by-products of the first urbanisation wave and the consumption patterns associated with it. The historical landmark of the second urban transition must be considered in the context of global environmental change and the ensuing ecological crisis threatening planetary systems.

Table 1.1: Infrastructure investment levels and shortcomings for world regions in the global south

Region	Need ($bn)	Actual Spend ($bn)	Financing gap ($bn)	Spend as % of GDP
Latin America	81.2	43.5	37.7	1.9%
East Asia	406.7	207	199.7	7.2%
South Asia	191.1	46	145.1	4.6%
Middle East and North Africa	75.8	43.8	22.7	6.9%
Sub-Saharan Africa	93.3	45.3	48	7.1%

Source: World Bank (2012)

1.1.2 Global environmental change

Global environmental change and the risk of ecological degradation and destruction are not only central to the environmental agenda, but also to the urban agenda. Accelerated climate change and subsequent global warming have dominated much of the sustainability discourse for some time. The 4th Intergovernmental Panel on Climate Change (IPCC) demonstrated the unequivocal reality of climate change by documenting the increase in concentration of greenhouse gases between 1970 and 2004[6] (IPCC, 2007). An "overwhelming body of scientific evidence now clearly indicates that climate change is a serious and urgent issue" (Stern, 2007: 2). Current trends dictate that temperatures will increase by 1.8 to 4 degrees centigrade without intervention, while an average temperature increase of 2 degrees will result in significantly negative ecological and socio-economic changes (IPCC, 2007). Unprecedented increases in temperature and changes to regional climates have already contributed to changes in natural systems and eco-systems, of which 60 percent are now degraded (United Nations, 2005; Stern, 2007). Furthermore, excessive abiotic resource extraction similarly contributes to the degradation of eco-systems on which humanity, through socio-economic activities, is entirely dependent (Brinhezu, 2011). It is ironic that those socio-economic activities that have maintained economic development over the past century are now being undermined by those same activities.

Over the past hundred years, while the global population has increased fourfold, a dramatic tenfold increase in material and energy consumption globally was recorded (Weisz & Steinberger, 2010). Dittrich et al. (2012) show that humanity extracts 70 billion tonnes of virgin materials for consumption annually, a figure that has grown 80 percent in absolute terms over the past 30 years. Figure 1.1 maps the trends in GDP and population while demonstrating the relatively poor improvements to material productivity between 1980 and 2008. Although material productivity, i.e. the economic value created per unit of consumed material, has improved by approximately 40 percent over the past two decades, total material consumption continues to increase (Dittrich et al., 2012). Moreover, the manner of resource extraction and production can be linked causally too, and is therefore largely responsible for widely documented changes to natural systems (United Nations, 2005; Fischer-Kowalski & Swilling, 2011). In other words, incumbent processing and conveying technologies are environmentally inefficient in that they have low levels of material productivity. This induces

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[6] The concentration of green house gasses increased from 28.7 Gt/$C0_2$-eq/yr to 49 Gt/$C0_2$-eq/yr between 1970 and 2005 (IPCC, 2007).

a negative cycle of ever increasing material inputs that decrease resource stocks while generating harmful emissions.

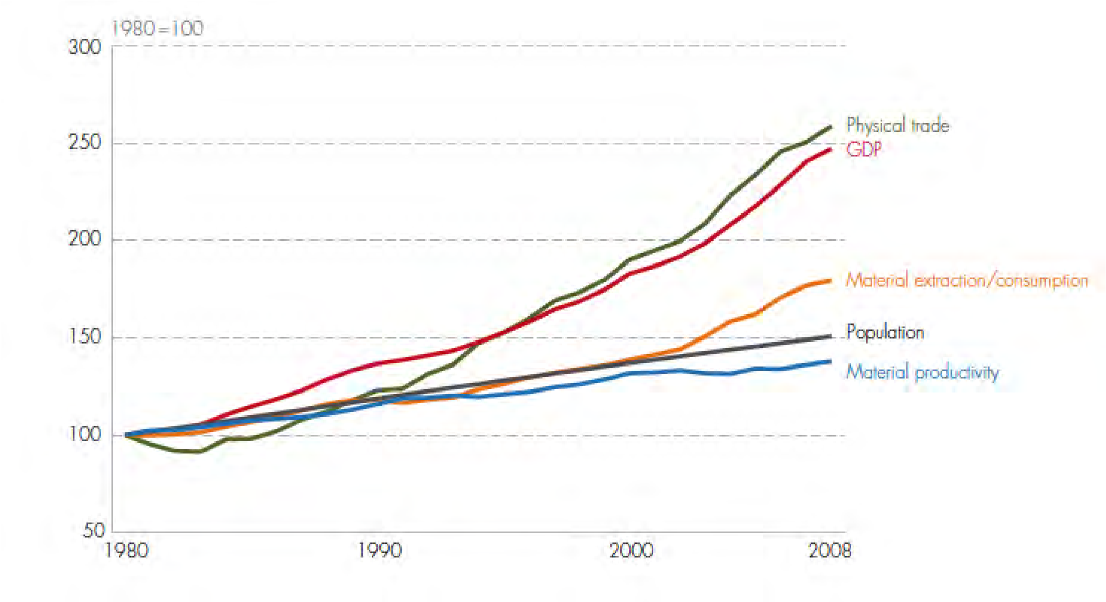

Figure 1.1: Global trends in GDP, population and material use (1980-2008)
Source: Dittrich et al. (2012: 33)

High levels of resource extraction, unaligned with population growth, shows that unbridled anthropocentric consumption patterns, even though it is vastly disproportionate, are responsible for the high socio-economic metabolic rate of the global economy. The metabolic rate is the accumulative resource consumption or material footprint that can be measured per capita or per county (Harberl et al., 2004; Weisz & Steinberger, 2010). The metabolic rate is also considered an acceptable measure for the per capita material standard of living (Krausman et al., 2009; Haberl et al., 2011). Together, these facts offer insight into two significant findings. Firstly, resources are being extracted and consumed at a higher rate than the earth can replenish these resources. Secondly, economic growth and high-income levels associated with over-consumption are largely responsible for environmental degradation, which undermines the assumption that population growth is to blame. Fischer-Kowalski and Swilling (2011) demonstrate that metabolic rates are dependent on the development status of a particular country and therefore low-income or developing countries typically have low metabolic rates and, simply, lower levels of resource consumption than developed countries. Measuring metabolic rates across cities, regions and countries illustrates the uneven distribution of resource consumption on a global scale. Importantly, this draws attention to the developmental strategies of low-income and developing countries, which are "now beginning the transition towards an industrial type social metabolism" (Krausman et al., 2009: 8). Questions emerge as to how these cities and countries will resolve the need to ensure human development through the provision of infrastructure in a resource-constrained world. The 20th century urban development trajectory seen in the global north cannot take place, in environmental terms, in the global south in the 21st century.

The conditions and trends described above directly link the urban agenda to the environmental agenda. The 5th IPCC report has set out in detail the role that cities play in climate change and climate change mitigation (IPCC, 2014) and the high rate of resource consumption (Giradet, 2010). While just over half the world's population lives in cities, urban populations collectively account for 67-76 percent of global energy consumption and 76 percent of energy-related carbon emissions (IPCC, 2014[7]). Moreover, those consumption patterns that are effecting global environmental change, supported by highly organised supply chains in a consumption-driven global economy, start and end in cities (Gowen, 2009; Swilling & Annecke, 2012). However, this argument does not imply the need to stall urbanisation since it is central to realising desirable levels of human development (Martine et al., 2008), but this requires equitable investment in infrastructure to ensure more sustainable forms of urbanism.

Consumption patterns are mediated by a very specific configuration of networked infrastructures that facilitate and mediate resource flows, and therefore resource use, in cities (Guy et al., 2001). Networked infrastructures lock society into a regime that is consistently reproduced and reinforced by formal and informal institutions. A central question, and the focus of this thesis, is how to best reconfigure infrastructure so as to ensure more sustainable urban development pathways. The IPCC (2014) argues that mitigation strategies, on the city scale, in developing cities offer the greatest opportunity for offsetting global environmental change. Herein lies the second link that speaks to networked urban infrastructure. Urban development along the current trajectory and the accompanying conventional infrastructure configurations in the global south will result in the exacerbation of existing consumption patterns, with devastating environmental, and therefore socio-economic, consequences.

1.2 Propositions that support an alternative

[7] It must be recognised that urban dwellers with relatively high incomes account for the bulk of this consumption.

At the core of prevailing crises is the overwhelming evidence that the growing urban population is increasingly vulnerable to the effects of resource scarcity, ecological degradation and consequential environmental changes. Trends however indicate that the material flows through the global economy will continue to increase with catastrophic consequences unless there is aggressive and immediate intervention (Fischer-Kowalski & Swilling, 2011). In its current form, the neo-liberal economic paradigm rewards "more instead of better consumption and private versus public investment in man-made rather than natural capital" (Martínez-Alier et al., 2010: 1741). Despite efforts to demonstrate the intrinsic limits to this model, social, economic and environmental crises are perpetuated by the continuous expansion of the middle-class supported by the financial economy (Martínez-Alier et al., 2010). Society is locked into consumption-driven growth in which markets reign supreme and prosperity is fostered through efficiency gains wherein traditional public goods and services are increasingly privatised and/or corporatised (Martínez-Alier et al., 2010). Resolving this crisis will depend on the systemic re-orientation of modernism, based on technological advancements that promote sustainable resource and material use, and dematerialisation of the economy (Geels, 2011a). Critically, interventions can under no circumstances deny residents of cities of the global south access to socio-economic metabolic activities delivered by essential, basic services that ensures the realisation of socio-economic rights.

The metabolism of the modern economy is determined by the specific configuration of networked urban infrastructures, which conduct the materials and resources, typically non-renewable, and data that fuel the global economy. Reconfiguring networked infrastructure provides an opportunity for transitioning onto a more sustainable development pathway at the city-scale (Hodson & Marvin, 2009a). Seen in this light, network infrastructure becomes a vital intervention point. Decoupling, as a theoretical notion, is offered as one of the means to resolve the tension between needing to deliver services and the environmental constraints of doing so. The next section strengthens these claims; however, first there is a brief introduction on the meaning of sustainable urban development and decoupling.

1.2.1 Sustainable urban development

The use of the phrases *sustainable development* and *sustainable urban development* on several occasions thus far signals the need to define what it means in the context of this thesis. Whilst sustainable development is now a commonly used phrase, there remains much debate around its value and purpose (Giddens, 2009; Pieterse, 2011). The phrase was officially coined in 1987 at the World Commission on Environment and Development (WCED), and drew an increasing amount of attention when political leadership from across the world endorsed the notion at the 1992 Rio Earth Summit (Meadowcroft, 2000). Sustainable development is defined by the Brundtland Report, *Our Common Future,* as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987: 43). The basic premise of the definition is that both current and future development should be sustainable, inherently overcoming the tension between economic growth for development and environmental conservation efforts while striking a balance between economic, social and ecological imperatives. This balance is depicted in Figure 1.2 where *SD* indicates *sustainable development*.

The conventional definition of sustainable development is critiqued for a number of reasons (see Pezzoli, 1997; Mebratu, 1998; Sachs, 1999; Allen, 2001; Redclift, 2005; Agyeman, 2013). Allen (2001) reminds us that there are inherent trade-offs and contradictions when seeking to realise social, environmental and economic goals, while Redclift (2005) goes as far as to suggest that the emerging discourses around sustainable development are mutually exclusive. The deliberate decision of the WCED to design the notion of sustainable development in an open-ended way to retain the intention of it being a "potentially unifying political meta-objective with a suggestive normative core" (Meadowcroft, 2000: 373) has left too much room for interpretation and not enough for integrated action.

Pieterse (2011) highlights how, despite the environmental challenges and socio-economic issues relating to poverty and inequality, "the economy is seen as a prerequisite for the reproduction of society. Reforms in the social and ecological domain are therefore conceived within the current model of extractive capitalism" (Pieterse 2011: 14). Economic growth and development trajectories are still firmly divergent from the *meta-objective*, following traditional economic assumptions. This "is anchored in an implicit assumption that economies are unchanging and efficient, and future growth will largely be a linear continuation of past trends" (Global Commission of Economy and Climate [GCEC], 2014: 15). A second major critique is that the idea of sustainable development is grounded in what Pieterse (2011) calls a *consensus model.* This approach is dependent on increased participation in decision-making through reforms in the political system (Hopwood et al., 2005). This suggests fundamental differences can be overcome through "rational democratic deliberation", but in fact results in "biased and shallow policy decisions that generally reinforce the status quo in unsustainable and unjust situations" (Pieterse, 2011: 14). Allen (2001) concludes that this model is inadequate for identifying and unpacking how these components of economic growth, social development, and environmental challenges and protection play out at the urban scale. It is more likely that these three systems are irrevocably interlinked for creating "sustainable lives and livelihoods … [wherein] the processes of social and ecological reproduction [are] non-linear, indeterminate, contextually specific, and attainable through multiple pathways." (NSFWUS, 2000:7).

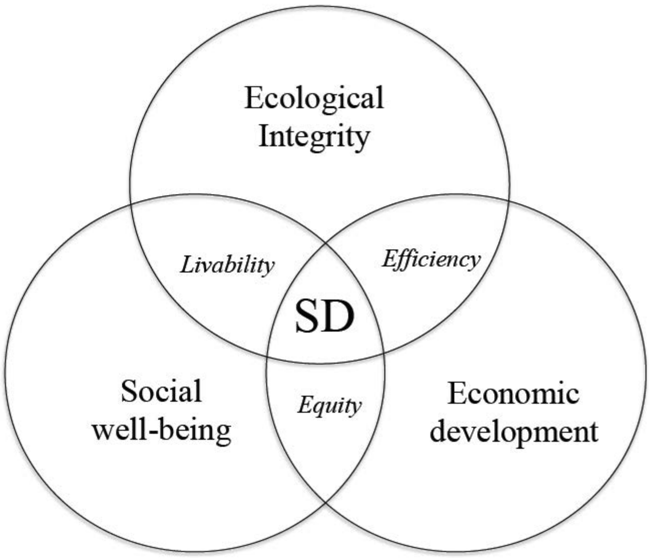

Figure 1.2: Conventional representation of sustainable development
Source: Adapted from Allen (2001: 154)

Recognising that cities are currently unsustainable necessitates further exploration of what sustainable development means in the effort to bring about sustainable urban development pathways. Allen (2001) offers a broad view that includes the three dimensions already discussed, namely economic, social and ecological systems, as well as the physical system, which represents the built environment and necessarily networked infrastructure, which supports urban living. These four dimensions are understood to be embedded in a political setting, the fifth dimension, where political and institutional decision-making link and regulate the dimensions of urban sustainability (Allen, 2009). The five dimensions of urban sustainability offered by Allen (2001) are illustrated in Figure 1.3 and are understood as follows:

1) *Economic sustainability* refers to the ability to make use of the surrounding bioregional capacity to sustain the economy without causing long-term damage to the

ecological system and diminishing the natural resource base faster than it can replenish itself.

2) *Social sustainability* is a fair and inclusive system supported by a set of actions and policies that improve quality of life and offer equal access to the use and appropriation of the natural and built environments as well as economic capital, with an emphasis on supporting marginalised communities.
3) *Ecological sustainability* reflects the rational management of production, consumption and associated wastes to maintain the health of ecosystem services to ensure that the bioregional carrying capacity remains intact.
4) *Physical sustainability* is concerned with the liveability and efficiency of the built environment and networked infrastructures to support urban living and economic activities in a way that maintains the urban regional environment.
5) *Political sustainability* implies democratic processes that encourage participatory decision-making, inclusive of local civil society. Significantly, the political sustainability of urban government ensures the management and regulation of the relationship between the previous four dimensions, guiding the actions of different actors within the various systems.

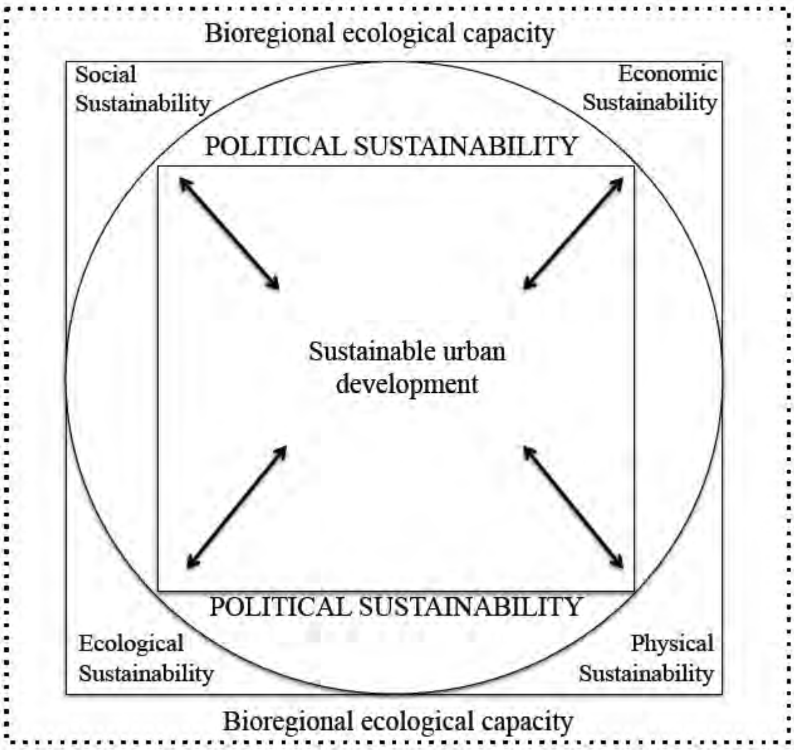

Figure 1.3: The five dimensions of urban sustainability
Source: Allen (2001: 156)

Viewing urban sustainability this way brings to the attention the political nature of urban sustainability processes. Interventions that seek to purposively encourage more sustainable urban development trajectories must take into account the political climate around decision-making. Importantly, Allen (2001) goes on to highlight how global political and economic factors influence local decision-making and, in fact, are the most significant determinants, significantly shifting power away from local actors. Complex processes, beyond the urban boundary, account for uneven geographical development characterised by socio-economic and socio-environmental inequalities (Cook & Swyngedow, 2014). Pieterse (2011) argues that realising more sustainable livelihoods is dependent on actively engaging in the political power differential and those vested interests that maintain it. Therefore, understanding the political and socio-institutional nature of purposive interventions is at the core of urban sustainability challenges. This thesis seeks to explore how Cape Town's metropolitan governing authority has responded to the international policy discourse and academic theory that encourages interventions for more sustainable development trajectories. These interventions are underpinned by the theoretical notion of decoupling, to which the discussion now turns.

1.2.2 Decoupling

To remain within the global environmental boundary, reduction targets have been set for material extraction and emissions. The IPCC recommends, in an attempt to keep within a 2 degree celsius temperature increase, that total carbon emissions per capita per annum should average 2.2 tonnes. This aligns with findings of the International Resource Panel (IRP), which has demonstrated that a sustainable and equitable global metabolic rate would depend on contracting material extraction to equate to an average of 6 tonnes per capita per annum (Fischer-Kowalski & Swilling, 2011). This translates into a decrease from the current 4.5 tonnes and 8 tonnes respectively.

These estimates from the IRP and the IPCC reflect the present reality, before Africa and Asia undergo full industrialisation, economic modernisation and reach the associated higher rates of consumption. Since the distribution of metabolic rates is highly unequal across countries and regions, addressing resource and emission reduction requires different strategies suited to the different contexts. Varying stages of economic development and consumption patterns mean that while some countries will have to decrease their metabolic rate significantly, others are likely to increase it in order to improve the quality of life for citizens. Consumption patterns therefore will have to be fundamentally restructured to achieve a reduction in the resource requirements and material throughput of the global economy (Bringezu et al., 2004).

The IRP Report, *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth,* (Fischer-Kowalski & Swilling, 2011) offers an explanation for the need to decrease and even out the distribution of resource consumption while making a convincing argument for the adoption of decoupling or dematerialisation as the means to achieve this. Decoupling is a means of achieving economic growth necessary to address basic material needs, while the demands on natural resources and ecosystem services are decreased by decoupling economic growth from environmental impacts via non-material intensive growth (Fischer-Kowalski & Swilling, 2011). The overarching intention is to increase human well-being and equality, while recognising that conventional consumption-driven economic growth cannot be relied on for this (Agyeman, 2013).

There are numerous critiques of the notion that we need continued economic growth. Some argue for a sustainable de-growth economy (Martínez Alier et al., 2010) or a steady-state economy (Czech & Daly, 2004), all of which are unlikely at present and unsuitable when attempting to rectify the social inequities of the global south. Decoupling can be linked to the notion of 'sustainable de-growth' which is discussed by Martínez-Alier et al. (2010). Sustainable de-growth refers to the physical downsizing of economic throughput, measured by material and energy flows, while the output continues to rise. This is achieved though increased resource productivity and resource intensity. Decoupling recognises that material and energy flows within the economy are necessary, especially in developing world contexts. It also reflects the need to identify an optimal metabolic rate that is within the earth's carrying capacity (Martínez-Alier et al., 2010). Du Plessis interprets this approach as one that seeks to determine "how much damage can feasibly be inflicted" (2012: 12); however, here the suggestion is the creation of an economy that is a means to an end, rather than an end in itself.

Non-material growth, as a means to achieve economic growth for human development and well-being, can take place within the resource-constrained economy (Gallopin, 2003). Therefore, the emphasis is on a *particular* type of growth. The concept of growth and development, and therefore standard of living, conventionally measured using GDP [8] (Blanchard, 2006),

[8] GDP per capita is the total output of an economy divided by the population (Blanchard , 2006).

necessarily must be rethought and reimagined[9]. Decoupling has as its foundation the recognition that conventional economic growth and development, as measured by GDP, does not as a rule result in improved human well-being and equality (UNDP, 1996; Agyeman, 2013).

Decoupling is either absolute or relative. Absolute decoupling is applicable when the rate of resource consumption is stable or decreasing while the economic growth rate is increasing. Relative decoupling is applicable if resource consumption is increasing but at a lower rate than economic growth (Fischer-Kowalski & Swilling, 2011; Schepelmann et al., 2010; Haberl et al., 2004). Similarly, the IRP identifies both resource and impact decoupling. Resource decoupling refers to the rate of virgin resource use compared to the growth rate, and thus concerns itself with the rapid extraction of non-renewable finite resources (Fischer-Kowalski & Swilling, 2011). Resource efficiency and productivity, through technological advancements, are central to achieving resource decoupling. Alternatively, impact decoupling refers to the relationship between economic growth and the consequential negative environmental impact actualised as a result (Fischer-Kowalski & Swilling, 2011). Negative environmental impacts are usually noted throughout the life cycle of resource use from extraction to disposal and as such, there are numerous opportunities for the improvement of the systems at each stage and overall. Decoupling the global economy from energy- and resource intensive-processes is theoretically possible if networked infrastructures are configured in a way that decreases the demand for natural resources and decreases the negative by-products of processing. As such, it is possible to envisage development without the negative environmental and social externalities of conventional economic growth. Figure 1.4 illustrates these principles.

[9] See Agyeman (2013) for an overview of alternative models that offer a better way to measure human well-being and development.

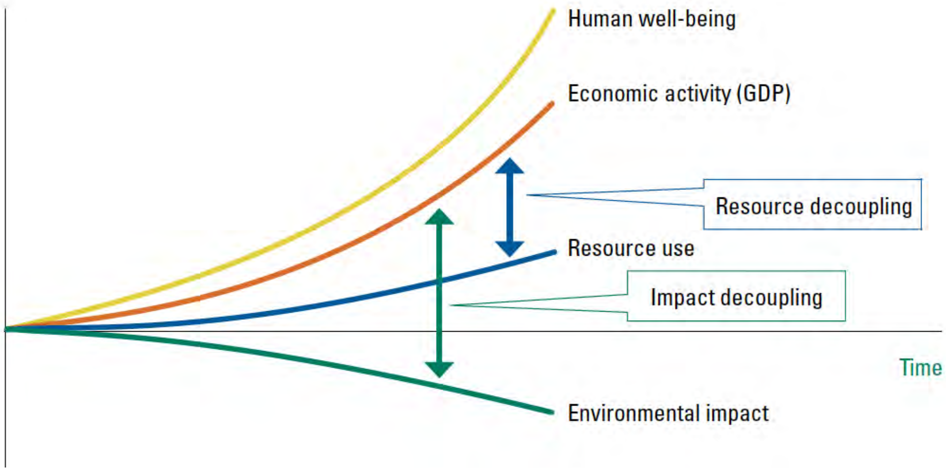

Figure 1.4: Stylised representation of decoupling
Source: Fischer-Kowalski & Swilling (2011: 5)

As the locality for unsustainable consumption, and the production of harmful wastes and emissions, cities are primed to be a critical scale for a shift toward more sustainable development pathways. The networked infrastructures on which they are dependent are the key strategic intervention points. Cities are inherently centres of agglomeration and innovation and therefore offer the possibility of reconfiguring socio-technical processes, which are the socio-economic, political, institutional, cultural, environmental and technical components that give rise to infrastructure system configuration (Guy et al., 2001). The inherent question is of course how the existing challenges in low and middle income cities in the global south, that lack institutional capacity and capability, political will and a sound fiscal base to enact sustainability transitions, will be interpreted, understood and acted on. It is important to understand the set of political-economic conditions that need to be present to allow these sustainability transitions to unfold. It is certain:

> that in the future we cannot continue to expand cities the way we have in the past. An unprecedented effort is required to accommodate the urban population of 2050 in a consistently livable way. It requires uncommon political courage and financial wizardry – hundreds of billions of euros will be spent in investments worldwide, and the way these will be spent can make the difference between a sustainable perspective and a catastrophe. It also requires new ideas, new knowledge, new models, new technologies, new forms of organization and ways of working, and a new urban policy. The world urgently needs a plan for its urban future. (Feddes et al., 2013: 7)

1.3 Responses to urban challenges

In response to the challenge of unsustainable resource flows in urban systems, a literature on sustainable urban infrastructure has emerged in academic theory and policy discourse. It flows from observations and analysis of experiments in sustainability on various scales in cities. The rationale of sustainable infrastructure suggests that if infrastructure systems are *reconfigured* using the principles of sustainability, natural resource consumption, especially non-renewable resources, and the subsequent impact of harmful emissions during the use thereof will decrease (Zavrl & Zeren, 2010; Bry Sarté, 2010; Nam et al., 2007; Suzuki et al., 2009; UNEP, 2012; IPCC, 2014). Therefore, sustainable urban infrastructure is considered a useful lens when looking at urban planning and specifically urban infrastructure configurations; the implication being that there must be a transition from the incumbent infrastructure regime to one that is more sustainable.

Guy et al. (2001) convincingly demonstrate, through the conceptual framework of flow management applied to case studies, how changes in infrastructure management can meaningfully improve efficiency and productivity of resource flows. Understanding the social organisation of infrastructure management; reconsidering the spatial scale of flow management; and an emphasis on the role that local context plays in managing flows are critical aspects of making adjustments in infrastructure management. This work has been broadened and deepened by Hodson and Marvin (2010b) who demonstrate the complex nature of urban infrastructure networks, which are described as the product of social, political and spatial processes and articulated as socio-technical processes. There are examples of world cities experimenting with climate change and resource scarcity adaption strategies through infrastructure reconfiguration, including: energy-saving models in Freiberg and Berlin; waste reduction and reuse in Copenhagen and Sydney; and water saving through monitoring and control systems in Tokyo (C40 Cities, 2011). These examples are articulated as best practise; it is however unclear whether this discourse has purchase in contexts of low-income and middle-income cities of the global south. Moreover, many of these solutions only marginally differ from the incumbent model of extractive capital, while avoiding the political nature of realising sustainable livelihoods as described by Allen (2001). The urgent call from Feddes et al. (2013) for new urban policy is drowned out by the loud voice of those vested interests that maintain the status quo.

Taking it as a given that cities of the global south are unique contexts that require new or adapted frameworks for research, case studies rooted in the global south must be explored to understand the conditions required for sustainable urban transitions better. The question therefore is whether the sustainable infrastructure literature assists in the endeavour to ensure sustainable urban development. Cape Town, located in the Western Cape Province, South Africa, is such a unique context. Currently, Cape Town is faced with natural resource constraints, a plethora of social issues and fiscal limits (Crane & Swilling, 2008; Swilling & Annecke, 2012). Furthermore, due to a historical legacy[10], the incumbent urban development paradigm is based on the extension of standardised, conventional networked infrastructure services, which is undermining the capacity of the local government to make meaningful inroads into the interrelated challenges faced. This incumbent paradigm is both financially and environmentally unsustainable (Gasson, 2002; Crane & Swilling, 2008). Nonetheless, Cape Town is fast becoming considered a locality for experimentation for a sustainability agenda, in particular for sustainable urban infrastructure, in light of a growing policy discourse and academic literature that is emerging from both public and academic institutions (Swilling, 2010; Pieterse, 2010a; Swilling & Annecke, 2012; City of Cape Town (CCT), 2003a; CCT, 2006a; CCT, 2007a; CCT, 2007b; CCT, 2009a; CCT, 2010a). Recent policy documents that have been produced by the City of Cape Town not only provide strategic plans and policy frameworks for sustainability but also demonstrate existing projects that are creating a receptive environment for an urban transition to sustainability.

This thesis focuses on the institutional organisation of socio-technical systems in Cape Town. Specifically, it evaluates how these systems have adapted and changed between 2000-2012, in light of the perceived receptive environment, in an effort to ascertain the significance of the sustainable urban infrastructure debates and discourse CCT's Utility Directorate, the institutional body, constituted by three separate departments, responsible for the management and operating of networked urban infrastructure in Cape Town. This pertains specifically to solid waste, water and sanitation and electricity networks. The Solid Waste Management Department has undergone in-depth analysis and the Electricity Services Department, and the Water and Sanitation Department have undergone general analysis. The research is specifically orientated to reveal how routines and institutions are established, and how to intervene purposefully to advance more sustainable development pathways through the progressive adoption of sustainable infrastructure.

1.4 Research Questions

The main argument of this thesis is that sustainable urban infrastructure as an enabler of more sustainable urban transitions is inadequately addressed from the perspective of middle-income

[10] Pre-1994 apartheid policies restricted service delivery to only certain sections of society. However, since 1994 official policy of the National Government has been to provide universal access to standardised, ubiquitous services.

cities of the global south. However, there is an urgent need for a deeper and grounded understanding of socio-technical transitions as the urban transition underway continues, in light of what is now understood about processes of global environmental change. The research questions that guided this research are therefore as follows:

1) Is *sustainable infrastructure* theory useful and relevant in the context of Cape Town?

2) How do the elements of the academic theory manifest within the policy discourse in the City of Cape Town?

3) To what extent is this discourse absorbed into routine decision-making and management within the primary utility departments of the City of Cape Town?

4) What is the use and relevance of *urban transitions* theory and knowledge when reflecting on the implementation of sustainable infrastructure?

5) What gaps in the sustainable infrastructure and urban transition knowledge can be identified through an exploration by means of a case study (Cape Town) in the global south?

6) How can the existing theory on sustainable infrastructure and urban transitions be enhanced through the insights generated from my case study?

1.5 Thesis Structure

Chapter 2 provides a review of available and pertinent infrastructure and sustainable infrastructure literature, in which the empirical research is grounded. The chapter links the mega-trends introduced in Chapter 1 to the notion of sustainable urban infrastructure as a socio-technical system in a detailed manner, while introducing and elaborating on responses within policy discourse and theory at a global scale. Using the overarching goal of establishing a clear definition of sustainable urban infrastructure, the review highlights the conventional approaches towards achieving more sustainable infrastructure configurations as well as the limitations of these approaches. Hereby the intention is to shift the discourse toward a more meaningful approach in dealing within the sustainability of infrastructure. Importantly, this chapter adds to the most recent theoretical and conceptual frameworks that are being developed for understanding transitions to sustainability, and the role of infrastructure reconfiguration in facilitating transitions.

Chapter 3 critically grounds the theory and discourse elaborated on in Chapter 2 in an institutional setting through an elaboration on how transitions are conceptualised, designed, implemented and effected. It highlights the institutional dynamics that play an under-appreciated yet fundamental role for infrastructure reconfigurations. Transition literature is used as an entry point to the field of institutional change within the ambit of public development management to draw an understanding of how organisations and the actors within them respond to uncertainty through learning processes. The central question here seeks to identify those institutional conditions that must exist for the notion of sustainable urban infrastructure to become mainstream. The chapter concludes with a summary of the conceptual frame that guides the institutional analysis.

Chapter 4 is a stand-alone chapter that explains how this research was conducted; as such it is the methodology chapter. Following confirmation in Chapter 2 and Chapter 3 of the research questions, this chapter clarifies the methods adopted to conduct the research. While scholarly literature is used as primary research method, empirical research locates the research in context and hereby elevates the story. The chapter reveals the rationale for the selection of the case study method while weaving through how the ethnographic research process unfolded during fieldwork. It is written in the first person to offer the reader an opportunity to grasp better some of the complexities of doing social research in a qualitative manner.

Chapter 5 outlines the background and context for the case study described in the empirical chapters. The chapter provides a brief overview of South Africa as a means to locate the empirical research, with a higher level of detail paid to the status quo of Cape Town and the (recent) historical and ecological conditions that have given rise to this status quo. It sets the scene of the broader political economy within which infrastructure decision-makers act and activate purposive urban transitions. A core component of this chapter is the evidence it offers of how the CCT is responding to socio-economic and environmental development challenges.

Chapters 6 and 7 are the main empirical chapters of the thesis. Chapter 6 presents the two secondary cases of the Water and Sanitation Department, and Electricity Services Department, which underwent general analysis. Chapter 7 presents the primary case of the Solid Waste Management Department, which underwent an in-depth analysis. These chapters describe the status quo of the two departments and provides an introduction to where relative innovation can be identified. The intention is to be descriptive in order to draw a parallel across the cases so as to be able to draw generalisable findings. Each of the chapters follows a similar structure in that the status quo is described in relation to the service delivery model from a technical and institutional perspective. This is illustrative of the socio-technical dynamics at play.

Chapter 8 extrapolates findings from the two empirical chapters in a way that responds to the research questions. As a starting point, the analysis introduces a set of variables that account for and shape the institutional uptake of purposive interventions. Hooks are used to draw out this novel offering, extrapolated from empirical evidence to build onto the conceptual frame that is delivered in Chapter 2. Using the conceptual frame, the chapter reveals how the sustainable urban infrastructure discourse has been adopted, in different ways, by the utilty departments and unassumedly used to legitimise purposive interventions for systemic change. The chapter then reflects on how this discourse is institutionally mediated. Specifically drawing on the findings of Chapter 3, this section reveals how Utility Departments are geared toward reproducing particular practices that militate against the adoption of purposive change. *Chapter 9* is a short and succinct chapter that reflects, with clarity, on the importance of this research. It highlights how the thesis has brought together disconnected literatures and devised frameworks for investigating the issues brought to the fore; the chapter highlights the substantive findings in the context of Cape Town, and lastly it considers how the case study offered provide lessons for other contexts.

2. Sustainable urban infrastructure: a review

The adverse effects of global environmental change have made pursuing sustainable urban transitions a priority. As the primary consumer of virgin materials and producer of waste and emissions, cities and the networked infrastructure on which cities rely, are key strategic intervention points for effecting a transition toward a more sustainable development trajectory. This chapter argues that the emerging policy approach of achieving universal service coverage and system efficiency through technological advancements and improved governance systems is critical to mitigate negative anthropocentric global environmental change. However, in contrast to the approaches advocated by the World Bank (Suzuki et al., 2009; Moffatt et al., 2012), United Nations (2011) and experimental responses emerging in World Cities (C40 Cities, 2011), it is argued that this class of responses will not be sufficient. It is possible that the mainstream approaches will, in fact, perpetuate the incumbent industrial socio-ecological regime that reinforces the existing (unsustainable) urban development trajectory.

The objective of this literature review is to present the latest thinking in literature concerning networked urban infrastructures and associated socio-technical systems. Due to the inherent interaction of social and technical dimensions of networked infrastructures, this review draws on literature from a multiplicity of disciplines, from engineering to sustainability to sociology to innovation. The result is an interdisciplinary description of the nature and dynamics of infrastructure, with reference to the historical technical transitions of infrastructure that speak to macro societal transitions, to broaden our understanding of the relationship between networked infrastructure and society. This review furthermore provides a reflection on the recent literature on sustainable urban infrastructure and associated discourses that have subsequently emerged in response to urban sustainability crises. Central to this review is the goal of moving toward a working definition of sustainable infrastructure – a phrase adopted by many, yet without adequate definition – that could act as a normative guide for reconfiguring networked infrastructure packages. The review reveals the unresolved concern of what conditions must be in place to enable the systemic, far-reaching engagement and adoption of the conceptual prescripts at a policy level. In light of this it draws on the development, public management, organisational learning and institutional change literature, which is explored in more detail in Chapter 3. The reason for this expansive treatment is that the concept of sustainable infrastructure and its institutional implications is relatively new and therefore the thesis is compelled to cover a lot of exploratory ground.

The review is structured in two parts. This first part discusses the rationale of considering infrastructure as one of the key leverage points for sustainable transitions; the second part interrogates the growing sustainable urban infrastructure literature and makes a contribution to how sustainability of infrastructures could be conceptualised. This review concludes by introducing the importance of the need to understand paradigmatic shifts for systemic change on the urban scale.

2.1 Infrastructure as an intervention point

Networked infrastructure systems, as the operating system of modern urbanism, influence the demand for resources, mediate resource flows and regulate the production of waste and emissions. Moreover, bundles of network infrastructure selected in the short term to meet urban needs, determine the long-term development trajectory and sustainability of a city (UNEP, 2012). Therefore, networked infrastructures are of great importance in the urban sustainability debate and are considered as a means to shift the existing development paradigm toward a more sustainable development pathway. Because infrastructure networks are part of a larger system of technical and social components they can be referred to as socio-technical systems (Loorbach et al., 2010), which intimates that such technological changes to infrastructure configurations cannot on their own bring about sustainable urban transitions. Infrastructures, and the associated socio-technical system, must be adapted and reconfigured to change urban resource flows and socio-economic metabolic rates fundamentally. This claim will be unpacked in this first section of the review.

Networked infrastructure ensures the socio-economic reproduction of the city (Guy et al., 2001; Graham, 2010). It is responsible for bringing into being the modalities and circulations of the city and the world (Graham, 2010). Roads, conduits, tunnels and wires, artifacts usually taken for granted, enable a consistent flow of people, goods, water, sewerage, energy and communication data to weave in, around and out of city boundaries. Reproduction occurs as resource inputs are transformed into usable properties and functions as a result of an urban metabolic process (Girardet, 2010). Industrial ecologists tell us that the urban metabolism is the "the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy et al., 2007: 44). Therefore, networked infrastructure both ensures, and determines the urban metabolism.

The value of the urban metabolism here is twofold[11]. Firstly, organising the city into a series of flows exposes the need to reconfigure existing production and consumption patterns fundamentally (Broto et al., 2012). Secondly, it opens up a way of seeing how resource, social and economic flows are either prioritised or marginalised (Broto et al., 2012). "Through the notions of flow and circulation, the concept of urban metabolism links material flows with ecological processes and social change." (Broto et al., 2012: 858). Therefore, the concept of the urban metabolism highlights networked infrastructure as a major source of contention when considering the high energy and material input currently required for the reproduction of cities (UNEP, 2013). Networked infrastructures of modern[12] cities are predominantly configured in a linear manner (see Figure 2.1). Large quantities of essential inputs such as food, energy and materials flow through the urban fabric via complex, inefficient throughput systems that result in large quantities of polluting outputs, such as harmful GHG emissions and solid waste (Girardet, 2010). Urban socio-economic activities consequently place momentous environmental pressure on both natural resources and ecosystem services (IPCC, 2014; Hodson & Marvin, 2009b; Martinez-Alier et al., 2010).

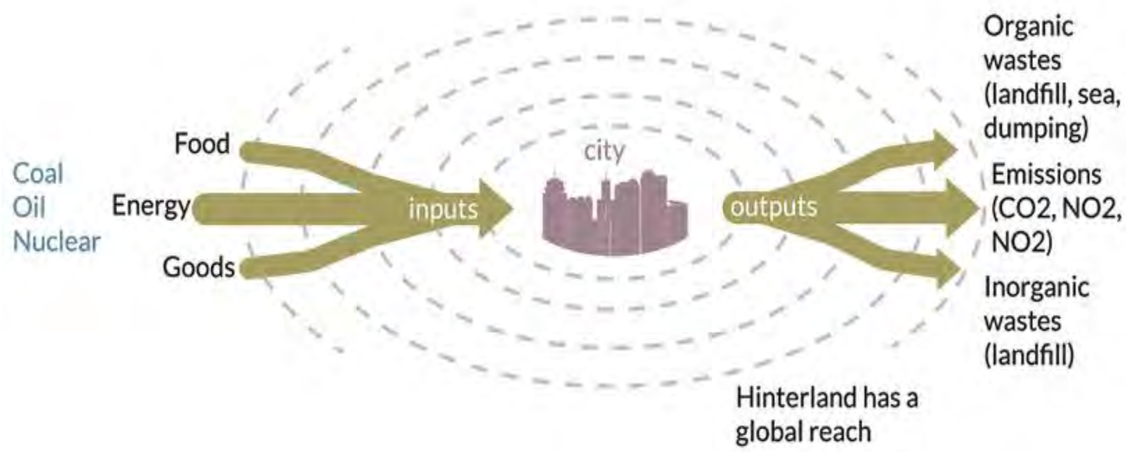

Figure 2.1: Linear urban metabolism
Source: Girardet (2010: 12)

[11] Broto et al. (2012) offer an overview of critical interdisciplinary perspectives of urban metabolism.
[12] Refers to those cities developed during and after the industrial revolution (Girardet, 2004).

Contemporary cities are largely dependent on (cheap) oil and other finite fossil fuels, and other natural resources. However, there is insufficient carbon space available, due to the phenomenon of accelerated climate change and adverse effects of global environmental change (IPCC, 2014), for contemporary cities to continue to be constructed in this manner. Moreover, resource peaking in natural resources such as oil, water, naturally sourced timber, food and soil, to name a few, is becoming increasingly common. Resource peaking is the phenomenon during which new discoveries and access to an exploitable finite, natural (cheap) resource does not equal demand[13]. Considered together, these factors demonstrate that perpetuating the incumbent urban development paradigm is no longer viable.

The origin of supplying linear ubiquitous networked infrastructures lies in the mid 19th century. However, these infrastructures became increasingly standardised post World War I, as Fordist management theory became consolidated as the dominant industrial development paradigm where modernist theory provided the rationale for design (Graham & Marvin, 2001). Graham (2010) describes how the expansion of centralised, cohesive infrastructure networks across vast landscapes was constructed to sustain a series of "flows, connections and metabolisms" with increasing efficiency (Graham, 2010: 1). Infrastructure networks form the base of production, distribution and consumption systems that underpin contemporary society. Since then, infrastructure projects have been considered a legitimate status symbol of modernisation, progress and power (Kaika & Swyngedouw, 2000). Their construction is still equated with the emergence of a better society (Kaika & Swyngedouw, 2000). While this symbolic power of infrastructure holds true for a while, it does not last. When these network infrastructures become ubiquitous and routine, as they fade from consciousness, they become *black boxed* (Kaika & Swyngedouw, 2000; Graham & Marvin, 2001). As a result, network infrastructures are assumed and taken for granted, rendering wholly dependent consumers ignorant of the underlying materiality of cities and disconnected from the origin of natural resource flows.

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13 The "oil peaking" phenomenon is a scenario in which oil production reaches a stable state and starts declining thereafter (Strahan, 2007). There are however some cases, like oil reserves, where although there might be considerable reserves left, even more than projected demand, the cost of extracting the resource becomes prohibitively expensive. Moreover, if the full environmental and social costs of extraction and processing were factored into the price, many of these resources would have peaked a long time ago.

2.1.1 Where infrastructure and decoupling meet

It was suggested in Chapter 1 that by adopting the notion of decoupling to inform decision-making for networked infrastructures, it is possible to envisage a more sustainable development trajectory to achieve a just and equitable target of 6 tonnes of material and 2.2 tonnes of carbon per capita per annum prescribed by the IRP and the IPCC respectively. Networked infrastructures that convey resource flows are an ideal intervention point because they partly determine the urban socio-economic metabolic rate. Two components of these systems are relevant to this discussion. Networked infrastructures have a resource demand component – i.e. the amount of material input required to produce a product or function, and an impact component – i.e. the negative environmental impact resulting from that specific production process. This links directly to the reconfiguration of network infrastructures in a way that decreases the resource demand of cities and minimises the consequential environmental damage, opening up room for a better kind of development for, especially, marginalised populations.

Girardet (2010) argues that, as an alternative to the incumbent, systemically flawed system, a circular one that mimics the ecology of natural systems should be designed and implemented (see Figure 2.2). In other words, a sustainable city has a more circular system of material flows, ideally to the extent that all wastes are eliminated and emmissions are radically reduced. As a result, input consumption decreases, while throughputs are more efficient and by-products are used again as inputs (Girardet, 2010; Doughty & Hammond, 2004). Moreover, Girardet (2010) suggests that these types of infrastructure systems have the capacity to regenerate natural systems, or what Birkeland (2008) refers to as the potential increase of natural capital. It is assumed that network infrastructure design that reflects the principles of the circular metabolism will have significant purchase in reconciling the sustainability challenges of the incumbent system with development needs of developing cities, as well as in retrofitting developed cities in a way that reduces the socio-economic metabolic rate. Collectively, reconfigured networked infrastructures that tend toward mimicking circular[14] metabolic systems are increasingly referred to as *sustainable urban infrastructure* (Zavrl & Zeren, 2010; Bry Sarté, 2010; Nam et al., 2007; Suzuki et al., 2009;

[14] While the logic of a closed loop is incorporated as a design principle, obtaining a zero waste metabolism, like in nature, is somewhat elusive. Inevitably, resource extraction and production processes will result in some waste; however, the important characteristic for urban systems to mimic is that by-products and wastes are well utilised and incorporated back into the system until they no longer hold energetic value. Only then are they discarded into the natural environment.

UNEP, 2012; IPCC, 2014). As a point of clarification: it is not suggested that urban systems will become closed off, localised and reliant on internal self-regulation; rather that the principles of decoupling and circular metabolisms be considered during infrastructure configuration decision-making processes.

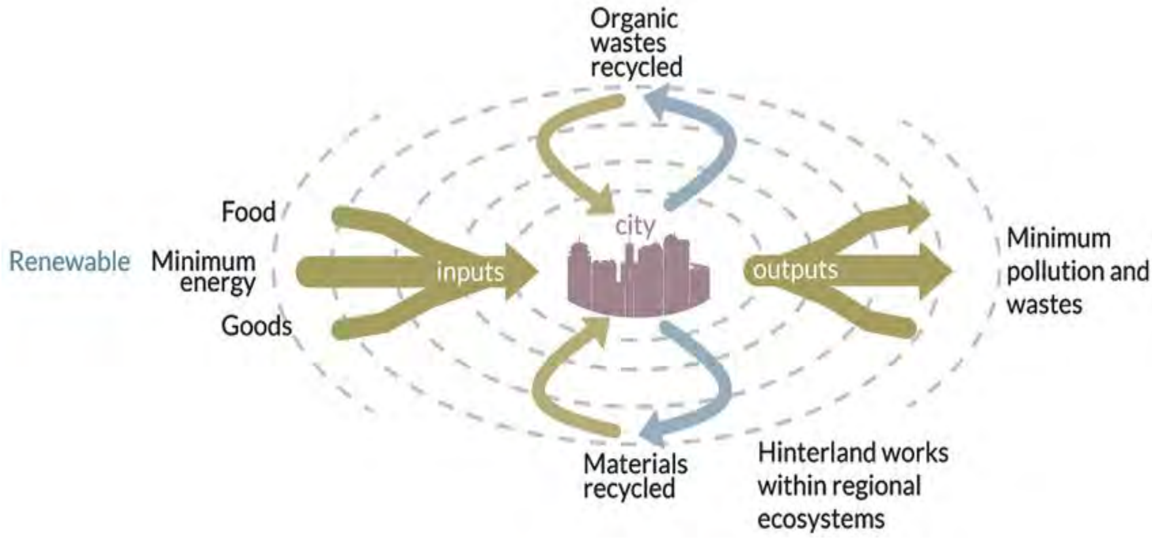

Figure 2.2: Circular urban metabolism
Source: Girardet (2010:12)

Decision-makers have at their disposal a number of concepts to assist them in the endeavour to configure more sustainable infrastructure systems, each with a set of ecological and economic opportunities and implications. By and large, best practise interventions use whole-systems thinking, in which compatibility and integration are central themes. It is suggested that rather than relying on distant hinterlands, cities should make use of the flux, renewable and secondary resources, from within their functional region (Rovers, 2007). By *multi-sourcing* (UN-Habitat, 2012) resources such as rainwater and solar energy there is an immediate reduction in the quantity of resources needed for urban reproduction. Expanding on this concept, *cascading resource use* is based on the principle of matching a resource flow to a specific requirement, depending on the quality, by assigning a value to all socio-economic metabolic flows, including production by-products (Rovers, 2007; Agudelo-Vera et al., 2012; UN-Habitat, 2012). Wastes are considered valuable rather than unwanted inconveniences needing treatment and disposal. For example, rather than using potable water for all needs, from drinking to removing wastes, it is possible to configure a system where grey water[15] from washing can be used to flush toilets, while the nutrient-dense black water[16] can be used for irrigation and compost (UN-Habitat, 2012). Together, this reduces the need for virgin resource flows while increasing the productivity of resource flows already in the system. Tasks can be achieved at the same standard yet using a lower quality resource flow, using substitution while unveiling hidden flows that reduce the overall demand for virgin resource flows. Other possibilities include *quality upgrading* and recycling resources on site at decentralised facilities or at semi-centralised facilities where dual systems are present (Agudelo-Vera et al., 2012). Decentralised and semi-centralised systems can be understood as distributed systems (World Bank, 2009). Facilities are located on site or at the neighbourhood scale and are designed with inherent flexibility and adaptability to meet the demand of that site or neighbourhood (UN-Habitat, 2012).

Following the example of water systems; these facilities are able to treat different kinds of wastewater and supply: i) reclaimed water for purposes such as street cleaning; ii) compost and fertilizer; and iii) depending on the facility, generate biogas from sewage sludge (UN-Habitat, 2012). Finally, *multi-functional design* is achieved through an integrated system that has the capacity to service different sectors from the same facility (World Bank, 2009). This strategy is represented by point three above, i.e. a water treatment facility that has the capacity to generate energy. Figure 2.3 provides an illustration of the comparison between conventional centralised infrastructure facilities and semi-centralised supply and treatment facilities. Identifying resource flows and the quality of those flows enables decision-makers to think more practically about how to design urban networked infrastructure. Table 2.1 provides a synthesis of a range of possible infrastructure options compared to conventional network infrastructure services.

[15] Grey water is potable water that has been used for human activities, which does not need to be treated before reuse for non-human activities, e.g. potable water from basins, showers, baths and washing machines can be used for flushing toilets.

[16] Black water is wastewater containing human faecal matter and urine.

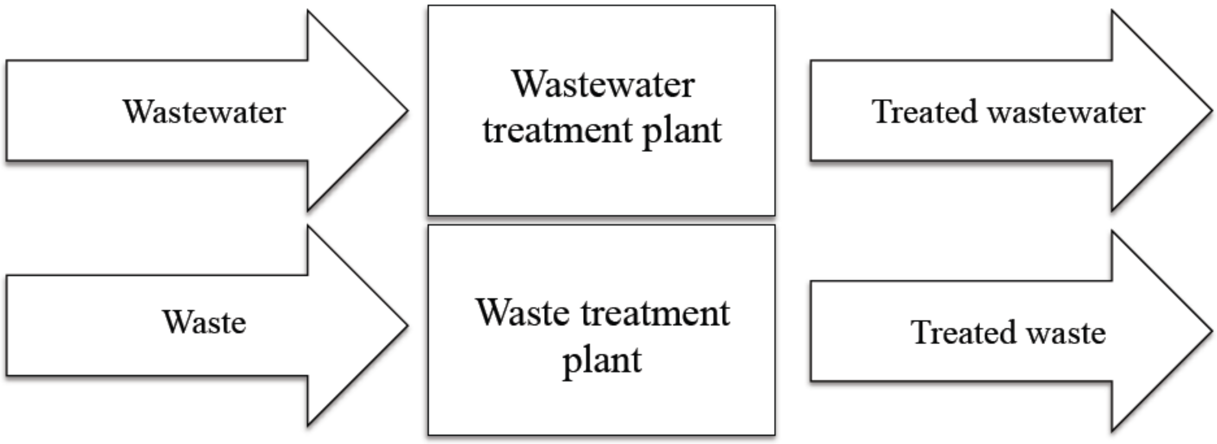

Figure: 2.3a: Conventional centralised infrastructure

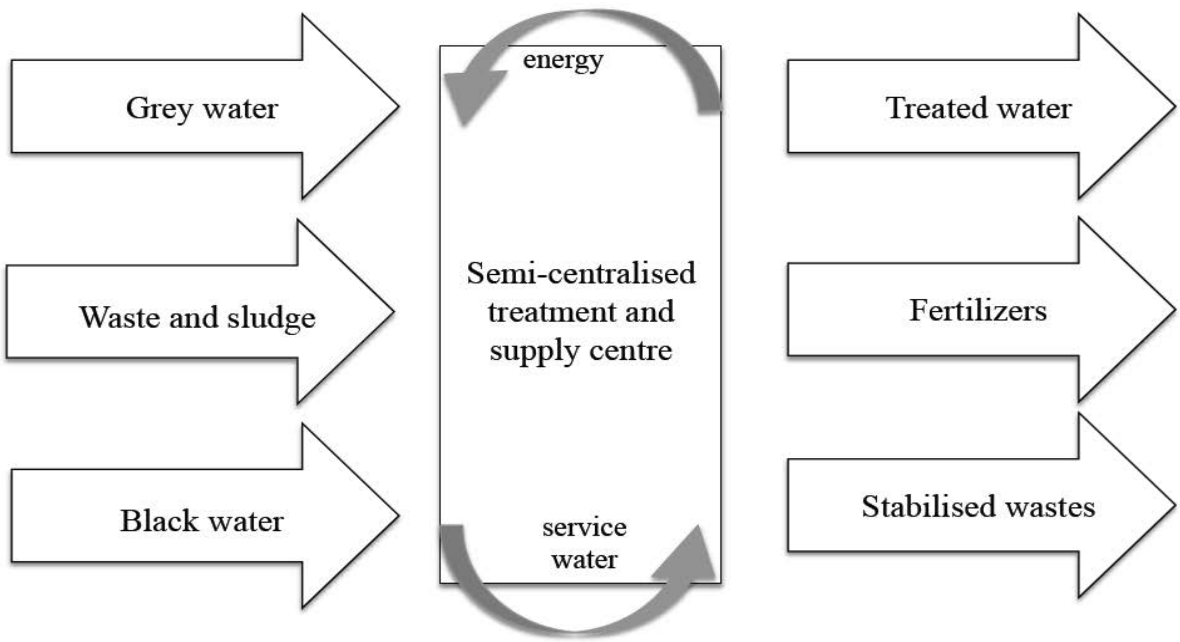

Figure: 2.3b: Alternative semi-centralised infrastructure

Figure 2.3: Comparison between conventional centralised infrastructure facilities for wastewater and solid waste (2.3a), and a Semi-centralised Supply and Treatment Centre (2.3b)

Source: Schramm (2011)

Table 2.1: Selection of conventioal infrastructure systems compared to alternative infrastructure systems

Sector	Conventional Technology	Resource Intensity	Emission/ negative impact	Alternative Technology Options	Resource Intensity	Emissions/ possible saving
Electricity	Coal fired power stations	Coal Water	469 to 1001g CO_2/kwh 78 kl / kWh	Concentrated Solar power	Solar	4 to 46g CO_2 eq /kwh
	Nuclear	Water	31-74 kl/ 1000kWh	Photovoltaic	Solar Water	14 to 19g CO_2 eq/kWh 10 kg / kWh
				Wind Turbines	Wind Water	Save 0.6 metric tonnes of CO_2 /MWh 1 kg / kWh
Water	Large dams, beyond the urban functional region	Rain water catchment at scale	Inefficiencies of treatment and reticulation	Water tanks/ urban water harvesting for low quality demands	Rain water	Offset potable water use/ offset treatment costs and emissions
				Desalination	Sea Water	1.8 kWh/m3
	Ground Water Aquifer Exploitation	Ground Water		Sustainable aquifer recharge	Treated waste water	Offset potable water demand
	Waste Water Treatment Works	Large scale treatment and disposal into natural water systems	CH_4 $C0_2$ Water contamination	Decentralised systems Dual Systems Vertically Integrated systems		Offset potable water demand

Sector	Conventional Technology, business as usual	Resource Intensity	Emission/ negative impact	Alternative Technology Options	Resource Intensity	Emissions/ possible saving
Solid Waste	Landfill	GHG gas Soil and water contamination Land use	CH_4 (45%-55%) CO_2 Mercury Titrium Leachate (combination of organic and inorganic, and metals and hazardous organic chemicals)	Avoidance, reuse, and recycle	Solid waste	Supply chain vast but improvements expected
	Incineration	GHG	1 Mg SW results in 0.7-1.2 Mg CO_2 N_2O	Composting / Anaerobic Digestion	Organic materials	Offset CH_4 emissions
				Gas capturing	Solid waste CO_2	Offset CH_4 emissions / energy demand

Source: Jones (2008) Evans et al. (2010); Elimelech & Phillip (2011); Sathaye et al. (2011); Moomaw et al. (2011); Wiser et al. (2011); Arvizu et al. (2011b); Raghab et al. (2013).

2.1.2 The nature of infrastructure

As it has been argued that networked infrastructure systems (with spatial restructuring) offer an opportunity to alter consumption patterns fundamentally, it would be useful to elaborate on how using infrastructures as an intervention point, a sustainable urban transition can be envisioned. Networked infrastructures are the mediators of resource flows, continually transforming nature into the urban (Kaika & Swyngedouw, 2006) and are actively involved in the "social production of urban natures" (Graham, 2010: 11). However, networked urban infrastructures are more than an accumulation of technical, inert components. Rather, they are a political construction balancing precariously on a foundation of social and vested interests (Pieterse, 2008; Graham, 2010). Significantly, infrastructures are complex and dynamic assemblages that fundamentally depend on human agency and contingency. As such they should not be considered autonomous and apolitical – or left to technicians. Geels articulates this imperative well:

> Artefacts by themselves have no power, they do nothing. Only in association with human agency and social structures and organisations do artefacts fulfill functions. In real-life situations (e.g. organisations, houses, cities) we never encounter artefacts per se but artefacts-in-context. For the analysis of functioning artefacts [i.e. infrastructure], it is the combination of the social and the technical that is the appropriate unit of analysis. (Geels, 2005: 365)

Thus, articulating network infrastructure as the physical manifestation of a series of complex political, technical, economic, social, cultural and environmental interactions allows one to rethink how these dynamic socio-technical processes are institutionally imagined and consequently managed (Guy et al., 2001). Moreover, different configurations, depending on the logic of network management, not only determine the nature of urbanism but also the socio-economic metabolic flows of the urban context.

Swilling (2011), building on the highly influential work of Graham and Marvin's (2001) seminal splintered urbanism thesis, describes a typology of urbanisms – inclusive urbanism, slum urbanism, green urbanism, and livable urbanism – using the lens of urban infrastructure. The logic of network management emerges in response to a set of conditions present at a particular moment, and therefore there is both a spatial and a temporal aspect to urbanism. As a departure point, the splintering urbanism thesis refers to the shift from the Keynesian welfare state, characterised by inclusivity, to liberalisation and privatisation, characterised by exclusion. Graham and Marvin reveal infrastructure, embedded in a socio-technical system, as being part of and subject to "the broader power relations of global capitalism" (2001: 190). This thesis is increasingly pertinent, considering how it has conceptualised the disintegrating nature of nationally integrated networked infrastructure to open a path for the establishment of the new spaces of agency (Bolton, 2011).

Inclusive urbanism is described as the outcome of the systematic expansion of standardised infrastructure services, initiated during the industrial revolution, consolidated in the post World War II mass production and consumption boom, and reaching its peak in the 1960s (Graham & Marvin, 2001). As "state-run, ecologically destructive, gas guzzling" infrastructure networks were extended through cities, the practice became institutionalised as the key to the modern western city (Swilling, 2011: 83). The result was an inclusive and equitable yet ecologically unsustainable (linear) system that supported the first urbanisation wave. Having the right to access affordable, high quality and reliable infrastructure services as inherent in the nature of inclusive urbanism is still, as an ideal, considered part of the social democratic vision and supported by state-run monopolies through complex cross subsidisation (United Nations, 2011; UN-Habitat, 2013).

As the polar opposite to inclusive urbanism, Graham and Marvin (2001) described *splintered urbanism* as the systematic dismantling of the social democratic governance and the emergence of the economic globalisation and financialisation. This dismantling included the privatisation and commodification of networked urban services, and handing over the decades of sunk investment to the private sector as well as access to abundant natural finite resources. The market unbundled urban infrastructure and subsequently supplied premium, high-tech, sophisticated infrastructure to globally connected enclaves that were based on the user pays principle (Swilling, 2011). The state-owned standardised systems built to achieve inclusive urbanism were thus replaced by splintered urbanism, an inequitable system leading to social fragmentation.

Swilling (2011) has contributed two additional lenses that can aid our understanding of the nature of urbanism. *Slum urbanism* has emerged as a means for slum dwellers and urban poor to incrementally eke out an existence alongside, yet distinct and isolated from, premium networked spaces. The messy urban form is the outcome of a protracted process whereby communities connect to networked infrastructure or create autonomous, self-managed systems, thus participating in the socio-economic metabolism. On the other end of the spectrum, *green urbanism* has become apparent in cities that are attempting to hedge against the infrastructure and ecological security obstacles they face by investing in a range of techno-fixes. Emphasis is on the reconfiguration of socio-economic metabolic flows through substantial public sector investments in networked infrastructures. While the overarching goal is to reduce damage to the environment, this legitimating ideology is at risk of preferring high-capital techno-fixes that are inherently "divorced from the realities of social process, culture and power", potentially resulting in the exclusionary practices of splintered urbanism (Swilling, 2011: 87).

As an alternative to the existing urbanisms, Swilling (2011) offers an aspirational ideal of *livable urbanism* that is based on the principle of *sufficiency* for decent livelihoods and regionalised bio-economic diversification. This is inspired by the influential work of Birkeland (2008), who advocates the need for a shift from "design for sterility to design for fertility" (Birkeland, 2008:3). Sufficiency, in principle, is achieved when the human rights of the poor are adequately met while high-income, over-consumers contract consumption to meet their material needs within the carrying capacity of nature (Swilling, 2011). Bio-economic diversification purposively includes the poor in new regionalised value-chains (Swilling, 2011). Livable urbanism, as "socially integrated bio-economic regions" are therefore the outcome of investments in social cohesion and innovation alongside investments into ecosystem service restoration (Swilling, 2011: 91).

While the logic of network management emerges in response to a set of ideological preferences present at the time, the underlying characteristics of modern network infrastructure have largely remained consistent. Only the dominating ideological theory shifts, which alters the underpinning model of delivery. Simply put, urban development theory shows that, historically, cities move in a linear trajectory from "primitive pre-modern" urban form to the "modern networked city" (Swilling 2011: 85). However, the modern networked city is not always achieved, and Swilling (2011) explicitly states how generally different urbanisms are juxtaposed within the same city.

Critically, while this discussion elaborates on the changing and contentious relationship between infrastructure provision, technology, consumption and urban planning, and the consequential restructuring of urban space, it is revealed as "both a symptom and a cause of the prevailing technical ideology of the networked city so long promulgated by discourses of urban engineers" (Graham, 2002: 176). At the core of the principles of the modern network city is the notion that sophisticated infrastructure is universally supplied across the city with a high level of economic and technical efficiency. Jonsson (2005) applies three characteristics to modern infrastructure: "cheap, convenient, and reliable" (Jonsson, 2005: 2). The sustainable urban infrastructure literature expresses the need to reconfigure infrastructure networks and thus make the primary characteristic that of sustainability when describing a networked city. The prevailing technical ideology must be replaced by new discourses that support the inclusion of sustainability when considering infrastructure network expansion.

Herein lies the link to reconfiguring networked infrastructures as socio-technical systems. The established urban development trajectory, facilitated by the expansion of infrastructure networks, must now be problematised and contested. Urban governments should actively promote the retooling of infrastructures, using decoupling as the theoretical underpinning, via combined effort between local governing bodies, the private and civic sectors. In this way, urban infrastructure can undergo a shift toward a more sustainable pathway. Several questions emerge: What kind of infrastructure *should* be invested in to ensure long-term sustainability? What are the options for existing infrastructures to be remade and retooled, as a socio-technical process, to become more sustainable in vastly different contexts? And lastly, how do network urban infrastructures transition to sustainable network infrastructure configurations? This is particularly significant for middle-income cities that face the challenges of resolving different patterns of urbanism present in one city, and where portions of the infrastructure networks are already in place. The major unresolved question is whether these interventions will offset the anticipated rise in Asia and Africa of a middle class that aspires to a level of consumption seen across the middle class in the global North. Ideally, cities must bear the characteristics of inclusive urbanism, without the techno-apartheid of splintering urbanism, while ensuring low carbon and resource-efficient urban development envisioned by green urbanism.

2.1.3 Infrastructure: obduracy or opportunity?

Investing in networked infrastructures is high on the agenda for cities and countries alike. In fact, over the next three decades, in order to accommodate urban populations, cities will spend USD 84.84 trillion[17,18] "on the construction, operation, and maintenance of urban infrastructure, including power production and distribution, residential and commercial buildings, water and waste systems, roads and transportation, and [an additional USD 43.63

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[17] Originally calculated at 350 trillion although this amount included expenditure on real estate.
[18] Calculated under business-as-usual assumptions and in constant U.S. dollars set at year 2000 (Pennell, et al., 2010).

trillion] on supporting information and communications technology" (Pennell, et al., 2010: 39). Pennell et al. (2010) explain that a relatively small increase in the up front investment in sustainable urban infrastructure will yield an enormous economic and environmental return because it will reduce investment requirements of the operating costs over its lifecycle, while reducing GHG emissions. The incentive is clear: not only are sustainable infrastructures ecologically imperative in the long run, they are financially feasible, and investment delays will raise future costs (GCEC, 2014). Some cities have already taken the initiative, successfully tailoring solutions that best suit their challenges, and begun to include ecologically based incentives and financial rescue plans (in light of the 2008 recession) (Swilling & Annecke, 2012; Pennell et al., 2010). Innovative financing strategies are a prerequisite when planning for infrastructure investment as a means to loosen the grip of capital financing restrictions (Pennell et al., 2010).

Nonetheless, opposing agendas and scarce financial resources stifle a broad base of political support for the kind of capital investments favoured by Pennell et al (2010). One of the arguments against the investments in infrastructure systems that promote sustainability is their *apparent* unaffordability (Suzuki et al., 2009). However, the incumbent paradigm focuses attention onto immediate costs, regardless of the fact that the lion's share of lifecycle costs of conventional infrastructure is in operation and maintenance (Suzuki et al., 2009). Also, there is a vast hidden economy around infrastructure maintenance and repair (Graham & Thrift, 2007) constituting as much as 10% of most urban economies of modern cities, "even though it is ignored in the accounts of the economies of contemporary cities" (Graham, 2010: 10). On the same note, a significant portion of local government revenue stems from utility sales that, paradoxically, make resource consumption efficiencies (for example in water and electricity flows) against their short-term financial interests.

The combination of these factors contributes to the obdurate, lock-in nature of existing networked infrastructures. Conventional systems have a high degree of path dependency that militates against sudden or risky change. A combination of factors account for the resistance to implementing alternative systems: physical embeddedness, sunk investments, which have increasing returns to scale (Van den Bergh, 2011), long-term financial liabilities and a substantial economic footprint in the urban system coupled with powerful regulatory and economic vested interests within the private and public sector that rely on favourable subsidies and regulations (Guy et al., 2011; Unruh, 2000). Summerton (1994) describes infrastructure as large technological systems (LTS), made up of a seamless web of both technical and non-technical components. These systems, constructed by system builders, develop a momentum and continually grow, due to increases in demand for services, into "large-scale, centralised and hierarchical systems built around a dominant technology … comprising of several sub-systems" (Moss, 2001: 44). System builders establish routines that regulate and maintain these conventional systems but lock out alternative systems, regardless of their demonstrable appropriateness (Unruh, 2000; Moss, 2001).

The discussion has thus far largely revolved around the resource flows through urban systems; however, during the formative years of a city's development a substantial portion of these flows accumulate within an urban system as 'material stock' (Niza & Ferrao, 2006). They form the nature and shape of the city, the urban form. In developed cities, decoupling, using infrastructure as an intervention point, will best be achieved by retrofitting cities, due to the vast quantity of embedded stock. In the instance of rapidly developing cities, opportunities are available for the design of sustainable infrastructure systems. Middle-income cities will have to find a balance between the two. Technical levers and interventions will differ in shape and size, determined as social and governance processes unfold. The increasing recognition of the importance of understanding the complexity of technological substitution as an outcome of fundamental social transformations, and vice versa, is significant. Central to this will be how vested interests view the relationship between cities, infrastructure and flows, and how the combination of governance, values and power intends to represent that relationship in the future (Hodson & Marvin, 2010a).

The discussion has highlighted the various contributions from the literature when considering sustainable urban infrastructure. In summary, it has shown that networked infrastructure is part of a larger socio-technical system in which institutions, both formal and informal, actively shape technical systems. Changes in the broader societal system, and the actors within them, account for changes to these technical systems. Therefore, purposive interventions that accept the socio-technical nature of infrastructure are critical for the implementation of sustainable infrastructure transitions. However, there are two major aspects that have been neglected in the literature: i) sustainable urban infrastructure remains under-defined, which limits the impact of this concept, and ii) the literature does not allocate sufficient attention to exploring under what conditions purposive interventions result in systemic changes and paradigmatic shifts. These aspects will be addressed in the remainder of this chapter and the next. It is also these issues that are at the heart of the relevance of the sustainable infrastructure perspective for growing middle-income cities in the global south.

2.2 Infrastructure transitions

An understanding of the conditions that must be present for the configuration of sustainable urban infrastructures is largely absent in the literature. Yet, these conditions determine infrastructure investment decisions. Having an aspiration for establishing the level of consumption articulated by the IPCC and IRP does not necessarily mean that a combination of interventions will yield that desired outcome. Cities have different development trajectories. Infrastructure decisions will be affected by the degree of urbanisation, population size, expected population increase, and the level, quality and type of existing services, as well as the capacity and capability of key decision-makers, but, most importantly, by the nature of the economy. The historical pathways of investment that account for the existing conditions in local contexts are of the utmost importance for infrastructure choices, and there is no single identifiable infrastructure package that can resolve urban challenges that drive unsustainability. Another critical aspect to this is moving beyond the notion of closing loops and improving urban metabolism, as suggested by Girardet (2010), to understanding what other criteria can or should be included to further encapsulate and explain what sustainable urban infrastructure actually means in practice. This refers to issues of decentralisation of services, the nature of material use versus resource intensity, and the degree of labour intensity versus capital intensity, for example.

2.2.1 Infrastructure transitions, sustainable configurations/reconfigurations

Cities have different contexts, and although solutions to complex urban challenges have been topical for some time, responses to urban pressures have varied. World cities have begun to secure strategic protection where possible by generating contextual knowledge to determine how to reshape their means of accessing and securing critical resources and materials (Hodson & Marvin, 2011). Moreover, there are some cities[19] that have begun to construct a more self-reliant urbanism through the internalising of resource endowments[20] as opposed to

[19] These are a very small proportion of cities and are generally located in Western Europe, USA and industrialised Asia.

[20] Hodson and Marvin (2009b) explain that in order to secure access to natural resource flows, cities have begun to internalise resource flows and create closed-loop systems that are self-sufficient. This reduces vulnerability to external environmental shocks and market volatility. Examples include renewable-powered desalination plants or decentralised energy plants.

the traditional method of seeking resources and waste sinks from distant locations (Hodson & Marvin, 2011). According to Hodson and Marvin this phenomenon has stimulated the creation of a "new network of global urban agglomerations", wherein these cities are working together to produce self-reliant urbanism by focusing on "protected space, bounding and enclosing resources" in order to guarantee intra-city and inter-world city mobility (2011: 57). Accumulatively these responses speak to the configuration of sustainable infrastructures; however, what sustainability means, and to whom, in these circumstances, has not been made clear by the authors. Admittedly, the authors do accept the prospect that sustainable infrastructure reconfiguration, as a meaningful response to global environmental change, might be replaced by 'green-lite' techno-fixes. Interventions that seek to simply minimise environmental damage through capital-intensive techno-fixes are in danger of losing touch with the human agency and contingency that is inherent to socio-technical systems.

The ideas of urban sustainability and sustainability of infrastructure found a niche in urban management processes through the notion of risk. The post-September 2001 awareness of an increasing threat of terrorist action against critical infrastructure sectors and the consequential disruption of economic reproduction and competitiveness brought to attention the vulnerability of infrastructure networks (Lewis, 2006; Hodson & Marvin 2009b). The fragile state of ageing networks across cities is further demonstrated by the increasing threat of climate change and the consequential increase in frequency of major natural disasters (Sattherwaite et al., 2007). These challenges coupled with the emerging threats associated with natural resources constraints, resulted in the infrastructure-protection agenda significantly shifting to the ecological-security agenda (Pirages & Cousins, 2005). Hodson and Marvin (2010a) interpret the restructuring socio-economic metabolic flows through the reconfiguration of infrastructures as an endeavour to generate *secure urbanism* and *resilient infrastructure* with the intention of producing *urban ecological security*. In essence, the multiple threats associated with networked infrastructure have highlighted the risk associated with networked infrastructure system failure. Significantly, this has brought to the fore fundamental questions about the nature and prospects of existing infrastructure network systems and the potential future responses to (re)configurations.

Hodson and Marvin (2010a) developed a conceptual framework of *new* responses as implemented in cities and regions across the world, which focuses on understanding the nature and scope of these responses (Hodson & Marvin, 2010a; 2010b; 2010c). This conceptual frame provides insight into different responses with regard to a city's socio-technical context, while locating these responses within the broader socio-ecological transition currently underway (Perez, 2007; Haberl et al., 2011). Furthermore, while each city has its own combination of challenges as well as opportunities, this typology was developed to assist decision-makers in identifying best practices and potentially appropriate solutions for urban infrastructure development and urban development. It also provides academic researchers a useful typology to cluster and potentially compare case studies.

Hodson and Marvin (2010a) identify four *rebundled network ecologies*[21] as alternative responses to the status quo. For the purposes of this thesis, these rebundled network ecologies will be referred to as *reconfigured networked infrastructure bundles* to simplify the language and focus on networked infrastructure. Each reconfigured networked infrastructure bundle is characterised by two dimensions: integrated/systemic or network based, and new development or existing legacy (which implies retrofit). This typology is represented by Figure 2.4. The first dimension, integrated/systemic versus network based, refers to the scale of an intervention, whether it is an integrated system change by building new developments and retrofitting entire systems or, alternatively, at the level of a specific infrastructure network (Hodson & Marvin, 2010a) The second dimension, new development versus existing stock, refers to whether an intervention is a new development with specific boundaries in which infrastructure solutions are developed or whether existing cities require the retrofitting of already installed urban infrastructures (Hodson & Marvin, 2010a). Responses at the urban level are based on the scale of the infrastructure reconfiguration, illustrating the potential for an alternative type of urbanism that reshapes the relationship between the city and networked infrastructure (Hodson & Marvin, 2010b). The four reconfigured networked infrastructure bundles are as follows:

New developments as integrated eco-urbanisms

As the heading indicates, these are new developments that provide integrated responses, across infrastructure networks, to urban challenges. This can be achieved on various scales, from houses and buildings to neighbourhoods and cities, on greenfield sites. The key principle is achieving integration on the scale of the project so as to realise varying degrees of resilience and self-reliance, thus producing urban

[21] This refers to the "process of selective repackaging of infrastructure networked, material resources, and the built environment at particular scales to produce rebundled network ecologies" (Hodson & Marvin, 2010a: 145)

ecological security. Interventions such as these are rarely concerned with wider transformation of the existing networks although they are often replicable, despite their somewhat experimental nature. Examples include eco-cities such as Dontang in China and eco-villages such as Gaviotas in Colombia.

Reconfiguring cities as systemic urban transitions

Purposive urban transitions in cities, in which cities deliberately attempt to reconfigure packages of infrastructures, recognise the socio-technical organisation of these systems. Technical components as well as social, institutional and political considerations are consciously taken into account through systemic strategic planning. In most instances this involves a variety of stakeholders who participate in building a vision for an existing city in preparation for climate change and resource constraints. The relationship between the city and existing infrastructure networks is thus purposively reconfigured. Curitiba in Brasil is an extensively documented example of this.

Constructing new urban networked technologies

While new developments have a specific boundary, new networked technologies are developed as an alternative and to work in conjunction with existing conventional infrastructure systems. Depending on the service, these technologies are new, constructed to work in parallel with existing systems or support them by restructuring resource interdependencies. These interventions generally improve the resilience of the entire urban system due to their role in hedging against resource insecurity, particularly in energy, waste and water networks, as well as mobility.

Retrofitting existing urban network technologies

The retrofitting of a specific infrastructure network is usually an outcome of policy, resource insecurity, or civic activism, wherein communities adopt the responsibility for provision of a particular service. These usually address a particular challenge in an urban context, although not necessarily a systemic change. It is often the case that these emerge as alternatives to address a short-term shortfall in the existing system, yet have a substantial impact.

<table>
<tr><td colspan="4">New Build/New Construction</td></tr>
<tr><td rowspan="2">Integrated/ Systemic</td><td>New Developments as Integrated Eco-Urbanisms</td><td>Constructing New Urban Networked Technologies</td><td rowspan="2">Network Based</td></tr>
<tr><td>Reconfiguring Cities as Systemic Urban Transitions</td><td>Retrofitting Existing Urban Networked Infrastructures</td></tr>
<tr><td colspan="4">Existing Cities/Retrofitting</td></tr>
</table>

Figure 2.4: Reconfigured networked infrastructure bundles
Source: Hodson & Marvin (2010: 87)

The four reconfigured networked infrastructure bundles describe the various possibilities for infrastructure (re)configuration as cities seek to decrease metabolic flows. These reflect a multitude of applicabilities for differing contexts, drawing conclusions from a series of case studies that have been extensively examined. Importantly, it represents the potential scenarios that cities will face when considering how to make a transition toward sustainability.

How exactly these transitions toward sustainability will play out is however uncertain. It is clear that the cases being documented are emerging as alternatives and investments are taking place in only a few cities and still account for a small percentage of total infrastructure investment (Shlyakhtenko & La Rocca, 2012). The required investment of at least USD 5 trillion a year for the *greening* of infrastructure is by no means being met (World Economic Forum, 2013). The cases of alternative configurations are considered outliers, while the bulk of capital investment is allocated to mainstream conventional technologies that support urban reproduction. The empirical chapters that follow provide evidence of the complexity and challenges of transitions from the status quo to the alternative, which accounts for the inertia around systemic change. Furthermore, there is the need to understand: i) the circumstances under which these transitions might be integrated/systemic or sectoral in nature, and ii) the principles that guide decision-makers on the specific infrastructure (re)configurations and on what scale it should take place. This will directly impact the effectiveness of purposive interventions for systemic transitions. Therefore, the notion of sustainable infrastructure needs to be more deeply explored and specified if it is to be used as a tool for decision-makers for academic inquiry and decision makers responsible for urban governance and management.

2.2.2 Principles underpinning sustainable urban infrastructure

The extent to which cities can contribute to the resolution of adverse global environmental change will depend on the specific infrastructure choices made and on what scale. A fairly substantial literature has been amassed promoting the value of sustainable infrastructure. Consensus regarding what sustainability means in this context has however not been clearly articulated. It is of course directly linked to the theory and discourse of sustainable development and in most texts it is referred to as infrastructure that promotes sustainability (Zavrl & Zeren, 2010; Bry Sarté, 2010; Nam et al., 2007; Suzuki et al., 2009). By and large, preferable network infrastructure systems are linked to the notion of infrastructure that decreases urban metabolic flows. Furthermore, instead of defining sustainable infrastructure, a trend has emerged that measures the sustainability of infrastructure (Zavrl & Zeren, 2010). Recognising the absence of an agreed definition in the literature, one of the most recent (one-dimensional) iterations of the definition of sustainable infrastructure is provided by Mainelli and Von Gunten:

> [Sustainable infrastructure] reduces the environmental impact of urban infrastructure such as energy efficiency and renewable energy projects; improves the climate resilience of urban areas by improving the ability of infrastructure to cope with the consequences of climate change; help to protect biodiversity and ecosystem services; supports the integration of nature-based assets into urban development (2015: 12).

It is clear that a definition must be agreed upon, or else there is the risk this notion will be doomed to the same fate as sustainable development: constituting a broad meta-objective without substantive impact.

To date, sustainable infrastructure as a notion has motivated world cities to act by investing in (what are colloquially knows as) 'green' high-tech systems to ensure their continuous reproduction, while setting a bench mark through acting as urban laboratory for others (Hodson & Marvin, 2010c). At the other end of the spectrum, small scale, low-tech alternatives have been seen to create inclusive self-sufficiency and a positive impact for the provisioning of services at the local level (Swilling et al., 2011; UNEP, 2012; UN-Habitat, 2012). These have been accounted for in the typology represented by Figure 2.4. While the

IRP and IPCC have made recommendations for per capita resource consumption and emissions, dividing environmental space remains a complex and highly politicised international process. Without a shared vision of the meaning of sustainable urban infrastructure, structured interventions will potentially derail sustainable transitions pathways. One can imagine that the understanding of an engineer, economist, politician, environmental scientist and social activist might be very different.

In order to fulfil the conceptual task of this thesis, it was important to organise the positions on sustainable infrastructure, which have been evolving in various forms over the past several decades. A device that artificially separates a range of overlapping yet distinct discursive domains was created to organise the literature and analyse the discursive mediation of infrastructure transitions. This artificial separation is necessary for the endeavour to analyse the data collected during the fieldwork; however, it is recognised that, in reality, the lines between these discursive frames are blurred and more nuanced then expressed here. The categorisation is the inspired by the work of both Allen (2001) and Swilling (2011) as discussed in sections 1.2.1 and 2.1.2 respectively, but the construction is based on the implications of the various interpretations of the literature. The basis for the separation, as will be shown below, is an analysis of the extent to which various positions and interpretations of sustainable urban infrastructure, as described in the literature, promote the attainment of ecological restoration and social justice.

The first discursive domain, of modern conventional infrastructure networks, based on the principles of cheap, convenient and reliable was introduced in the preceding part of this chapter. Generally speaking, these systems are maintained through a commitment to urban reproduction and the status quo through service delivery and ongoing maintenance.

This section begins with what can be considered as the second discursive domain of infrastructure. Interventions that configure *efficient infrastructures* primarily seek to improve energy efficiency. These are generally stand-alone, techno-fixes that reduce wasteful resource and energy consumption of networks and the built environment. The third discursive domain can be regarded as *eco-efficient infrastructures* that inherently refer to both the economy and ecology, seeking to ensure the productivity (and efficiency) of both. The fourth discursive domain is considered as *regenerative infrastructures* that are designed with the intention of contributing to environmental and ecological enhancement from an ecosystems services perspective. Lastly, the fifth discursive domain, although not directly related to the sustainable infrastructure literature, is related to the role of infrastructure service delivery for human development. It is described as infrastructure that secures *social justice.* Read together, these domains help to organise the data and build an evaluative framework of the sustainable urban infrastructure literature. It points to the spectrum of choices with regard to infrastructure sectors that decision-makers could draw from.

2.2.2.1 Second discursive domain: efficiency gains through technological interventions

In the second discursive domain, interventions are commonly used to promote goals of 'efficiency improvements' (Weisz & Steinberger, 2010), 'low impact design' and 'low carbon cities' (Maassen, 2012; Siemans AG, 2010), and as such these configurations have been categorised here as *efficient infrastructure.* The primary interest here is energy efficiency as a means to address the challenge of accelerated climate change and global warming. Considering that the cities produce 80 percent of carbon emissions, this is clearly important. Therefore, this paradigm is somewhat obsessed with improvements to electricity generation, transportation, the construction industry and the built environment, which have become significant strategic intervention points.

Material and energy intensity of cities follows a somewhat similar usage trajectory through the urbanisation process; however, as urbanisation stabilises, energy intensity continues to increase while material intensity reduces considerably (Fernandez, 2007). Efficiency gains in these sectors therefore have substantial potential (Siemans AG, 2010). Figure 2.5 represents this simple principle. As the built environment is the single largest sector in energy end users, technological interventions are focused here: insulation improvements, efficient heating and passive heating, the use of efficient appliances and lighting, as well as selection of environmentally and energy efficient material during construction are considered to be vital for successful carbon emission reduction (Lior, 2008; Siemans AG, 2010). It is argued that if cities take advantage of all the energy-saving potential available, achieved through efficiency interventions, it will be possible to generate sufficient energy from renewable and low carbon resources to meet the needs of an average large European city (Siemans AG, 2010). However, this begs the question as to how growing cities in the global south that are still undergoing urbanisation processes when both material and energy intensity is extremely high, will meet energy demands without a rigorous reconfiguration of infrastructure networks, unlike the technological modifications suggested in this approach.

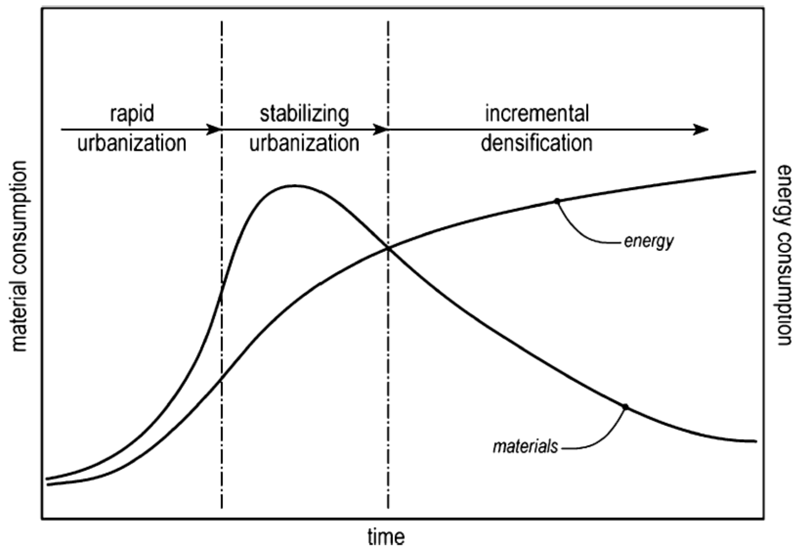

Figure 2.5: Material versus energy consumption during urbanisation
Source: Fernandez (2007: 107)

Efficiency has its roots within the engineering discipline, where the focus is on obtaining the most efficient output per unit of input or "delivering the best service using the least amount of resources" (Sahely et al., 2005: 75). Resources in this instance pertain to natural, human and financial resources. Therefore, inputs include material input but also financial input – the latter traditionally being the overriding concern for decision-makers, who are instrumental in configuring network infrastructure bundles – and consumers, and as such carry more weight when determining overall 'sustainability' of a particular infrastructure network (Sahely et al., 2005). Moreover, because engineering by and large understands sustainability as a "multi-objective optimisation" problem, trade-offs are inevitable (Sahely et al., 2005). Therefore, when the sustainability of infrastructures comes into question, ensuring the ecological and financial, as well as engineering integrity of a system is of importance. It is common that during decision-making processes, if the engineering integrity or financial sustainability is presumed to be potentially in danger, the ecological efficiency elements will be traded off. Efficient infrastructures are therefore concerned with minimising material and energy flows while ensuring sufficient revenues are generated over the lifespan of the infrastructure to cover the installation, operational, maintenance and replacement costs (Sahely et al., 2005).

Significantly, efficient energy-saving technologies have a high initial cost and therefore require higher up front capital investment, for which consumers – citizens and industry – and the public sector will be equally responsible (Siemans AG, 2010). It is argued that a reduction in operational costs and energy savings generated over the product lifecycle will offset the initial investment required, while urban centres will gain a competitive advantage (Siemans

AG, 2010; Pennell et al., 2010). The major concern with this approach is that it is dependent on consumers and private investors being able to recognise the long-term benefits of these investments. This will be an enormous challenge for a society that is only able to grapple with what is local in "both space (things that we are immediately involved with) and time (not very far in the future)" (Flood, 1999: 129).

Moreover, interventions proposed by the efficiency school are by and large techno-fixes that do not take into account the significant role that human behaviour plays in consumption patterns. Through efficiency interventions it has been suggested that citizens will **not** have to adjust their behaviour fundamentally to reach ambitious carbon emission reduction goals (Siemans AG, 2010). However, this is contrary to the sustainability imperatives that depend on consumption patterns changing fundamentally. Efficiency gains will more than likely be offset by the rebound-effect[22] as existing patterns of behaviour remain largely entrenched (Weisz & Steinberger, 2010). Moreover, household income, it has been shown, correlates with energy and material usage, and as income increases through conventional developmental processes, it is likely that the income-effect[23] will be activated. Harberl et al., (2004) argue that proactive measures can counter behaviour such as 'socio-ecological tax incentives' that incentivise energy savings through an increase in the cost of energy while reducing the cost of energy saving services; yet it is unlikely that this type of parallel intervention would be seen within the efficiency paradigm. Networked infrastructure is not merely an assemblage of material components; rather, it is the result of complex technical, social, economic, ecological and political processes and should be treated as such. The socio-technical nature of infrastructure must be explicitly considered, if not fully understood, to prepare for the nuances that emerge during development processes. An example of the causal logic is as follows: as the second urbanisation wave unfolds, it is assumed that parts of the population will shift into the middle-class income bracket, which will significantly change consumption patterns leading to an increase in consumption and the consequential losses to efficiency gains.

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[22] The rebound-effect refers to the increased consumption of energy services due to the reduced cost achieved through energy efficiency gains (Swilling & Annecke, 2012). However, Swilling and Annecke (2012) question whether, in light of rising commodity prices, the rebound-effect is really still a significant threat.

[23] The income-effect is an economic phenomenon wherein income is positively related to the quantity demanded of a good or service. Therefore, as income increase, so does the demand for material and energy in urban areas (Blanchard, 2006).

That being said, the question is whether technical fixes have sufficient purchase in resolving the issues of resource scarcity and the overarching crisis that is emerging due to global environmental change or whether it does have a role in successful urban transitions. With Allen's (2001) description of urban sustainability in mind, while these interventions will contribute to minimising the resource flows required to reproduce the city, these interventions are unlikely to alter urban metabolic flows in a manner that would shift the urban system onto a sustainable development pathway. Is it necessary to recognise not only the physical and environmental dimensions of sustainability but also the economic, social and political nature of urban sustainability processes (Allen, 2001).

2.2.2.2 Third discursive domain: utilising the model of eco-efficiency

The notion of *eco-efficiency* has emerged as an alternative superior to conventional understanding, which accepts trade-offs as inevitable and environmental degradation as an externality (Nam et al., 2007; Suzuki et al., 2009). While the origins of this concept lie in management philosophy, eco-efficiency has been deepened and broadened and can now be applied to the sustainable infrastructure discourse.

Eco-efficiency is established through the "delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle" (WBCSD, 2000:9). At the more basic level this concept brings together the economy, environment and efficiency, transcending efficiency by creating synergies as opposed to trade-offs (Suzuki et al., 2009; United Nations, 2011). In this way the prefix *eco* refers to economy and ecology. Furthermore, the notion is underpinned by the rationale of *doing more with less* as well as creating added value. Ekins and Tomei (2007) elaborate by explaining that eco-efficiency is concerned with productivity, which is broadly concerned with the production of welfare. It measures the effectiveness of the economy as a generator of added value from the use of nature (Ekins & Tomei, 2007). Therefore, it does not only concern itself with reducing material and energy intensity of an economy but increasing the productivity thereof (Nam, et al., 2007). Eco-efficiency is therefore closely linked to decoupling, considering economic growth that supports human development as a necessary condition, while minimising environmental damage. As such, this approach seeks to address both consumption and production patterns. Nam et al. (2007) argue that for eco-efficiency to be achieved, major shifts are required in society's metabolism.

Transitioning to sustainable metabolic rates using eco-efficiency principles links the environment to economic activities as a consequence of the increasing recognition of the embedded and interrelated nature of the relationship between the two (Nam et al., 2007; Suzuki et al., 2009; United Nations, 2011). This, together with the acceptance that infrastructure facilitates urban socio-economic metabolisms, has strengthened the argument for using *eco-efficiency* as the lens when making infrastructure decisions. As a result, a discourse around *eco-efficient infrastructure* has been developed. Numerous technologies, developed in response to the ecological crisis, can be applied to meet the criteria of these preferable infrastructures systems and extend across sectors to include transport, energy, water and waste systems; some of these are described in section 2.1.1 and Table 2.1.

Much of what is described by Suzuki et al. (2009) reflects an approach that adopts eco-efficiency. Investing in both the urban economy and ecology, in which it is embedded, is articulated as a means of driving (and ensuring) economic competiveness through which quality of life is maintained or improved (Suzuki et al., 2009). This is supported by the notion of the city as a centre of productivity and innovation – the engine of the knowledge economy (Amin & Thrift, 2002). In other words, ensuring the eco-efficiency of the urban system ensures that it will remain competitive as the prices of commodities and carbon increase, while resources become increasingly scarce. This is achieved by configuring system-wide networked infrastructures with an eye on the entire lifecycle, using an integrated approach. Suzuki et al., (2009) use the notion of a one-system approach wherein decentralised local governments[24] are the principle actors and take the lead in interventions processes. Planning, designing, operationalising and managing processes of the urban system are therefore integrated across sectors within a particular urban context. Coordinating the networked infrastructure system design that considers both resource flows and urban form is therefore central to achieving eco-efficiency (Suzuki et al., 2009; Moffatt et al., 2011). With a clear understanding of the urban form the nature of resource demand can be determined, as well as the various parameters that need to be taken into consideration when operationalising infrastructure systems. Herein is another significant advancement of eco-efficient infrastructure – it is demand-side orientated, rather than supply-side. An integrated, one-

[24] The decentralisation of fiscal and adminstrative responsibility has transferred decision-making and management power to local governments, allowing cities to activate agency through proactive leadership (Suzuki et al., 2009).

system approach assumes the development of synergies across sectors (Suzuki et al., 2009; Moffatt et al., 2011).

The core premise of using eco-efficiency, “to satisfy human needs and bring quality of life” (WBCSD, 2000: 9) does not however translate meaningfully into practice. Strictly speaking, eco-efficient infrastructures do not address the social aspect of sustainability. Reference is made to the role eco-efficient infrastructure systems play in improving social infrastructure, amenities, and even urban aesthetics, and therefore quality of life. Suzuki et al. go as far as to consider well-coordinated urban planning as the means to “help integrate the urban poor into economic, social and physical fabric of the city” (2009: 24). However, this is somewhat detached from the reality of urbanisation processes occurring in the global south. It is still assumed within global policy discourse that it is possible to avoid the proliferation of informal settlements in the global south with immediate investments (Mainelli & Von Gunten, 2015: 12). This however is unlikely considering the major structural challenges that face governance institutions in these contexts.

In response, the United Nations (2011) developed guidelines for the implementation of Eco-Efficient and Socially Inclusive Infrastructure that extends access to quality services to all urban citizens. What this actually translates into is the notion of universal access as prescribed by traditional, conventional infrastructure planning. Embedded in this notion is also the idea that society should play a role in infrastructure management and maintenance. This discourse from the United Nations (2011) utilises all the key phrases that reflect a socially orientated governance approach, including ‘stakeholder partnerships’, ‘community involvement’ or ‘participation’, especially for developing cities. It assumes democratic deliberation, but the conceptual blind spot of eco-efficiency is the absence of any real engagement with power or vested interests that maintain the status quo.

Eco-efficient infrastructures can, alternatively, be thought of as allowing environmentally friendly economic growth (Haberl et al., 2011) so as to ensure developing cities have an opportunity to accumulate some level of urban stock. Here, relative **resource** and **impact** decoupling directly links, as a notion, to the practise of eco-efficiency. Relative decoupling will not however be sufficient to transition the global socio-economic metabolism to a more sustainable development trajectory that is within the limits of the earth’s carrying capacity. The intention is not to be overly critical of relative decoupling through eco-efficient networked infrastructure – this is a crucial component of achieving a transition toward sustainability. It is, in fact, likely that a combination of relative and absolute decoupling will be seen in various cities, depending on the stage of development, as material-flow-analysis (MFA)[25] becomes a regular practice. While MFAs are increasingly common, they are not always a comprehensive accounting of *all* urban stocks and flows, because they vary in scale and nature. Yet, there is evidence of the value of this measurement system for determining urban resource flows and comparing experiences across time and space. Examples include Gasson (2002), Meinzinger (2010) and Weidmann (2013).

The question remains – to what end? Theoretically eco-efficiency does not do justice to what sustainable infrastructure should equate to. As early as 2002, Martinez-Alier (2002) critiqued the gospel of eco-efficiency. This points at the necessity of realising absolute decoupling – especially if humanity is to stay within the earth's carrying capacity, as it is "unrealistic to assume that eco-efficiency could achieve the reduction in resource use by industrialized countries per capita and per year that sustainable [urban] development requires" (Haberl, et al., 2011: 8) as per Allens's (2001) definition. The re-orientation of modernism, using the principles of clean-tech/green-tech dematerialisation and eco-efficiency, holds closely to the modernist principles of technical progress, science, control and economic growth (Geels, 2011a). Cognizance must be taken of the agenda underlying eco-efficient infrastructures, when considered in the broader sense of an urban system. Much of the eco-efficient infrastructure literature is illustrative of attempts to ensure the continued material reproduction of the city in a manner that facilitates the over-consumption of the global elite while ignoring the issue of resource politics and uneven access (Hodson & Marvin, 2010c). In this case, sustainable development as an aspiration has been hijacked by neoliberal accumulation strategies. "The organization of cities, infrastructures and resource flows and the relationship between them … are complex, deeply political and rooted in ideological struggle, governed through inter-institutional negotiations, often mediated through the notions of competitiveness, [and] entrepreneurialism" (Hodson & Marvin, 2010a: 29). Considering the sentiment of Haberal et al. (2011), this is an inadequate theory of change and it is clear that a new development paradigm that transcends the failure of modernist values and ideals is needed.

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[25] The Material Flow Analysis (MFA) was developed as a means of calculating material stocks and flows within a spatially and temporally defined system, and quantifying the relationship between the environment and its embedded systems (Niza & Ferroa, 2006).

2.2.2.3 Fourth discursive domain: regenerative cities

Girardet (2010), following Reed's (2007) description of *regenerative design*, changes register by introducing the idea of *regenerative cities* that are beyond efficiency, eco-efficient, or low carbon systems. This approach fundamentally seeks to protect and promote the integrity of ecosystem services on which society and urban systems depend. Simply minimising damage[26] will not resolve the multiplicity of environmental challenges that continually reinforce one another. Rather, networked infrastructure systems need to be designed to restore natural systems and ecosystem services. The regenerative cities discursive domain is based on Girardet's (2010) logic of a circular system that aims to achieve resource efficiency and productivity while replenishing degraded ecosystem services. This is the outcome of what Girardet (2010) calls comprehensive strategies across political, technological and financial domains that are designed to create a restorative relationship between cities and the ecosystems services that they depend on. Regenerative infrastructure is aligned with Birkeland's case for the provision of "infrastructure for nature to regenerate, flourish and deliver ecosystem goods and services in perpetuity" (2008: 4). However, regenerative infrastructure must not be misinterpreted as ecological infrastructure (the earth's natural capital), which requires investment and protection in its own right (Wilson & Browning, 2012). Rather sustainable, networked infrastructures must be configured so as to compliment ecological infrastructure through design that is sensitive to ecosystem services, whereby development processes would have a net positive benefit. Through this approach, in which systemic behaviour change is the departure point, expanding nature becomes possible, and therefore so does urban resilience (Birkeland, 2008; Girardet, 2010; Geels, 2011a; Du Plessis, 2012).

Thus, the overarching objective of the development process is creating "a future where people can live in mutually supportive symbiosis with their social and biophysical environment (their whole ecological system) – supporting their mutual evolution" (Du Plessis, 2012: 17). Du Plessis (2012) however reminds us that because urban sustainability is a systemic problem, it will not be resolved through a series of individual economic, technical, political or financial interventions; rather, urban sustainability will be the outcome of the interaction between these larger components. Therefore, a paradigm that gives preference to regenerative infrastructure:

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[26] Non-renewable resources, which took billions of years to accumulate, have over the past 300 years been largely depleted through 20th century industrialisation processes.

> attempts to address the dysfunctional human–nature relationship by entering into a co-creative partnership with nature. It aims to restore and regenerate the global social–ecological system through a set of localized ecological design and engineering practices rooted in the context and its social– ecological narratives (du Plessis, 2012: 19)

It is suggested that a regenerative paradigm is uniquely differentiated from eco-efficiency in that it arises out of a condition that supports the flourishing of all life (Du Plessis, 2012). However, similar to ecological modernisation through eco-efficiency, where environmental problems are framed as a business opportunity, retaining the priority of economic development (Baker, 2007), in the regenerative paradigm, the regeneration of ecosystem services is prioritised. Where then is the consideration of social justice and equity? (Baker, 2007; Keil, 2007).

2.2.2.4 Fifth discursive domain: restoration aligned with social justice

The fifth discursive domain seeks to address the question of social justice and equity in urban territories, where differentiated socio-economic rights are pervasive. In fact, "issues of injustice, inequality, exclusion and exploitation are central to the nexus of cities and nature" (Cook & Swyngedow, 2014: 183). It is further recognised that the production and reproduction of the urban space result in injustices across the city; some win and others lose (DeFilippis & Rivero, 2014). However, Agyeman (2013) is clear in his assertion that more sustainable cities recognise the dependence of the economy on a healthy society and a healthy society is "dependent … on greater [social] justice and equality" (Agyeman, 2013: 18).

The transformation of nature into the urban through socio-economic metabolic processes shapes socio-ecological and socio-economic relations, and, as a result, urban injustices (Cook & Swyngedow, 2012). The primary interest of this thesis is networked urban infrastructure, and, therefore, the specific role of infrastructure networks in the facilitation of these transformation processes. It brings to the attention how the configuration of infrastructure affects urban justice and injustices by determining who benefits, at the expense of others. This advances the argument for the reconfiguration metabolic flows, not only for environmental restoration but also for social justice.

When considering the future social-ecological development trajectories it is impossible not to agree with Cook and Swyngedow (2014) who remind us of the intensely political processes that characterise development. Power relations shape the production of urban space in a particular manner that reflects only the preferences and desires of some groups, while ignoring others (DeFilippis & Rivero, 2014). At the same time, wealthy elite, corporate and private interests, and even governments, consciously and implicitly act against systemic change in the effort to hold onto existing structures that maintain economic growth and dominance (Agyeman, 2013). The poor and marginalised, on the other hand, generally lack sufficient economic demand, constraining their capability to access basic services, and are encumbered by political weakness characterised by their inability to exert any significant pressure on public sectors responsible for delivery (McGranahan, 2015). Those power relations that entrench and reproduce development patterns must be contested and shifted. Engagement in the political processes that arise out of discussions about future socio-ecological urban development trajectories must reflect an inclusive approach wherein the departure point is securing human rights for marginalised social groups, in an effort to realise higher levels[27] of social justice. Importantly, this debate must shift from one that focuses on democratic rights only to include socio-economic rights.

Parnell and Pieterse (2010) posit that improved socio-economic outcomes are to be realised through a rights-based approach wherein a commitment to citizen participation in urban reimagining is both fundamental and mandatory. Nyamu-Musembi and Cornwall (2004) explain that this approach emphasises equality through a more equal distribution of available resources and, by its nature, is political in that it assists the marginalised to voice, and assert their right to access those resources. Swilling's (2011) principle of sufficiency is echoed here. In this way it is underpinned by an approach wherein the principles of fairness, social justice and equity are deeply embedded (Nyamu-Musembi & Cornwall, 2004). The articulation of priorities and participation in decision-making processes by people whose lives are and will be affected by interventions, serve as a simple yet effective yardstick for development (Uvin, 2007). However, this must be matched by citizens' claiming accountability from service providers, regardless of their institutional makeup (Nyamu-Musembi & Cornwall, 2004). It is then possible to transform the incumbent power relations and structures between various development actors by extending the degree of control of decision-making by citizens (Purcell, 2003). Achieving an equal balance between individual rights (first-generation rights)

[27] Agyeman (2013), following Sen (2009), is aware of the multiple meanings of justice and therefore co-opts Sen's (2009) goal of "reducing manifest injustice rather than seeking perfect justice" (Agyeman, 2013: 30).

and collective rights is the key to unlocking socio-economic outcomes that support broad-based developmental objectives (Parnell & Pieterse, 2010). Parnell and Pieterse (2010) argue that through this balance, marginalised groups are able to activate their collective right to the city, where the focus on individual democratic rights is balanced with: i) second-generation (collective) rights that provide affordable and viable infrastructure services for households and neighbourhoods, and ii) third-generation rights wherein public goods, such as safe environments and mobility, allow citizens access to participate in the socio-economic flows of the city. Using a rights-based lens, it is possible to see how the ability to access land, resources and technology forms part of the basic capabilities that are necessary for development and poverty alleviation but have been denied to billions of people (Agyeman, 2013).

Swilling's (2011) aspirational notion of livable urbanism and Allen's (2001) explanation for social sustainability[28], embedded in political sustainability[29], would fit comfortably within this discursive domain. Specifically, when considering the sustainability of urban infrastructure, questions around ecological restoration and socio-economic justice, through sufficiency, are dealt with. These ideas and principles force decision-makers to take note of the immediate, local context for which an infrastructure bundle is being configured and, importantly, for whom. Significantly, these reconnect the materiality of cities to urban consumption by bringing sources of resource supply into the immediate vicinity of urban functioning (Leduc & Van Kann, 2010). In this way, where urban stock and flow work together toward sustainable functioning, urban regions become productive rather than purely consumptive (Leduc & Van Kann, 2010). In parallel, it takes note of the concerns regarding the "wider distributional questions about uneven access to resource politics" raised by Hodson and Marvin (2010b: 311). By offering marginalised communities an equal stake in urban reimagining, social justice and cohesion become embedded in developmental processes. In this way, service delivery efficacy is not merely about the efficiency of input and thoughputs

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[28] *Social sustainability* is a fair and inclusive system supported by a set of actions and policies that improve quality of life and offer equal access to the use and appropriation of the natural and built environment, and economic capital with an emphasis on supporting marginalised communities.

[29] *Political sustainability* implies democratic processes that encourage participatory decision-making, inclusive of local civil society. Significantly, the political sustainability of urban government ensures the management and regulation of the relationship between the previous four dimensions, guiding the actions of different actors within the various systems.

but how a particular configuration of infrastructure bundles enables the attainment of social justice.

Much hope is pinned on the sustainable urban infrastructure. Sustainable infrastructure, in theory, promotes eco-system integrity and environmental regeneration, does not contribute to global environmental degradation and other adverse phenomena, and provides economic as well as social goods and services that ensure distributively and socially just cities. This is a high expectation. However, as Haberl et al. (2011) explain, it is as difficult to imagine what a sustainable transition would and should look like as it would have been for a 16^{th} century population to imagine the industrial society of today. Notably, it is not suggested that infrastructure interventions will provide the solution to the multiple crises facing cities; however, infrastructure choices for cities today will help them transition to more sustainable modes of behaviour in the future. There is precedent for transitions; ensuring it is shaped in the most appropriate way can largely be achieved if the principles discussed become embedded in an alternative urban development paradigm.

2.2.2.5 Revealing the implications of sustainable urban infrastructure

Considering Allen's (2001) urban sustainability framework, the sustainable infrastructure literature neatly explains how to achieve economic and physical sustainability through the principles of eco-efficiency and efficiency, and ecological sustainability through the principles of restoration and regeneration. However, it lacks real engagement with social sustainability and the political domain within which these four dimensions are embedded. Interventions that seek simply to minimise environmental damage are unlikely to be sufficient to drive socially just sustainability, and therefore, when considering cities in the global south the fifth discursive domain is an indispensible and preferable lens.

Poverty and deprivation at the urban scale will have to be addressed through development processes. Evidently, there are inherent ecological limits to expanding conventional infrastructure systems. While techno-fixes and eco-efficiency gains may well offer short-term solutions, these are likely to be incompatible with the urban contexts of developing cities where informality predominates and will continue to do so for the foreseeable future. The alternative is to restore ecological systems by configuring regenerative infrastructures through a range of interventions, without losing touch with the human agency and contingency that is inherent to socio-technical systems. Moreover, there must be an acceptance that some level of resource extraction will be necessary to allow the marginalised populations who inhabit cities of the global south to access basic human rights and services. The fifth discursive frame illustrates that through efforts to reduce the reproduction of social injustices, socio-economic rights can be realised. Citizens and communities are therefore to be seen as inherent components of that socio-technical system.

Possibilities for reconfiguring networked infrastructure become tangible when Hodson and Marvin's (2010) typology of reconfigured networked infrastructure bundles is expanded through the unpacking of the various discursive frames to broaden our understanding of the various possibilities when considering future socio-ecological development trajectories. Clarifying the various possibilities for purposive interventions into definitive discursive domains helps to imagine the future scenarios that the sustainable urban infrastructure literature offers. Despite the blurring lines between these domains, each has different technical answers, and different economic opportunities and possibilities. Figure 2.6 illustrates this conceptual device, representing the domains graphically in an effort to illustrate the implications of each discursive domain. Figure 2.6 illustrates the tension that arises out of the varying interpretations and positions, categorised into discursive domains. Typically, any intervention will have socio-economic implications, which affects the long term urban development trajectory. For example, consider using the *efficient infrastructure* discursive domain as the basis of interventions for alternative urban futures. Demand side interventions alone, that promote efficiency gains have a ceiling for success, and at the same time ensure the reproduction of the incumbent configuration. On the other hand, if *regenerative cities* was alone the priority, ecosystem services may again begin to flourish in perpetuity however, at the same time, without the inclusion of principles such sufficiency, social justice maybe overlooked resulting in the exclusion of billions of people from accessing socio-economic metabolic flows that support and enable human development. This illustration attempts to reveal the inconsistencies between and implications of the various discursive domains and how the long term development trajectory will be directly and differently influenced by each.

In practical terms, developed and developing cities will have very different development pathways. Shifting toward more sustainable urban development pathways in the North may require managing both retrofitting and renewal of existing urban stock, whether incrementally at an integrated, systemic scale or at the network scale. Conversely, if the ideas of sustainable urban infrastructure are incorporated into decision-making processes, a very different scenario is likley to emerge in the developing south. Cities may shift directly toward the more sustainable development pathways and avoid the destructive nature of conventional infrastructure systems. While not referring directly to the issue of sustainability, Amin is concerned with the potential of perverting the opportunity that cities offer, due to their inherent qualities as centres of "competitive advantage and prosperity generation", by using the city as the source of the "future world economic surge … in the post-industrial economy" (2013: 5). Amin goes on to argue that the city must be envisioned as a "provisioning and indivisible commons" (2013: 5) in which every citizen has an equal right. Therefore, technical interventions, as levers for change, require support through proactive policy approaches and substantial investments that are underpinned by the principles of sustainability, managed carefully by governing institutions. Governance systems, political cultures, institutional capacity and fiscal systems directly influence how infrastructure is planned and operationalised. These details are exposed in the empirical chapters with particular focus on networked urban infrastructures as utility sectors. The utility departments of the City of Cape Town, including solid waste management, electricity services, and water and sanitation services, will be examined with reference to the institutional dynamics and the power relations that influence those sectors.

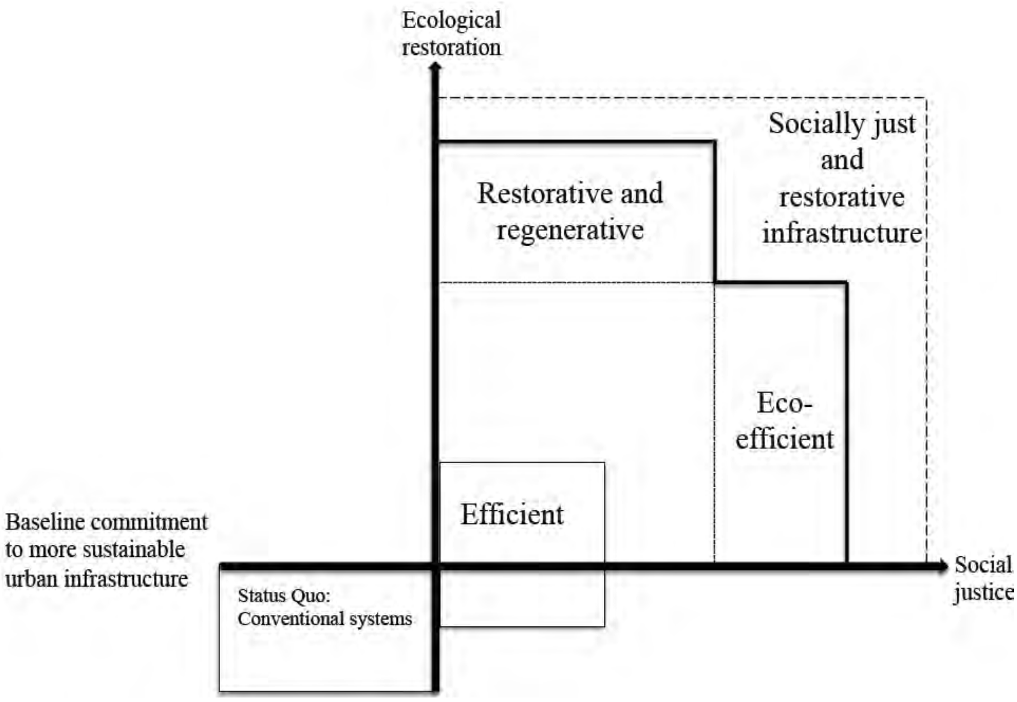

Figure 2.6: Representation of the discursive domains of sustainable infrastructure
Source: Author

2.3 Conclusion

Sustainable functioning of an urban system in the long term will be heavily influenced by the decisions for infrastructure configurations made in the short term. This simple yet significant rationale has influenced both the content and structure of the empirical chapters in this thesis. The City of Cape Town, and in particular the Utility Directorate, is faced with a number of environmental and social, as well as institutional and financial challenges while navigating the complexity of routine service delivery pressures. However, the processes that transpire during the period under analysis, 2000-2012, are interesting for understanding the relationship between macro-level theoretical prescripts laid out in the literature and the concrete institutional prospects for reconfiguring networked infrastructures in middle-income cities of the global south.

Although introducing sustainable urban infrastructure solutions alone will not contribute to the necessary sustainability transitions, purposive interventions with the intention to improve metabolic rates of cities will promote more sustainable development pathways. Purposive interventions that promote sustainability transitions must transcend the increasingly adopted alternative approaches that favour the second and third discursive domains of efficiency and eco-efficiencies, which amount to relative improvements. Cities cannot be satisfied with just **any** technical lever as an intervention for efficiency and productivity gains. This must be part of a larger, systematic approach with an overarching goal that amounts to socio-technical transition.

Integrated purposive interventions that meet the long-term objective of creating restorative, inclusive, and socially just cities are a key driver of this thesis. The discursive domains categorised and described in this chapter provide a means to engage directly with often loosely and disparate literatures that require integration, or at the least coherent interpretation. Particularly these domains offer a means to understand the different interpretations in relation to one another, which inturn offers a means to begin to unpack the implications of the various interpretations. However, the literature does not adequately deal with how to grapple with successful purposive interventions for such paradigmatic shifts. The sustainable urban infrastructure literature and the socio-technical transitions literature do not adequately come to grips with what is most likely to bring about paradigmatic change. Therefore the following chapter is concerned with determining how the multiple interacting dynamics of socio-cultural values, institutional behaviours and cultural norms effect change or maintain inertia.

The next chapter considers under what condition transitions occur and identifies some of the challenges associated with this.

3. Unlocking the key to innovation for systemic change

Systemic change is needed for paradigmatic shifts that lead to more sustainable urban development pathways. However, the question is to what extent and under which conditions infrastructure systems can actually transition from one configuration to another, fundamentally different, configuration, considering the constraints posed by lock-in and path-dependency discussed in Chapter 2. This chapter addresses this question while exploring the institutional conditions that contribute to socio-technical transitions. The concern is to understand what constitutes the underlying drivers of the existing logic of network management, from which we may be able to discern whether there is potential for the introduction of an alternative logic of network management and how this might take place. This is not a simple undertaking, since deliberate, purposive transitions are not simple (Hodson & Marvin, 2009a).

As demonstrated in the previous two chapters, networked infrastructure is now conceptually understood as more than the mere technical components that make up the bulk, reticulation, distribution and collection systems that support urban living. However, this literature has not yet matured to the point where it can offer concrete tools to transform the framing discourses and decision-making of urban managers when considering infrastructure investment choices. Bureaucrats, technocrats and engineers have an established socio-technical regime, reinforced by a set of ideas, practices, routines, and experiences of actors and social groups that reproduce the socio-technical system (Geels & Shot, 2007). Therefore, it is important to understand how a shift in the discourse and conceptualisation of infrastructures could take place: under which conditions sustainable urban infrastructure as an ideal, principle and practice can become mainstream. This section introduces transition literature as a useful resource that offers an entry point to addressing this question.

3.1 Sustainability transitions

Transitions are crucial if the global ecological and social crises are to be addressed in a substantive and meaningful way. For this to be a reality, "radical, large-scale and integrated socio-technical changes" coupled with "fundamental changes in economic and wider social-cultural conditions" are prerequisites (Van den Bergh et al., 2011: 8). While the idea of transitions is not a new concept, the notion of socio-technical transitions to an environmentally sustainable economy, now considered *sustainability transitions,* has become a priority for the EU and international organisations such as the OECD and World Bank (Van den Bergh et al., 2011) and seems uniquely able to hold all the connotations that emerge when researching socio-technical systems[30].

Swilling and Annecke (2012, chapter three) provide an overview of the history of socio-ecological transitions, industrial transitions and the associated technological transitions aligned with global development cycles. Table 3.1 provides a synthesis of these findings, but also includes reference to Swilling's (2011) four urbanisms and the discursive domains of sustainable urban infrastructure categorised and discussed in Chapter 2. This is useful to locate how numerous transitions during the 20th century have influenced incumbent patterns of economic growth, resource flows, emergent urbanisms and the nature of infrastructure configurations.

The reconfiguration of networked infrastructure and the transition to sustainable urban infrastructure are critical for wider socio-ecological transitions. Researchers have therefore begun to explore technological transitions within wider societal changes (Geels & Kemp, 2007; Smith et al., 2010). However, the main concern here is how "socio-technical systems evolve toward greater sustainability" (Stamm et al., 2009: 25). The literature, based on empirical research, has found that, over time, elements of the socio-technical systems adjust and transform – these can include markets, technology, infrastructure or regulatory frameworks – as different institutions and actors, working at different levels, organise and reorganise systems (Loorbach et al., 2010; Geels & Kemp, 2007; Geels & Schot, 2007; Lawhon & Murphy, 2012). A transition is therefore a transformative process during which a particular system undergoes deep structural change (Grin et al., 2010).

It is accepted that successful sustainability transitions, which have the required far-reaching impacts on resource productivity and efficiency that support ecological restoration, will depend on system innovation (Stamm et al., 2009, Nill & Kemp, 2009; Tukker, 2005). System innovation is broadly defined as a process during which "one socio-technical system [transitions] to another, qualitatively different one" (Geels & Elzen in Stamm et al., 2009: 26).

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30 For a summary of the various approaches to researching and a discussion of sustainability transitions, see Van den Bergh et al. (2011). This inaugural issue of *Environment Innovations and Societal Transitions* offers a thorough overview of the field and presents a compilation of the state of the art literature on transitions from a socio-technical perspective.

Table 3.1: Synthesis of transitions with reference to urbanism and infrastructure

	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s	2030s
Phase of industrial transition (Perez 2009)	Synergy		Maturity	Irruption		Frenzy	Synergy		Maturity
4th Industrial transition	Deployment of the age of oil and coal, post-WWII institutional matrix			Persistence of post-WWII US hegemony, plus globalization and new industrialisers			Decline		
5th Industrial transition			Invention, then irruption and frenzy period of the information age				Deployment phase of the information age, new post-oil, post-US Hegemony institutional matrix		
Pattern of Economic Development	Equalising			Unequalising			Toward equalizing?		Equalising?
Resource flows (Fischer Kowalski and Swilling, 2011)	Mainly biomass 1020 bt/yr	Doubling of non-biomass materials, 20-30bt/yr	Non-biomass materials become dominant, increase to 50 bt/yr				Two thirds non-biomass 60 bt/yr (relative decoupling	Absolute resource reduction?	Absolute resource reduction?
Socio-ecological regime (Fischer Kowalski and Swilling, 2011)	Industrial socio-ecological regime						Sustainable socio-ecological regime?		
Urbanism (Swilling, 2011)	Inclusive/Slum		Splintered / Slum				Green/Slum		Livable/slum
Typology of infrastructure configurations	Modern imperative of development with the principles of technical sophistication and economic efficiency					Efficiency and eco-efficient infrastructure		Restorative and regenerative?	Restorative infrastructure for social justice?

Source: Adapted from Swilling and Annecke (2012) to include Swilling (2011) and the discursive domains of sustainable urban infrastructure discussed in Chapter 2.

By definition, innovation is the result of ongoing **learning processes** through interaction between elements and actors, within established networks, during the production, diffusion and use of economically useful knowledge, and its incorporation into institutional arrangements (Lundvall, 2007). When considering this type of innovation, Geels (2004) suggests that meeting a societal need is central, and therefore the focus is on the functionality of an innovation for society, not only the innovation in narrow technical terms.

The nature of innovation is determined by a specific set of dominant political and economic ideologies present at particular moment (Montalvo, 2008: 2). A paradigmatic shift is needed in which the ideology that directs innovations is underpinned by the notion of decoupling to ensure the dematerialisation of socio-economic systems while contributing to urban sustainability, restoration and social justice during socio-economic activities (Stamm et al., 2009; Montalvo, 2008). For systemic change, Swilling and Annecke (2012) argue that technological, institutional and relational innovations are necessary. That being said, while innovation is a response to specific pressures, the nature of innovation is closely related to how the pressures or challenges are anticipated, understood and responded to by the networks of institutions and individuals within that specific context (Hodson & Marvin, 2009a).

It has also been argued that new solutions can become blocked by the existing system, due to production and regulatory barriers, financial and investment needs, and the obdurate lock-in nature of those systems (Elzen & Wieczorek, 2005). Jonsson describes this aptly as follows:

> Implementing nontrivial changes in established and mature socio-technical systems is not uncomplicated. Institutions resistant to change have already been developed. The organisational cultures surrounding the [socio-technical system] are firmly rooted and the related power structures are strong. The system culture of an infrastructure system contributes to successful implementation of changes in line with the system culture. But a strong system culture can also conceal technical and institutional possibilities (2005: 3).

Institutional culture is the manifestation of people's behaviour that is shaped by "written and unwritten rules and practices" (Flood, 1999: 87). Therefore, actors do not act independently, but within a defined set of rules, which, Geels (2004) argues, coordinate and structure activities. Geels (2004) differentiates between three different types of rules to which we are bound. *Cognitive* rules dictate and reproduce the nature of our actions and therefore limit the perspective and world view to particular knowledge, expertise and skills. Competencies that have been developed over time build upon one another, refining existing knowledge, and in this way they frame how people make sense of the world, which contributes to path dependency. *Normative* rules are the values, norms and morals learnt and internalised during socialisation, which determine what is acceptable behaviour. Lastly, *formal* rules are the explicit, official and legally binding regulations, universally applied to a particular context, that regulate interaction. Actors do not therefore act independently but are structured by the rules of a regime. While these rules are not necessarily fixed, rules and routines generate momentum, which maintains the status quo despite changes to external circumstances (Flood, 1999). This means that individuals and organisations have an option of transformation, but it depends on various factors such as the nature of the organisation and embedded institutions, and the capacity and capability for learning. That being said, Poole (2004) cautions that change and innovation are subject to powerful yet subtle unknowable dynamics, a challenge to manage, let alone script. Therefore, learning with the intention of realising developmental objectives is important for socio-cultural institutional changes that support socio-technical transitions towards more sustainable development pathways.

3.2 Learning for development, building consensus through differences

Development is the result of purposive interventions and deliberate actions that have the intention to enable positive change and improvement for society (Johnson & Wilson, 2009). Moreover, Johnson and Wilson (2009) reason that development thinking is urgent, due to the inherent complexity of global change underway. For this to materialise, collective learning experiences (Johnson & Wilson, 2009) or learning events (Bernard & Armstrong, 1998) that ensure a "process of changing norms, ideologies and institutions" (Johnson & Wilson, 2009: 5) are needed for the development of integrated interventions[31] (Bernard & Armstrong, 1998). Herein lies the link to understanding the conditions needed for the paradigmatic shift necessary for the implementation of sustainable urban infrastructures. Reflexive learning must be actively sought to ensure systemic change whereby the norms and rules governing decisions can be re-written.

However, considering the unknowable nature and dynamics of change and innovation, it is useful to consider Flood's (1999) notion of systemic thinking. Flood (1999) argues that

[31] Because integrated interventions are the outcome of collective learning processes during which those involved are able to progressively derive meaning and create a shared understanding of a particular challenge or goal, system change through innovation takes place (Bernard & Armstrong, 1998).

systemic thinking should be adopted as a response to the inevitability of *learning within the unknowable* during problem solving for development, as it helps us to intervene despite the complexity[32] that characterises our experiences of the world. He argues that it is only possible to grapple with what is local to us in "both space (things that we are immediately involved with) and time (not very far in the future)" (Flood, 1999: 129). Alternatively, according to Weick (1995), we can only grapple with, or make sense of phenomena through a lived experience that allows us to develop frames for sense-making. This speaks closely to what constitutes the rules that are used to make sense of phenomena (Geels, 2004). Complexity, inherent in the unknowable, is domesticated through the introduction of a particular boundary (Flood, 1999). In fact, complexity must necessarily be bounded, for the sake of pragmatism, in order to operate within a set of limits that are manageable and relevant (Flood, 1999).

By determining the boundary and scope of action, learning can commence as individuals and social groups are able to engage within a set of tangible parameters. Boundary judgments are ethical in nature and critical or subjective choice is inevitable (Flood, 1999). Moreover, it is important who draws the boundary, because it reveals the predetermined rationality that informs the choice. Therefore the idea of bounding is a fundamental one in learning theory that pertains to complexity. Carley and Christie (1993) explain that if a boundary is defined too broadly the challenge would seem overwhelming, or if too narrowly, critical factors might be excluded which will negate development plans. That being said, a boundary will adjust over time depending on the nature of the challenge and the capability of the organisation (Carley & Christie, 1993).

When considering how this might play out in a large public institution or, more specifically, utility departments made up of predominantly engineers and technicians, it is useful to consider the *administrative man*[33]. Marinetto's (1999) notion demonstrates a limited form of rational behaviour, because in principle there are inherent restrictions of human and psychological capacities. Significantly:

> [n]ormal bureaucracies (…) tend to define any problem as either within their area of competence, and therefore their problem, or outside their area of competence and therefore not

[32] For an exceptional review of the key elements of complexity theory see Cilliers (1998).

[33] This is in direct contrast to the conventional or classical thought, which assumes governments operate and maintain policy through the process of rational actions by the economic man who possesses rationality (Marinetto, 1999).

> their responsibility. Once a problem is defined in a particular way, a superstructure of programs, political and funding commitments and careers is usually built around that definition (Carley & Christie, 1993: 166).

The insight offered by Carley and Christie (1993), recorded here above, reveals the tangible barriers that can inhibit change processes. (See Chapters 6 and 7 for empirical evidence to support this, and Chapter 8 for an explicit explanation of these tangible barriers). Learning and adaptability are considered critical to change processes and therefore the consistent development and redevelopment of various knowledge sets available, including, technical, policy, and context-specific knowledge, is vital (Hodson &Marvin, 2010b). However, learning cannot be understood as a merely linear process. Rather, interactive and iterative, dynamic and positive processes are needed for meaningful shared knowledge creation and learning processes (Wilson & Johnson, 2009). Learning is the outcome of interactions between different actors or organisations that represent coordinated social groups with similar preferences, perceptions, and problem agendas (Geels, 2004). Through interaction, different groups form networks that generally have mutual dependencies and a collective anticipation of a set of emerging challenges (Hodson & Marvin, 2009a). However, because of the unique personal knowledge preferences and social experiences, solutions will be viewed differently (Bernard & Armstrong, 1998).

Flood (1999) recommends the deployment of interdisciplinary teams to ensure the diversity of expertise is represented that will enable them to contend with a set of unknown circumstances inherent in problematic situations. Moreover, through this process, teams "learn and grow as individuals and as a group in the situation [and] … the result is synergistic" (Flood, 1999: 88). Along the same line, Johnson and Wilson (2009) have made use of Habermas' theory of communicative action, which is based on the principle that a participatory approach can lead to emancipatory learning processes. Here the emphasis is on the agent-based nature of discourse (Avelino & Rotmans, 2009). This amounts to what Flood (1999) describes as experiential learning, which "releases people from their mental models that otherwise shape their view of the world" (Flood, 1999: 88). Action-learning spaces facilitate experiential learning, where people from different fields, histories and organisations, and embedded in different institutions are able to come "together, learn though expression and acknowledgement of difference, and engage in new approaches to development, however modest those new approaches might be" (Johnson & Wilson, 2009: 52). According to Carley and Christie (1993) action-learning is fundamental to resolving crises that emerge in rapidly changing, complex contexts.

What are considered truths, norms or standards can dictate what is deemed permissible as knowledge, which then determines how a challenge is perceived and responded to (Johnson & Wilson, 2009). This leads to the phenomenon that alternatives may be rejected or disregarded due to the established truths or rules held by participants. Mental models, as Flood (1999) calls them, "can be thought of as the particular ways that truth and regimes of truth are articulated" (Johnson & Wilson, 2009: 33). Here the emphasis is on the structural nature of discourse (Avelino & Rotmans, 2009). Significantly, these truths cannot simply be reconstructed and applied by powerful actors with agency. Rather, through knowledge exchange and learning, new experiences subtly permeate society and become established as truths, although it is unlikely that it would be universally accepted by society (Johnson & Wilson, 2009). Therefore, the introduction of an alternative discourse is not enough to challenge that which already exists. Long (2001) explains that it is more common that discrepancies are revealed at moments of crisis, which demonstrates the inappropriateness of an established orthodoxy to frame real-life circumstances.

Considering that "it takes much time to acquire new knowledge and build up competencies" (Geels, 2004: 910), maintaining consensus is more likely to occur when learning processes are incremental and iterative, in which case the purpose of interventions becomes clear and participants have an opportunity to internalise the new logic established fully (Bernard & Armstrong, 1998). Social engagement is dependent on how individuals interact with the organisation, how the organisation functions and the broader socio-economic conditions (Johnson & Wilson, 2009). The individuals involved in interdisciplinary teams have a significant influence in determining the outcome. Therefore, reading these two points together we see that it is the manipulative and transformative actions of individuals and institutions that account for learning and change; "[o]r should we say that it is the encounter between, or confrontation of, actors ... and their ideas and values that perpetuate or transform dominant discourse" (Long, 2001: 53).

3.3 Consensus and difference, establishing trust and envisioning futures

Difference, confrontation and consensus are recurring themes throughout this literature. It is neatly linked to the idea that through learning processes it becomes possible to challenge the established dominant discourse that provides the frame for future decision-making. It is usual for numerous actors and participants to perceive, understand, and interpret issues and problematic situations differently (Bernard & Armstong, 1998). Carley and Christie argue that conflict over "resources, power and influence is inevitable" because actors generally believe that satisfaction for all parties cannot be achieved (1993: 174). However, "difference, not commonality is ultimately the source of learning and new knowledge" (Johnson & Wilson, 2009: 26). Moreover, when there is ample prior commonality and background consensus, in a 'community of practice' wherein individuals have shared experiences and a similar range of knowledge, it can limit the ability to generate new types of knowledge (Johnson & Wilson, 2009: 51). Long (2001) uses the concept *domain* to capture a similar notion of a social group sharing a set of core values, and although these values are not perceived in the same way, there is sufficient commonality to generate a social commitment. Being acutely aware of this nuance opens up opportunity for those who are able to take advantage of inherent differences present in learning networks. Marinetto reminds us that governments are not unified organisations but in fact consist of a myriad of "competing interest groups that bring within the body of politics different values and ideologies" (1999: 7). This presents a dilemma, as "multiple voices and contested realities" emerge when the boundaries of an arena are being constructed (Long, 2001: 50). However, during conflict and contestation differences emerge among various communities of practice, and it is during these times that emancipatory and transformative learning can take place.

Hodson and Marvin (2009a) criticise transition literature for emphasising consensus while neglecting power relationships. It cannot be assumed that consensus and a shared vision for the future will be established. Furthermore, consensus relies on a participatory process characterised by struggle and negotiation, during which support is mobilised from numerous social actors (Hodson & Marvin, 2010b). Eventually, how problematic situations are experienced, perceived and translated may converge into a shared understanding while divergent views are accommodated. Establishing a common language between social groups and networks is important, because it assists in the facilitation of dialogue (Bernard & Armstrong, 1998) Moreover, this vision does not necessarily remain fixed and "there are always possibilities for dissenting from it" (Long, 2001: 50). As conditions change and boundaries are redrawn, new actors maybe included or, in the same breath, excluded.

Smith et al. (2005) bring to attention how resources flow between actors and through networks or coalitions while establishing a vision, and the important role of the position of actors. In other words, the power exercised by actors and coalitions, in relation to the specific set of challenges, determines the direction of technology, financial, political and knowledge resource flows, and therefore the vision for the future. However, given the nature of reflexivity, the boundary of a challenge will be adjusted as it becomes more clearly understood and a greater number of different, social and vested interests become involved. Social action is inherently heterogeneous due to the range of social domains that intersect (Long, 2001). In light of this, Hodson and Marvin question, "who, or which social interests, produce … these visions of the future and with what expectations" (2010b: 482). The vision should be moulded by a range of views included in the participation process, and the more participation at the early stages of the process the better to ensure that there is shared ownership and thereby the appropriate knowledge and expertise are included to put the vision into action (Hodson & Marvin, 2010b). Herein lies the link to the fifth discursive domain described in Chapter 1. Social alignment is however not a straightforward process, due to competing concerns and priorities (Guy et al., 2011). Generating a shared vision through learning that translates into action and purposive interventions, especially in bureaucratic institutions, will require leadership capability and facilitation.

3.4 Intermediaries versus the role of networks

Facilitation is an important aspect of learning processes. During these processes knowledge may be generated, but there is no certainty that actors will change their perspective or course of action. In these instances it is common that a process of negotiation takes place, in which case an intermediary emerges.

Van Lente et al. (2003) explain that the primary role of intermediaries is to act as mediators, facilitating flows of information between the various actors and social interests in a multi-disciplinary fashion, generating knowledge. Furthermore, intermediaries can be existing organisations that could include research institutions, knowledge-intensive industries and business or technological organisations. There are two types of intermediation at the operational level; these are i) hard and ii) soft intermediation (Van Lente et al., 2003). In the former, there is a concrete transfer of knowledge or technical service, while in the latter an intermediary provides organisational support in the form of management, institutional assistance or cultural development. Intermediaries are generally included in transition processes by central and powerful players, usually when additional knowledge is required (UNEP, 2013).

Guy et al. (2011) describe several cases in which intermediaries play a critical role in shaping urban- specific transitions. Intermediaries take "different forms, emerge in very diverse contexts, operate in multiple ways and pursue their own agendas" (Guy et al., 2011: 209). Intermediaries deliberately position themselves in-between various social interests and facilitate the alignment of different perspectives to produce a novel outcome (Hodson & Marvin, 2009a). It is assumed that these outcomes would not have been achieved, or not as effectively, without assistance from that intermediary and therefore Hodson and Marvin (2009a) suggest they become *strategic* intermediaries. While intermediaries can shape the direction of the transition, or an understanding of a problematic situation, due to the unique contextual knowledge of strategic intermediaries who emerge in context, these organisations are perceived to be able to provide the capacity and capability for transforming the vision of change into action (Hodson & Marvin, 2010b). This is especially useful in instances where institutions lack both capacity and capability to mediate potential technological changes and various competing social interests.

In Carley and Christie's (1993) view, action-centred networks are central to systemic change wherein participants undergo a co-learning process leading to collaborative problem solving. This is particularly useful for overcoming the inevitable conflict that arises as different organisations and individuals compete for scarce resources to support their agendas. Following a task-orientated approach, action-centred networks have a central focus or purpose for the network that integrates the participants and social groups, creating more tightly coupled interactions (Carley & Christie, 1993). While this view accepts that a broker, negotiator, strategic intermediary (Hodson & Marvin, 2009a) or linking-pin organisation (Carley & Christie, 1993) might be necessary, there is less emphasis on the centrality of the intermediary in resolving challenges and generating innovative responses to pressing issues. Rather, in Carley and Christie's (1993) approach, linking-pin organisations possess expert knowledge, but, more importantly, are part of the action network and directly participate in learning processes. In addition, they are key to communications between network members and other domains, and act as a catalyst for initiating learning and change processes (Carley & Christie, 1993). In both instances, the authors are fully aware of the associated knowledge–power dynamic.

A more sympathetic view is that of Johnson and Wilson (2009), who identify establishing trust as a fundamental aspect of learning processes. In instances where trust is limited, intermediaries can act as broker and assist during negotiation processes. Therefore, intermediaries can play an important role in facilitation and mediation that can generate trust while explicitly naming the overarching interests, values and intended goals of an intervention. Intermediaries therefore "facilitate mutual learning" (Johnson & Wilson, 2009: 48).

An additional point of interest when exploring the role of networks in processes of change is the collective, as explained by Long (2001). Acknowledging the critical role of non-human actors in the framing and response of problematic issues can significantly contribute to how social groups position themselves within networks. Materials, texts and technologies are considered to be part of and inherent to the organisation of a network of actors (Long, 2001). Using socio-technical systems to develop this point, the logic follows that: i) human actors or organisations are central to the construction and operations of socio-technical systems, ii) these actors are constrained or enabled by the set of rules and discourses of the organisation, and the actors in turn reproduce them, establishing a socio-technical regime, iii) socio-technical systems gain momentum and develop a path dependency, which re-enforces the regime (Geels, 2004). Figure 3.1 illustrates the dynamic and inter-related nature of regimes, systems and actors. Therefore, individual agency is embedded within a broader social system as well as a structural setting.

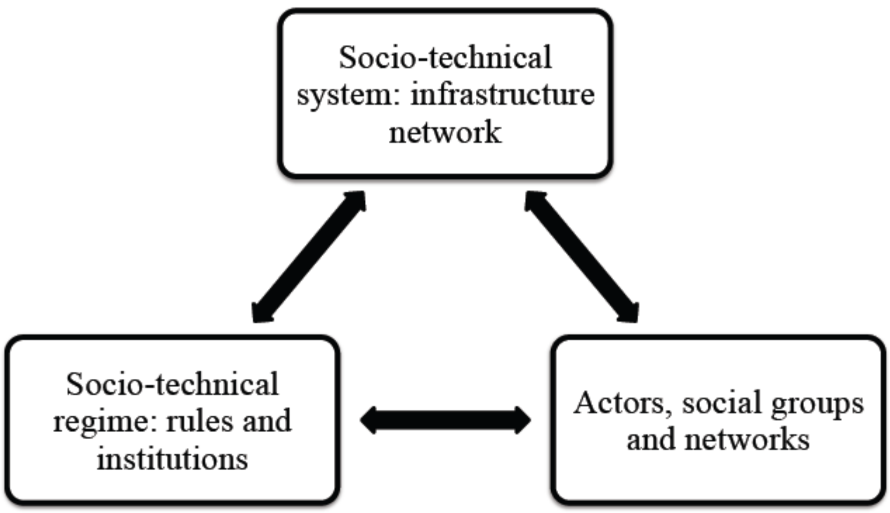

Figure 3.1: Three interrelated dimensions of social-technical systems
Adapted from Geels (2004: 903)

3.5 Capacity and capability for transformative learning

There is a well-established and vast literature that explores capability and capacity in organisations (Lichtenthaler & Lichtenthaler, 2009). Remaining within the realm of networks and individuals, Smith et al. (2005) explain that transformation and change, whether it is intended or emergent, is a function of a coordinated approach that organises a number of actors and resources across institutions and networks within a system. This is dependent on sufficient coordinating capacity and mobilising capability within the network, needed to initiate interventions for change to the incumbent paradigm (Hodson & Marvin, 2010b). Agency is implied here, and is therefore central to the discussion. The role of human agency in change and innovation is crucial, but can be underrepresented and obscured by the complexity of large-scale change that involves multiple actors and units over a long period of time (Poole, 2004). Moreover, in instances where multiple agents are involved, agency is more complex, as "it is difficult to know whose intention counts in such cases" (Poole, 2004: 18). Agency of individuals, organisations or networks refers not only to the intention of taking action, but the ability to process experiences and through reflexive interpretation, take action. "Agency implies both a certain knowledgeability… and capability to command relevant skills, access to materials and non-material resources and engagement in particular organising practices" (Long, 2001: 49). Moreover, it "presumes that groups of people have sufficient and legitimate power to implement an agreed solution to a recognised public problem" (Smith et al., 2005: 1503). As such, two aspects that relate to agency can be identified: knowledge and power.

Although networks are often considered to be a well-balanced set of relations guided by the principle of reciprocity, in reality there are generally "uneven and partial sets of relations that strain towards patterns of centralisation and hierarchy" (Long, 2001: 56). The accumulation of power can account for such tensions. Avelino and Rotmans consider power to be the "ability of actors to mobilise resources to achieve a certain goal" (Avelino & Rotmans, 2009: 550), and are therefore concerned with the power of actors as opposed to the power of the system. They furthermore expand the notion of resources to include assets, materials or capital, including human, mental, monetary, artifacts and natural resources. Therefore, not only are materials, texts and technologies considered to be part of and inherent to the organisation of a network of actors (Long, 2001), they only become 'power-laden', to a more or lesser extent, when mobilised by actors (Avelino & Rotmans, 2009). Considering power this way allows us to question which resources hold more power in certain contexts, how power can best be leveraged in action-centred networks, and by whom.

Engagement between individuals within an organisation and beyond, involves a particular set of power relations where hierarchy and power can inhibit (Johnson & Wilson, 2009) or harness (Avelino & Rotmans, 2009) the knowledge-sharing and learning processes that lead to changing practice. Considering the emphasis of collaborative learning and knowledge creation, having power over knowledge in terms of access, nature and purpose in learning processes, has inherent challenges for activating and intervening for positive change. Moreover, that resources can *become* powerful is extremely interesting for the purposes of empirical study.

Flood (1999) explains knowledge–power relations as a phenomenon that influences what is considered valid knowledge, or accepted 'truths', which determines what is considered valid action as determined by the powerful people within a particular domain. However, powerful actors can also determine if, and how, these 'truths' are perpetuated or challenged (Johnson & Wilson, 2009). Power relations therefore determine how commonalities and difference, critical for learning, are understood and acted on. Where these relations exist, established patterns of behaviour and institutional cultures can bias and thus pervert the outcome of engagement processes, in which case only minor changes take place or the status quo remains (Flood, 1999). The result is the alienation and exclusion of 'non-powerful' actors and this significantly undermines the learning organisation (Flood, 1999).

Johnson and Wilson (2009) provide a useful reminder. On the one hand, knowledge generated through experience in a part of an organisation may be the source of power, as a possession, and therefore those who hold it may not wish to share it. On the other, those with power created or reinforce established norms and the associated routines, and don't want these changed. A consequence of this is that alternative options to conduct routine activities will not be encouraged or even considered, because it could undermine the power relations associated with the status quo. This is obviously not conducive to knowledge sharing, which usually requires the allocation of time and resources, in the form of staff or funding, from those who hold power. Smith et al. aptly state that "power facilitates agency … [and] power also circumscribes agency" (Smith et al., 2005: 1503).

Recognising Longs' (2001) assertion that agency implies knowledgeability and capability to command skills, as stated above, reflecting on the role of leadership adds another dimension when considering power and agency within the discussion around capacity and capabilities for change processes. Effective leadership is an undeniable and significant component of change processes (Gill, 2002). Leadership here should not be confused with the conventional understanding of a *leader,* either an individual or office, who is able to exercise allocated power through a designated hierarchical structure (Schweigert, 2007); nor *management,* which involves the maintenance and operating of a process or system through planning, control, budgeting and staffing (Kotter, 1999). Leadership is rather "the development of vision and strategies, the alignment of relevant people behind those strategies, and the empowerment of individuals to make the vision happen, despite obstacles" (Kotter, 1999: 10). Above and beyond this definition is the recognition of three traits, which determine the difference between leadership and effective leadership. Grint (2007) differentiates between *techne* (know how and skill)*, espisteme* (know why through theory) and *phronesis* (wisdom) as a way to elucidate that leadership comprises an array of elements that result in different outcomes. The presence of skills and theoretical knowledge, which are easily transferrable, are necessary but insufficient for effective leading and leadership. Practical wisdom, which is explained as "knowing what to do and how to do it, at the right time, with the right people, with the mix of persuasion and challenge and the right sense of what to leave unsaid and undone" is the crucial requirement (Schweigert, 2007: 339). Herein possibly lies the difference between successful and unsuccessful purposive interventions: practical wisdom as well as knowledgeability and capability. Through practical wisdom, gained through experience, executed in a particular situation, it becomes possible to realise justice (Kessels & Korthagen, 1996; Grint, 2007). It is therefore context specific and underpinned by a moral imperative (Grint, 2007).

Interestingly, Bernard and Armstrong (1998) suggest that learning is not always necessarily about fundamental change. Rather, learning offers the ability to assess and accommodate what new knowledge and experience is valuable, and adapt accordingly while holding on to those existing, useful frames of reference (Bernard & Armstrong, 1998), echoing the presence of *phronesis* (Grint, 2007). Alternating between stability and change is a necessary "feature of all learning, whether spontaneous or facilitated; it enables us to achieve both the radical paradigm shifts and the sustained application of new patterns of thought needed to develop negotiated policy decisions" (Bernard & Armstrong, 1998: 6).

3.6 Building a conceptual frame

The purpose of this section has been to unpack and explore how socio-technical systems might transition from one system to another, fundamentally different system. More specifically, it explored some of the conditions required to realise functional system innovation that supports sustainability transitions. Evidently, the role of learning and learning processes is considered critical in change and transitions, hence the emphasis on it here. Equally important are regimes of truth of the existing system and the social interest groups that surround that regime. Acknowledging the presence of agency, power and knowledge clearly links to the ability of a particular system to respond and engage with crisis and consequential interventions, as well as the intended or unintended impacts. The relationship between these elements is represented in Figure 3.1.

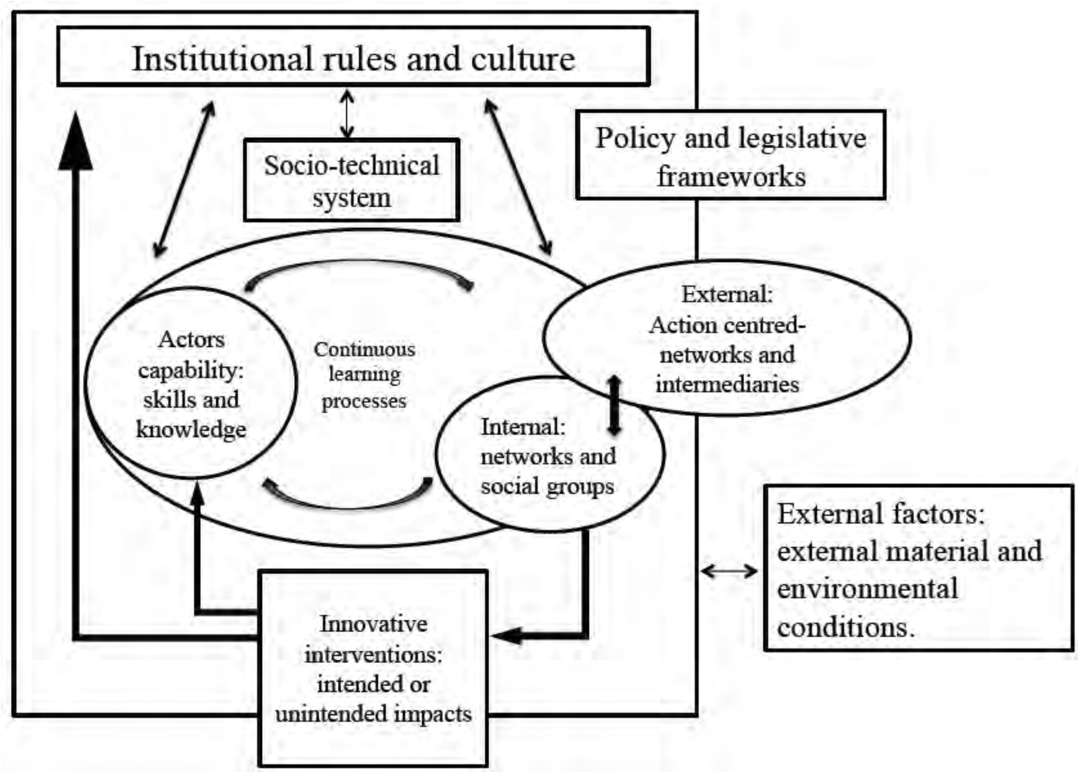

Figure 3.2: Illustration of the dynamic interaction between the components that account for systemic change
Source: Inspired by Geels (2004); National Treasury (2013)

Figure 3.2 is useful because it provides some structure to the various social groups, factors and systems, made up of actors with particular capacity and capabilities, and resources, and the interactions between them. For purposive interventions to take place, learning processes are expected to continually filter through the various networks into the system, possibly facilitated by action-networks or intermediaries. One of the most important aspects is the ability to respond to the impacts of interventions and incorporate lessons into the institutional culture and rules. Evidence of this is provided in the empirical chapters that follow.

The system depicted here is used as the conceptual frame in the analysis chapters. It was suggested in Chapter 2 that inadequate attention is paid to how infrastructure transitions actually take root in institutions that are responsible for the management and operating of networked infrastructure. The case study of the City of Cape Town Utility Departments offers insight into the dynamics that influence the shifts for sustainable development pathways. The literature suggests change is not random, or the result of a specific catalytic event; rather, socio-technical transitions are the result of learning processes and policy pressures on existing systems that allows sufficiently developed innovations to inform and alter the socio-technical regime, either improving it or replacing it (Smith & Kern in Stamn et al., 2009). The empirical chapters reveal to what extent this is possible.

3.7 Conclusion

In an effort to establish how socio-technical systems can be unlocked and can transition from one system to another, considerable research has been conducted that seeks to determine how these systems evolve over time. The literature discussed in this chapter illustrated how change and innovation might take place within public institutions. Components of the socio-technical system adjust over time as different actors within different social groups interact to organise and reorganise systems. Key to this adaptive process is innovation; critical, however, is the ongoing learning processes, fundamentally dependent on a wide variety of social actors and groups to ensure collaborative knowledge building. Innovation was defined here as the outcome of learning processes between the various actors within a system. Learning is therefore a central theme when intervening for purposive transitions. Moreover, learning is the outcome of active engagement between people and networks with a range of experiences and perspectives. Diversity is key to realising real co-production of knowledge between participants, in order to establish some sort of shared vision for the future configurations of networked infrastructure. Knowledge generated must be incorporated into institutions for change to take place. A common feature of all learning, whether spontaneous or facilitated, is that it enables us to achieve both the radical paradigm shifts and the sustained application of new patterns of thought needed to develop negotiated policy decisions.

What follows in chapter 4 is an explanation of how this thesis employs the literature to explore and understand the empirical evidence collected during fieldwork. It unpacks the tools, strategy and tactics used to collect empirical data in a way that brings to life the complexity of transitions processes in what can be considered an exploratory study, with an emerging literature in an under-studied context. The empirical research reveals what accounts for, or disrupts, transitions pathways toward more sustainable infrastructure configurations in Cape Town.

4. Methodology

The mega trends introduced in Chapter 1 have brought to attention the need to reconfigure urban systems in a way that creates sustainable urban futures. Chapter 2 reviewed the emerging sustainable urban infrastructure literature, which reflects on the value of reconfiguring urban systems to resolve some of the challenges facing cities in the 21st century. The purpose of this research is to explore and understand the prospects and relevance of the idea of sustainable urban infrastructure in middle-income cities of the global south. The literature however fails to address how cities without adequate capacity and resources might contend with these challenges and effect the requisite transitions. Chapter 3 lays-out the relevant public development management and institutional change literatures to make inroads to closing the gap, however much is left unanswered. This thesis seeks to contribute to addressing this failure through an in-depth exploration of the dynamic conditions at play in the Utility Directorate in Cape Town's metropolitan governing authority, the City of Cape Town (CCT). The departments under analysis include the Solid Waste Management (SWM) Department, Electricity Services (ES) Department and the Water and Sanitation (W&S) Department. The empirical research reveals what accounts for, or disrupts, transitions pathways toward more sustainable infrastructure configurations in Cape Town. The literature discussion has provided the conceptual frame that guided the fieldwork. Narrowly speaking, the purpose of the empirical chapters is to answer the research questions. However, the overarching intention is to contribute to the existing theoretical and conceptual debates in the literature.

The purpose of this chapter is to offer insight into the research methods and design appropriateness for this research. However, there is a disjuncture between the textbook approach to conducting research and research methods, and the lived reality of fieldwork (Bryman, 2013). In an effort to move beyond a systematic methodological description prescribed by the literature, a first-person account is preferred here. Such accounts can be fascinating "because of their provision of a picture of the social research enterprise which reveals the quirkiness and messiness that social researchers experience" (Bryman, 2013: 1). Therefore, this chapter is largely written in the first person as a deliberate strategy to emphasise the author's experience during the research process. The research design is based on qualitative research techniques and I *do* social research. Moreover, inevitably, issues of positionality, subjectivity and bias comes into the process. Expressing the motivation and rationale of the process and challenges experienced with clarity, from my own perspective, will not only assist in resolving issues that might emerge, but offer different ways to confront social research.

My aim is to offer an interesting account and rich description of my research. I use what can be construed as traditional points of interest, which are necessary for this dissertation, including a review of the research design, methods and aims, but also an account of some of my experiences and the tactics I adopted to complete the research successfully. Therefore, the research methods and rationale is interwoven with an account of the messiness and quirkiness as described by Bryman (2013) to which I will add frustration, of research.

4.1 Research design and method

My interest in sustainability was fostered and consolidated during the time that I spent at the Sustainability Institute[34] working toward my master's degree. However, once I had graduated, I had more questions than answers. I was intrigued by cities, the resource flows that support them, and the role that networked infrastructures play within that. The burning question being: How and where do sustainability and urban infrastructure meet? My history and biography made it impossible not to ask the follow up question: What does this mean for Cape Town and other contexts of the global south? In order to answer some of these questions, I endeavoured to scan the literature and more deeply grasp the complexity of urban socio-technical dynamics in unique and unexplored contexts. Chapter 2 confirmed the need to understand what sustainable urban infrastructure means for contexts so different from cities with well-developed institutions with capacity to implement purposive interventions. These factors have informed the research questions, recounted here:

- Is *sustainable infrastructure* theory useful and relevant in the context of Cape Town?
- How do the elements of the academic theory manifest within the policy discourse in the City of Cape Town?
- To what extent is this discourse absorbed into routine decision-making and management within the primary utility departments of the City of Cape Town?
- What is the use and relevance of *urban transitions* theory and knowledge when reflecting on the implementation of sustainable infrastructure?

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[34] Sustainability Institute is an NGO that houses the Stellenbosch University's, School of Public Leadership master course, Sustainable Development, Management and Planning see: www.sustainabilityinstitute.net

- What gaps in the sustainable infrastructure and urban transition knowledge can be identified through an exploration by means of a case study (Cape Town) rooted in the global south?
- How can the existing theory on sustainable infrastructure and urban transitions be enhanced through this insight generated from my case study?

The analysis in Chapter 2 confirmed the importance and relevance of these research questions. The positioning of the challenge as a socio-technical one required a range of research methods. A qualitative inquiry was necessary because of the need to explore the day-to-day operations of a real-life organisation, in a nuanced way, while offering valid and empirically sound evidence. An interpretivist approach such as this is particularly useful when applying mid-level theory to empirical research and helps to alleviate some of the methodological challenges posed. By its nature, the interpretivist approach allows researchers to "address the complexity and meaning of situations" (Black, 2006: 319). Yin (2011:3) provides a compelling description of qualitative research, describing it as a means to "discover how people cope and thrive … in a real-world setting … and capture the contextual richness of people's everyday lives". I have found this description incredibly useful throughout my fieldwork, especially because it has allowed me to move beyond what is represented as fact by policy, to something more intanglible that underpins daily practice of the CCT. Moreover, innate to this approach is the use of "multiple sources of evidence" when learning about complex social systems (Yin, 2011). These two characteristics of qualitative research have been critical focus points for data collection and accounts for the value of the research. The starting point was however a thorough literature review and analysis.

4.1.1 Scholarly literature

Reviewing literature is the departure point for the research, and as Mouton (2002) argues, is the cornerstone of any research project. Building the conceptual framework was a means to understand how the field has been conceptualised and theorised by leading scholars. The literature review confirmed the importance of the research questions and allowed me to formulate a comprehensive and coherent narrative of the research problem. The review is a thematic literature review, in other words it is organised around a particular topic (Mouton, 2002). Both Chapter 2 and Chapter 3 have provided the conceptual framing for this research. The discursive domain conceptual frame allowed me to separate the literature artificially, while the conceptual frame in Chapter 3 provided a mechanism to understand the insitutional mediation of those discursive frames.

Through a broad search of the literature, using my research interests and preliminary literature review as a starting point, I was able to identify key and critical texts. Mouton (2002) advises that a good literature review should at the least be comprehensive, topical and not dated, making the most of the multiple resources available and well organised. As such, I organised my search of the literature into themes that would reveal, as far as possible, an exhaustive collection of relevant information from which I could discern what was pertinent to the main aspects of the research. Through numerous searches, as the process evolved, links emerged between seemingly unconnected literatures – an interesting and rewarding process. The most significant sources were journal articles, books and international reports; however; I also made use of conference papers, magazines and completed theses.

The field of sustainable urban infrastructure is not grounded in a single discipline. Multiple, intersecting and mutually reinforcing challenges accounted for the emergence of this notion, emphasising the need to select a range of disciplines that helped to organise a conceptual frame, made up of a variety of concepts and perspectives, to understand these challenges and respond in a meaningful way. I therefore organised my search according to themes, complimented by specific key words and phrases, reflected in Table 4.1.

Table 4.1: Research themes, key words and phrases selected for the literature review

Theme	**Key word/Phrase**
Sustainable development	Natural resources Climate change Poverty/inequality Population growth Urbanisation trends
The urban environment	Cities Resource consumption Infrastructure Infrastructure configuration Infrastructure lock-in Sustainable/sustainability
Decoupling	Footprint Metabolism Material flow analysis Resource efficiency

Theme	Key word/Phrase
	Resource productivity Sustainable urban infrastructure
Socio-Technical Systems	Sustainable urban infrastructure Infrastructure configuration Reconfiguration Innovation Multi-levelled perspective Socio-technical transition Urban transition
Conditions for Change	Public organisations Innovation Institutions Insitutional change Change management Power Agency Intermediaries Learning

Source: Author

One of the major challenges experienced was that I cast my net too wide and found myself reviewing potentially relevant, yet not pertinent literature. I originally intended to use transitions literature alone to understand transitions and processes of change, and from that extract an all-encompassing set of factors that would help to build an understanding of changes processes. However, I found it inadequate to deal with and understand the complexities that are present in large institutions, such as the units of analysis. Another challenge was leaving certain ideas and models behind; for example, I spent a lot of time delving into the field of transitions and transition governance. Particularly, the allure of the Multi-levelled Perspective (MLP) [35] (Geels, 2002; 2004; 2011b) as a conceptual and

[35] The MLP framework offers an approach to analyse the dynamics of transition processes from the micro, meso, and macro scales and therefore provides "...an overall view of the multi-dimensional complexity of changes in socio-technical systems" (Geels, 2010: 495). The macro level or socio-technical landscape encompasses all macro level trends, exogenous to actors within the system, it is made up of social trends, environmental conditions, economic cycles and political constellations that

methodological tool to analyse socio-technical transitions, was almost too difficult to distance myself from. However, the MLP's usefulness for analysing the development and entrenchment of technology in society is overshadowed by several critiques. These include an inattention to agency, the question of scale and boundedness, and the challenge of preferencing the bottom-up versus top down change models, for example (Genus & Coles, 2008; Geels, 2011a; Haysom, 2014). Moreover, it did little to help me understand the variables that shape institutional uptake of desired alternatives within an organisation like the City of Cape Town. Therefore, I decided to focus on established literatures to broaden my conceptual scope rather than the relatively new literature, complicated by jargon and technical, untested, phrases. This included public management development literature (Long, 2001; Johson & Wilson, 2009), linked to insights from institutional change literature (Flood, 1999; Carley & Christie, 1993), which includes learning organisations literature (Johson & Wilson, 2009). These established literatures provided a lens for me to really begin to understand the nature of socio-technical systems in large institutions where multiple actors are present.

4.1.2 Empirical research

The literature review reinforced the importance of the research and confirmed the research questions. Futhermore, it provided the conceptual framework for the fieldwork that lay ahead. I selected the CCT's Utility Departments as the key to unlocking the questions that had emerged. Using this as a departure point, I began to design the most appropriate research approach that would provide for the necessary data collection and analysis while contributing to scholarship. Specifically, I selected a qualitative case study approach. It might be of interest that this design was not fixed, but rather acted as an approximate strategy that initially orientated my approach to the ethnographic research but remained consistently under review. Following Neyland's (2008) advice, I attempted to retain coherence by constantly considering and adapting the strategy as challenges or new problems emerged – which certainly occurred. Flyvbjerg (2011) is somewhat flippant in his review of the various definitions of a *case study*, but is very clear on his preference, described in the Merriam-Webster (2009) online

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are slow to adjust depending on indirect changes at the lower levels while providing the overarching structure for the meso and micro levels (Geels 2002). The meso or socio-technical regime is embedded within the macro level and characterised by established institutions, technologies and routines that provide societal functions (Geels 2002). Lastly, the micro level consists of innovation niches which emerge as a result of pressures from the landscape levels and periods of crisis at the regime level.

dictionary as "[a]n intensive analysis of an individual unit (as a person or community) stressing developmental factors in relation to environment".

On accepting this definition, it became clear that using the case study approach would best fit the intended research. The value here, as asserted in the definition, is that it allowed me to select a specific, bounded *unit* for analysis. In complex social systems, the boundary between the context and the phenomenon of interest can become blurred (Yin, 1994). This is a challenge I experienced. However, through process of *casing* as Ragin (1992) aptly states, it became possible draw a conceptual boundary around a particular phenomenon, or case unit, and focus on what occurs within that unit, distinguishing it from the context. The second valuable point is the idea that a case study is an *intensive analysis*. In other words, case studies inherently recognise a high level of complexity of social systems and are therefore a rich, detailed and complete account of the unit of analysis (Flyvbjerg, 2011). Although, in retrospect, it is safe to assert that my account of the Uitlity Departments is as complete as possible, considering the nature of access information from a public institution within the ambit of time constraints. However, Duminy et al. (2014) remind us that while case studies can demand a great deal of time to ensure an exhaustive analysis, short, intensive engagements are effective in accruing sufficient data for analysis to gain theoretical insight. The primary goal has been to demonstrate a mastery of *how* and *why* particular events evolved in a given context. In this way, the development and the changes that take place in a spatial and temporal setting, are explained in relation to the larger environment (Flyvbjerg, 2011). As will become evident in Chapters 6 and 7, I have attempted to provide a rich and thick description of the case; therefore much of the empirical chapters is descriptive in my effort to retain as much of the narrative as possible to offer the reader the full story.

The definition and explanation of case study research illustrate the suitability of such an approach when studying dynamic, real-life processes where multiple components are involved in a particular phenomenon. As such, it is exceedingly useful for the study of large socio-technical systems where the intention is to answer questions around *how* the system operates on a daily basis, *how* the system operations have changed over time and *why* certain developments have taken place. Moreover, case study research is known for usefulness in developing "new understanding and knowledge, particularly in the context of novel institutional arrangements and understudied organisations" (Mukhija, 2010: 418). This suited the cases selected for undergoing empirical inquiry: the CCT's SWM Department, the ES

Department and the W&S Department, which together manage Cape Town's networked infrastructure system. The use of a case study as a research strategy has been criticised[36] for several reasons: for example its inadequacy to generalise findings and interpret causality, and that case knowledge does not match the rigor of general, theoretical knowledge (Flyvbjerg, 2011; Mukhija, 2010). Moreover, debates in the literature pit against each other the value of single case studies for in-depth understanding versus multiple case studies for broader understanding. While I agree with Flyvbjerg's (2011) thorough dismissal of the misunderstandings regarding case study research, and although "much of what we know about the empirical world has been generated by case studies, [which] … constitute a large portion of the work generated by the social science disciplines … the method is generally unappreciated" (Gerring, 2007: 8).

I felt comforted and I was inspired by Mukhija's (2010) idea of *N of One plus Some* approach, which offered a way to overcome any potential challenges that might emerge by relying solely on one single case. Mukhija's (2010) *N of One plus Some* approach builds on the existing case study method to propose a slightly altered strategy, extracting useful aspects for both the single and multiple case study strategy. Mukhija (2010) explains this strategy as one that is based on a single primary research case, informed by secondary cases. The primary case is complemented by the secondary, adding to its completeness by identifying issues and challenges to expect, information to look for or information that might be inconspicuously absent. The primary case of the SWM Department underwent specific empirical inquiry of open-ended inductive research providing rich, in-depth, and detailed narrative, while the secondary cases of the ES Department, and W&S Department underwent general analysis.

Although it was never my intention to conduct in-depth case studies for each of the utility departments, recognising the enormity of the task, I wanted to know as much detail about the case as possible, while ensuring the validity of the claims. Originally, I sought to overcome

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[36] Flyvbjerg (2011: 302) brings to attention and refutes five misunderstandings that are held by the orthodoxy of the case study: "Misunderstanding 1: General, theoretical knowledge is more valuable than concrete case knowledge. Misunderstanding 2: One cannot generalize on the basis of an individual case; therefore, the case study cannot contribute to scientific development. Misunderstanding 3: The case study is most useful for generating hypotheses; that is, in the first stage of a total research process, while other methods are more suitable for hypotheses testing and theory building. Misunderstanding 4: The case study contains a bias toward verification, that is, a tendency to confirm the researcher's preconceived notions. Misunderstanding 5: It is often difficult to summarize and develop general propositions and theories on the basis of specific case studies."

this by focusing on one department for in-depth analysis, the SWM Department, and included the remaining two departments in the utility directorate as contextual background for my analysis. However, it was sometimes confusing and challenging to remain focused on achieving depth in one case, with the knowledge that breadth is important. In this way, the issue of drawing clear boundary between the context and phenomenon was *real* for me. However, after considering Mukhija's (2010) approach, I realised that I had overlooked the value of these departments as secondary, supporting cases. This was a particularly useful turning point during my fieldwork, shifting my view to considering the latter two departments as cases and key informants rather than merely for general contextual analysis.

Following Yin (2003), I used a mixed methods approach which included the use of narratives to provide a thick description of the case, collected by structured, semi-structured and exploratory interviews with selected stakeholders within the case boundary, and participant observation to provide an insider perspective of the case. In retrospect, this combination was invaluable in my endeavour to construct an institutional ethnography. Institutional ethnography "is designed to explicate social relations and how these relations come to govern those individuals involved … [and hereby] … explicate the interconnections between everyday life and institutional processes" (Walby, 2007: 1013). This provided a method to explore the dynamics presented in the conceptual frame, as the specific data captured is not the topic of interest but rather, as Campbell (1998) contends, the entry point into the social dynamics of the organisation; to which I will add: the socio-technical dynamics of the organisation.

My starting point was to access a key informant with whom I already had a strong rapport, Barry Coetzee, the Director of Technical Strategic Support for Utility Services for the CCT. Using a narrative approach I began make sense of *what is going on* through a retrospective exploration exercise of the past in an effort to reconstruct a story around certain critical events in the respective departments and the CCT. From here I began to gain access, through referrals, to other individuals within the organisation. Yin argues that because case study research "relates to phenomena that have more variables of interest than data points", a key tactic of case researchers is to utilise "multiple sources of evidence" (Yin, 2009: 315). Therefore, in order to gather sufficient data to build a thick description, I made use of complementary methodological tools. Additional tools included participant observation, and while I was not participating in activities within the organisation, through observation I was able to gather onsite data in the form of existing textual data.

4.1.3 Case study selection

The case selected to form the basis of the empirical study was the SWM Department of the CCT in Cape Town Metropolitan region. In conjunction with this case selected for specific inquiry, the remaining utility departments, which include the ES and W&S Departments, underwent general analysis. The rationale for selection was as follows. The literature demonstrated the socio-technical nature of infrastructure embedded in a larger framework, the socio-technical regime, which together determine the configuration of networked infrastructures. This conceptual framing of infrastructure and the ensuing analysis hinges on multiple variables that demand a comprehensive and holistic account of the social processes (Yin, 1994). As the central goal was to demonstrate a mastery of *how* and *why* particular events evolved in a given context, I needed to capture the nature of dynamics between actors and social groups, as social processes, within the system rather than just between the actors themselves. In order to understand and unpack the interactions between the various actors, networks and institutions it was necessary to engage with those who directly influence the configuration of infrastructures in Cape Town.

For the reasons discussed above, I considered the Utility Directorate of the CCT as critical to my research. The Utility Directorate, consisting of the utility departments, are intimately involved with and responsible for the management and operation of networked infrastructure in Cape Town. In order to ensure the research was possible and doable within the given timeframe I conducted both a preliminary review of the CCT Utility Department's policy and strategies, and a preliminary interview with a key informant to determine where to focus my attention. I considered the SWM Department to have made significant progress (in comparison to the other departments) in transitioning toward a more sustainable development pathway. I selected the department as the primary unit of inquiry because of the presence of a sustainability discourse throughout policy documents and my assumption that this discourse would transcend to the day-to-day activities of officials and technicians who manage the system. In hindsight, although I was conscious of avoiding bias, this selection was influenced by the informant at the CCT with whom I discussed matters and whose focus at the time was on the challenge of solid waste in Cape Town. My hunch that selecting the SWM Department as a unit of analysis would offer rich information and therefore be interesting for the purposes of the study was confirmed. My findings, which are discussed in Chapters 7 and 8, only partially support my preliminary understanding of the department.

Flyvbjerg (2011: 207) identifies four types of non-mutually exclusive cases that are the outcome of an information-orientated selection[37]: 1) extreme or deviant, 2) maximum variation cases, 3) critical cases, and 4) paradigmatic cases. Type one and four are most useful for understanding the CCT Utility Departments because extreme or deviant cases are useful for demonstrating the limits of existing theory in explaining certain phenomena and therefore develop new theories and concepts that can account for these outliers (Flyvbjerg, 2011). Considering the findings of the literature review that existing sustainable urban infrastructure theory does not adequately explore sustainable urban infrastructure in certain *outlier* contexts, this empirical research seeks to expand existing theory. Pushing this further, paradigmatic cases are those that shine, as a well-constructed metaphor making the complex social dynamics between discourse, action and context clear, and in this way "may function as a focal point for the founding of schools of thought" (Flyvbjerg, 2011: 80). Paradigmatic cases set a standard and are therefore central to learning, but rely on intuition for identification (Flyvbjerg, 2011). The nature of the research conducted was seemingly addressing a deviant case when identified, but as the analysis unfolded, a paradigmatic shift emerged, making a significant contribution to conceptual knowledge pertaining to the variables that shape institutional uptake to alternative networked infrastructure configurations

4.2 Conducting fieldwork

I began my fieldwork in August 2012. However, I continually straddled between fieldwork and analysing findings, only truly exiting the field once I had completed my empirical chapters in October 2014. Following cues from Yin (2011), I sought to include multiple sources of different types of evidence collected by "1) interviewing, 2) observing,

[37] Information-oriented selection is useful "to maximize the utility of information from small samples and single cases. Cases are selected on the basis of expectations about their information content. *Extreme/deviant cases*: To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense. To understand the limits of existing theories and to develop new concepts, variables, and theories that are able to account for deviant cases; *Maximum variation cases*: To obtain information about the significance of various circumstances for case process and outcome; e.g., three to four cases that are very different on one dimension: size, form of organization, location, budget, etc. *Critical cases*: To achieve information that permits logical deductions of the type, "If this is (not) valid for this case, then it applies to all (no) cases." *Paradigmatic cases*: To develop a metaphor or establish a school for the domain that the case concerns." (Flyvbjerg, 2011: 207)

3) collecting and examining, and 4) feeling" (Yin, 2011: 130). In this way, the empirical chapters are the outcome of the three main research methodologies: interviews, secondary data analysis and content analysis. I primarily made use of semi-structured, in-depth *interviews* as a research technique, from which I extracted and made extensive use of direct quotations. *Collecting* and *examining* departmental business plans and reports, policies and strategy as secondary sources of grey literature as well as numerous council minutes, employee records, and department budget allocations, as primary sources of information, provided additional and invaluable data to support findings. *Observations* and *feeling* activities were used in a more obscure way to support my primary data collection tools.

I consciously combined these ways to gather information, not only to compile a sufficiently rich and detailed account of the case but to also achieve triangulation and cross-check through feedback processes to ensure the accuracy of the data and interpretation of my findings (Maxwell, 2009). It became evident during interviews that triangulation would be critical to ensure the accuracy of information provided by interviewees, due to knowledge imbalances and uncertainties, and my interpretation thereof. Moreover, this directed the search for supporting information in the form of additional primary sources, and secondary sources of grey literature. My data collection process was therefore an iterative and reflexive process.

4.2.1 Collecting and examining

The primary and secondary cases presented in the empirical chapters are concerned with the period between 2000 and 2012 with a focus on if and where innovation and learning lies within the units of analysis, and how this manifests in the daily operations. Significantly, the history of Cape Town's development and the parallel infrastructure investment are inherently linked and affect how the CCT currently makes decisions around various networked infrastructures. The recent history of Cape Town therefore provides the background and context for the cases presented, which are described in Chapter 5.

The preliminary scan of official policy documents provided the initial review of the policy discourse that has been emerging in the CCT and some of the key identifiable shifts and developments in the utility directorate over the past decade. Furthermore, this assisted in framing my initial preliminary interviews, which provided the official selection of the SWM Department as the primary case study.

I analysed the content of texts and documents to explore what *had been going on* in the CCT over the past decade, making extensive use of annual reports, policy documents and the Integrated Development Plans (IDP) between 2000 and 2012. This was an exploratory process. Using casual questions, I reconstructed a chain of events that were seemingly catalytic in development and change processes. Therefore, I was able to map out a sequence of events that I used to focus and narrow down my search when conducting further content analysis as well as fieldwork. Considering the iterative and reflexive nature of the research I found myself between content analysis and ethnographic research, where the content analysis informed my ethnographic research and vice versa.

Existing secondary textual data that informed the empirical chapters include published CCT annual reports, policy and strategy, and unpublished departmental business plans and budget allocations as well external reports, collated by consultants. Moreover, utilising the Promotion of Access to Information Act (Promotion of Access to Information Act, 2 of 2000), I requested internal CCT human resources, budget allocation and project plan information, which I used to cross reference decision-making with budget allocations and the individual responsible for various mandates. I made use of secondary data analysis together with content analysis, as I received both numeric and textual data. Partly through this process, I was able to identify pertinent actors and individuals for interviews and embark on the process of gathering empirical evidence required for a thick description of the case. The purpose was to reveal some of the causes and triggers of change identified during content analysis, and then understand why these changes came about.

The other significant source of primary data was the CCT council minutes, which are available on the CCT website[38]. While trawling through the numerous listings of council meetings was extremely time consuming, I was able to extract useful information not only about the time frame of pertinent decisions but also who makes decisions, how the decisions are made and what evidence is provided that influences those decisions. In this way it was possible to extrapolate and track how the utility departments had made investment decisions over time.

4.2.2 Interviewing and observing

Interviews were widely used and were critical sources of data. By using qualitative

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[38] Available at: www.capetown.gov.za/council/minutes.

interviews, I was able to interrogate how participants "on their own terms … make meaning of their own lives, experiences, and cognitive processes" (Brenner, 2006: 357). Considering the conceptual framework described in the literature review, the sense-making processes of participants, embedded within the larger organisation, are important for a thorough understanding of the research problem. Moreover, the freedom of this method allowed me to understand the perspective of individuals, and therefore the real-life social processes they are involved in in an intimate manner. In the initial stages of the interview process, I used a targeted approach to identify interviewees by linking my *event map* to the CCT officials that were part of my existing network at the CCT within the utility departments. Using this as the access point, I followed a snowballing sampling method where participants helped to identify relevant and influential actors. In this way, I was able to access key data directly and additional information indirectly. Participants helped me to identify relevant and important key informants as well as reports and documents that I had not yet come across. Moreover, this new information provided discussion points for future interviews. I determined that I had reached an interview saturation point once participants pointed me back to informants whom I had already interviewed.

Throughout interviews, I retained a specific mental framework that I used to orientate the discussion. Interviews were largely semi-structured. Weller (1998) explains that people are able to recall events more clearly when prompted, but when little is known about an arena, unstructured, open-ended methods are appropriate. I used exploratory, open-ended and flexible questions, weaving around the responses to evoke an interesting conversation rather than using a structured set of questions. Specifically, I embraced Kvale's literal interpretation of a qualitative interview, in that "the qualitative research interview is a construction site of knowledge. An interview is literally an inter-view, an interchange of views between two persons conversing about a common theme" (2008: 21). In this way, as a conversation progressed, and once I had learnt the language of the participant, I was able to phrase questions more adequately in a targeted manner.

The nature of the interview was however dependent on the setting, my ability to phrase questions in a targeted manner and my relationship with the interviewee. In some instances I had already developed rapport with participants, established during previous research projects and engagements. This made access straightforward and interviewees were generally relaxed. However, I found most participants from within the utility departments skeptical of my interest in the routine management and operations of Cape Town's networked infrastructure. Therefore, in instances where I had never met the participants, I had to actively establish rapport to avoid having the statements of policy documents simply recounted for me. A key observation across the interviews was that participants were concerned about how they would be portrayed. Moreover, I felt that my identity as a young woman researching infrastructure and utilities, without an engineering or technical background, was a source of consternation for participants, especially those in the technical branches. I therefore structured the conservation topics around the existing work of the participants, emphasising their role as an expert, so they would converse with ease and confidence, and then gently directed the conversation to my research topic. Using phrases like *I need your help* and *I don't understand, please explain this carefully to me* were useful for accessing detailed information. Most certainly, the more time I spent with participants, and the more communication we had (via email for example) the more willing participants were to reveal their opinion and understanding of the challenges, the culture and the various formal and informal institutions within the organisation.

Self-reported data was collected during these interviews. However, accessing the right informants and participants was not straightforward. In fact, I was not able to interview all the key players that could offer valuable insight for the empirical chapters. In some cases it was impossible to schedule and confirm interviews with key informants, especially executive management[39]. Interviews were sometimes postponed at the last minute and I would be directed to an alternative individual to discuss a matter with. This was highly unsatisfactory, frustrating, and infuriating at times. In fact, after receiving a dismissal for the third time from the same individual, I responded in irrational haste with a dissmive note suggesting that it was not likely the person would contribute anything of value to my research in any case. The response did nothing to help me secure an interview in the future, and reflecting on the number of emails sent to CCT officials to request interviews, I have noted the fine line between the eagerness of a young researcher and harassment of over-worked government employees.

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[39] Although staff at the executive management level would provide critical sources of information and their absence may be construed as a major limitation, the spread of interviews included senior and middle management who offered a wealth of information, and therefore it does not detract from the legitimacy of the findings. Moreover, I have elected to draw attention to their absence to highlight the challenges of this type of research, which I elaborate on as the section continues.

Although, those untargeted actors were largely in middle management or technicians with little agency in actual decision-making in CCT, I gained much insight into the organisation from both a historical and practical perspective. I learnt what it actually takes to ensure that, in the executive mayor's words, "the lights are on, the water is running and the refuse is collected – for all residents" (CCT, 2013a: 4).

The inaccessibility was likely the result of interview fatigue amoung *some* critical actors. Cape Town and the CCT have been the topic of interest in a number of research projects, which, over time, has been demanding on the CCT's officals. Potential participants in some instances simply did not have the time or the inclination to submit themselves to an interview. The other major challenge was the absence of sufficient and adequate human capacity within the organisation; while many of the officials, technicians and managers are professional, highly knowledgeable and skilled, many of them are overworked and departments are understaffed. One participant within the SWM Department expressed the following in her response to my request for an interview:

> "The problem is my over 1000 unanswered emails, on top of project work which I need to get through and strategic matters which our small team of 3 are supposed to drive for the whole City" (Davison, 2013).

A similar response was received from the Water and Sanitation Department's Finance Manager: "I normally try to help but at the moment I just have too much on my plate. I unfortunately have to decline" (Saayman, 2013a). It is clear that my frustration was matched by the frustration of officials.

By and large, interviews lasted for approximately one hour. In instances where I wanted to collect a more detailed account of events, I identified a key informant and scheduled longer interviews, sometimes lasting for up to three hours. Usually, I scheduled these longer interviews with the branch heads within the SWM Department and they were attended by two or more additional employees of the branch. All interviews were recorded with the permission of the participants. In addition, I took notes during interviews, which generally pertained to observations of tone and expression, and as a means of self-reflection on what transpired. These carefully noted observations (in fieldwork journals) complemented the analysis of documents and artefacts, which, when triangulated, contributed to the rigor of the research. If I needed clarification or felt I might have misinterpreted self-reported data when reviewing journal entries and fieldwork notes, I either conducted a second interview or emailed the participants to obtain respondent validation (Maxwell, 2009).

In reviewing my fieldwork journals, I noted a very clear disjuncture that emerged regarding my feeling about the interviewees and the work of the technicians and officials as a whole. During interviews I would jot down points of reference on the relevant part of the page as well as make notes about my impression of the interviews. On the one hand, my overwhelming feeling during my fieldwork was a deep appreciation for the officials of the CCT, especially at the lower levels of management. By and large, I felt that although many employees worked within an extremely constraining environment, they were still able to ensure that the service delivery mandate and the expectations of the executive mayor were met (CCT, 2013a). However, the margins of my journals told a different story. Read together, it was clear that my immediate experience during interviews was one where I was blown away by the levels of ignorance shown by bureaucrats of the networked infrastructure system as a whole in relation to the socio-economic and environmental context of Cape Town. There is generally very little awareness about what is happening beyond their department and in some extreme cases beyond their branch. Very few officials were able to see the bigger picture associated with networked infrastructure.

4.3 Validity of the research

Throughout this chapter I have implicitly brought attention to how I ensured the validity of the research. I will make this explicit here, using Maxwell's (2009) seven strategies for ensuring the validity of claims.

Table 4.2: Validity of research

Maxwell's Strategy for Validity (2009:244)	My effort to ensure validity
Intensive long-term [field] involvement—to produce a complete and in-depth understanding of field situations, including the opportunity to make repeated observations and interviews	Although I moved in and out of the field, I allocated sufficient time over the past 3 years to ensure I had interviewed all critical actors in a substantial way. Not all interviews can be considered in-depth but I paid close attention to participants who were key informants.
Rich data—to cover fully the field observations and interviews with detailed and varied data	I considered grey literature, primary textual data and observations to be as critical as data gathered through interviews, and therefore focused a substantial amount of time and effort to accrue relevant and pertinent documents and reports that

Maxwell's Strategy for Validity (2009:244)	**My effort to ensure validity**
	could shed light on the events within my selected case.
Respondent validation—to obtain feedback from the people studied, to lessen the misinterpretation of their self- reported behaviors and views	To avoid misinterpreting self-reported data, I devoted time to understanding the participant's interpretation of events. During interviews I listened closely and rephrased my interpretation for confirmation if I was unsure. This was more of a challenge during analysis, especially as I made use of observations from my fieldwork journals. I did however make use of follow-up communication via email and in some instances a second interview was necessary.
Search for discrepant evidence and negative cases—to test rival or competing explanations;	I made a constant effort to either confirm or disregard any information gathered. In this way, I did not take anything at face value, but rather searched for a competing explanation for why events transpired the way they did. As such, I remained sceptical of my findings until I was confident of its facticity and truth.
Triangulation—to collect converging evidence from different sources;	Throughout my research I sought to confirm data and findings using multiple and different sources in order to counteract any bias. First prize was to have my observation and interpretation of data confirmed by a participant involved and to have it similarly described in a written format or report, for example. In some instances, where there was no available textual information about a phenomenon or event, I had to rely on conversing with actors involved several times to ensure the 'versions of events' were complimentary and consistent.
Quasi- statistics—to use actual numbers instead of adjectives, such as when claiming something is "typical," "rare," or "prevalent"	Wherever possible throughout the empirical chapters I endeavoured to use quantifiable claims when speaking to practical changes to operations of utilities. For example, the reduction in resource flows or changes to budget allocation.
Comparison—to compare explicitly the results across different settings, groups, or events	By using a primary case for in-depth analysis as well as two secondary cases for general analysis, the research has both depth and breadth. While this is not a comparative case study, completeness is ensured by cross-referencing the three departments, which provided the opportunity to identify issues and challenges that were not noticeable in only one department. Of great value was the access to the number of officials and

Maxwell's Strategy for Validity (2009:244)	My effort to ensure validity
	technicians afforded by the three departments to ensure a rich and detailed story emerged. This would not have been possible if only one department had been analysed.

Source: Maxwell (2009); Author

4.4 Ethical considerations

Considering the nature of the research, there are very few ethical considerations at stake. While my research included human subjects, no vulnerable and disadvantaged individuals or communities provided any type of data. Moreover, interview participants were either CCT officials, private sector consultants or academics, and therefore educated professionals who willingly consented to participate in the interviews. This is not to suggest that I was not sensitive to ethics of confidentiality or anonymity. I followed the University of Cape Town's code for research involving human subjects as sources of data, and received my Ethical Clearance notice from the Engineering and Built Environment faculty's Ethics in Research Committee prior to commencing my fieldwork in 2012. Because my fieldwork spanned across three years, I reapplied in 2013 and 2014, and was granted clearance to conduct my research.

Once in the field, before beginning interviews, I asked permission to digitally record interviews and to quote directly from participants. All participants agreed to have the interview recorded, which was interesting because of the generally skeptical attitude among a number of the participants. Most participants agreed to be quoted directly, except one participant who, when asked direct questions about the internal dynamics of the SWM Department, requested that the answer be 'off the record'. While this was not included in the research findings, it provided useful background information and provided insight during further interviews. Moreover, by and large, the remaining respondents were happy to answer any question I posed as soon as rapport had been established, and therefore the research was not compromised. Any data gathered was managed with care and stored in a secure location in an effort to reassure participants. All interviews were logged and field notes recorded in what I call 'fieldwork journals' that contain interview notes as well as observations and reflections about the interview. Interview recordings were downloaded and stored on an external hard drive and in a personal ‘dropbox’ folder[40] linked to my personal computer. In both cases, I am the only one who has access to the files.

4.5 Limitations and positionality

As with any research project, there are a number of limitations pertaining to the conceptual framing and methodological challenges that must be considered. The foremost limitation is my positionality within the research context, as “the main research instrument for collecting data in a qualitative study” (Yin, 2011: 12). Although I was in search of facticity to ensure the truth and therefore validity of my findings, because qualitative research is seldom objective, there are multiple possible interpretations of data. I remained conscious of not imposing my own interpretation onto the participant’s interpretation of events, but it is a limitation that must be acknowledged. By strongly emphasising my research lens rather than my own biases I, as much as possible, remain true to the conceptual frame and research questions.

Accessibility of data can be construed as a limitation. Although I spent a lot of time gathering empirical data, there is a substantial amount that I do not know about the cases under analysis. Information may well have been available but I had either overlooked it, was not aware of it, or had not phrased questions adequately to prompt participants to share it. In other instances I had too much information at my fingertips and in such cases I had to make hard decisions about what was pertinent to the study and what was not.

The empirical scope of the research has been focused on one primary case study, complemented by two additional cases, and restricted to one geographical location. However, conceptually I am interested in the broader questions of sustainability, urban infrastructure, and purposive transitions for more sustainable urban development pathways. Therefore, questions emerge as to generalisability of the research findings. This is overcome by the fact that this is inherently a ground-clearing exploratory study that has applied an emerging literature to an under-studied context. As such, this case offers a critical and significant opportunity to broaden and deepen understanding of sustainable urban infrastructure in middle-income cities of the global south.

[40] It may be unorthodox to store interviews on the internet in a cloud. However, I did this as a backup to my external hard drive after my first external hard drive was stolen during the early stages of my research in Cape Town.

From a more practical perspective, if additional locations for research were identified, I would not have been familiar with the context, nor would I have had any access to actors and key informants; consequently, the empirical research was restricted to one location; Cape Town in the Western Cape.

Chapter 5 that follows introduces the context of Cape Town in order to locate the empirical material. The chapter describes the case context in two ways. Firstly, it provides background information about the recent history of the city and its incumbent socio-economic and environmental conditions. Secondly, it offers an explanation of institutional nature of the CCT and where the Utility Departments are located within the context.

5. Introducing Cape Town

The purpose of this chapter is to introduce the context of the cases under analysis. The argument thus far has brought together a number of conceptual strands that frame the research. The nature of global environmental change places cities at the heart of a range of possible interventions necessary to reduce uncertainty and risk associated with negative global environmental change. Networked urban infrastructures have been brought to the forefront of the debate because of the role that these socio-technical systems play in unsustainable urban metabolic processes. Particularly, it has been suggested that it will be necessary to reconfigure bundles of networked urban infrastructure, based on the principles of sustainable urban infrastructure, discussed in Chapter 2.

Sustainable infrastructure theory has brought to light resource scarcity, carbon intensity, and resultant risks associated with conventional infrastructure. However, the appetite for alternative systems in middle-income cities remains unknown, partly because what triggers, occasions and sustains transitions in these contexts is hardly discussed in the literature. In connecting this literature to middle-income contexts, different factors need to be considered, especially around issues of the reproduction of urban injustices. There is an urgency to connect excluded and marginalised groups to the socio-economic flows of the city, due to dire socio-economic conditions, while the environmental consequences of excluding citizens from sustainable resource flows exacerbate incumbent challenges. Networked infrastructure is considered a primary means of realising human development, through the improvement of socio-economic conditions.

There is more to the debate than simply replacing redundant, conventional systems with sustainable urban infrastructure. Cape Town, located in the Western Province, South offers an opportunity for understanding urban transitions and provides useful lessons for purposive interventions that support more sustainable urban transitions. Here, the formula for the delivery of conventional systems, designed using modern notions of economic efficiency, is unsustainable. That universal coverage of basic, affordable services depends on the collection of consumption-based user charges to ensure the maintenance and rehabilitation of the network, and the continuity and security of that service while the environmental impacts associated with the configuration of those services remain inconsequential and irrelevant. Due to the way the cost structure and revenue models of these infrastructures have been defined, there is very little concern for the underpinning natural resource requirements of conventional systems. Moreover, the assumption that conventional infrastructure systems are, in fact, adequate in the long run reduces the willingness of decision-makers to experiment with alternative infrastructure configurations. Put differently, political leaders and, executive and senior managers have confidence that conventional infrastructure systems and technologies are adequate to meet current and future demand, as long as sufficient financial resources can be mobilised to continuously extend and maintain the network.

This chapter begins with an introduction of Cape Town, with the intent of demonstrating the mutually re-enforcing urban challenges of urbanisation, informality, and ecological degradation in a context where standardised and ubiquitous service delivery is still desired, and institutional capacity is suitable for the status quo but not necessarily for system change. Currently, Cape Town is faced with natural resource constraints, a plethora of social issues and fiscal limits. Furthermore, due to a historical legacy, the incumbent urban development paradigm is based on the extension of networked infrastructure services, which undermines the capacity of the local government to make meaningful inroads into the interrelated challenges. The incumbent development paradigm is both financially and environmentally unsustainable (Crane & Swilling, 2008).

Despite these challenges, in an optimistic reading, Swilling (2014: 3190) sees Cape Town as a locality for experimentation for the sustainability agenda and as the "epicenter of an emerging green consciousness [in South Africa] driven in part by an active research community interested in these issues based in the city's major Universities[41]". It is further driven in part by a growing policy discourse that is emerging from public sector institutions (CCT, 2003a; CCT, 2006a; CCT, 2007a; CCT, 2007b; CCT, 2009a; CCT, 2010a). Recent policy documents produced by the City of Cape Town do not only provide strategic plans and policy frameworks that speak to the sustainability agenda but also demonstrate existing projects that are creating a receptive environment for an urban transition to sustainability. The extent to which this policy trend is being adopted by the utility departments and internalised into day-to-day operational practices is the focus of the empirical chapters. The purpose of this chapter is to provide an overview of Cape Town and the CCT.

[41] These universities include Stellenbosch University, the University of Cape Town, and University of the Western Cape.

5.1 Setting the scene: the South African context

South African cities still carry the visible scars of the apartheid regime's spatial planning and dislocation policies that divided the population on racial lines for three decades. Spatial dislocation accompanied by socio-economic depravation has manifested as widespread poverty, inequality and unemployment for large segments of the population. Now, on its way to a third decade of democracy, South Africa is a country plagued with contradictions. With a population of 51, 8 million, South Africa is an upper middle-income country, and is considered a newly industrialised economy, the second largest on the African continent. Significantly, large income disparities remain, demonstrated by a Gini coefficient[42] of 65 (World Bank, 2015) and unemployment rate of approximately 25% (Taborda, 2015). As South African cities continue to grow, so does the demand for economic, physical and social services. An overwhelming contradiction faces the South African government is how to ensure the necessary redistributive agenda while trying to position South Africa as a global economy and investment destination in Africa. Currently, the economy is more closely aligned with "uneven capitalist development and neoliberal policymaking … required to compete effectively [in the global market]" (McDonald, 2008: 6) rather than with the resolution of growing inequalities.

The South African government has nonetheless been active in its efforts to address the service delivery challenges and improve the basic living standards of previously excluded individuals. Since democratisation three distinctive approaches have been adopted and can be summarised into three prominent themes that, more or less, reflect the liberal global economic environment; (i) *reconstruction* underpinned by values of democracy and reconciliation, (ii) *delivery* underpinned by the values of rights and responsibility, and (iii) *development* underpinned by the values of social justice (Mc Lennan, 2007). Overall, the intention to address poverty, exclusion and inequality was expressed in the Reconstruction and Development Program (RDP) (implemented in 1994), but overshadowed by the cautious macro-economic management that favoured austerity, articulated in the Growth, Employment and Redistribution Policy (GEAR) of 1996, which sat alongside the RDP with a competing

[42] The Gini coefficient provides a measure of the extent of inequality within an economy, or the extent to which income distribution deviates from a perfectly equal distribution; a perfectly equal distribution is represented as a measure of 0 while perfect inequality is represented as a measure of 100 (World Bank, 2015).

macro-development approach. The ineffectiveness of these policies placed a greater emphasis on a social grant system and free basic services, the only real driving force of progress after apartheid (Turok & Parnell, 2009). However, these policies were arguably effective, but they could not resolve the scale of the structural poverty and inequality. Moreover, during a relatively short period, these developmental themes have significantly influenced infrastructure and service delivery at the local sphere, in terms of both nature and means.

A common misperception is that service delivery is a technical process that can be carefully managed to ensure success, as it was during the previous government's rule. Mc Lennan (2009) shows that the high levels of regulation and hierarchical forms of organisation that defined the apartheid regime was inherited by the new government and adopted as the means to achieve service delivery, albeit based on a new set of values, policies and practices. A disjuncture between the policy intent and the established institutional structure has limited the effectiveness of developmental and progressive policy, because an "essentially technical solution [was applied] to an inherently political process" (Mc Lennan, 2007: 16). Approaches adopted by the State therefore depoliticised service delivery, reducing it to a process of technical choices cleverly concealing decision-making that entrenches unequal distribution and exclusionary practices (Mc Lennan, 2007). Significantly, Turok and Parnell (2009) reference the absence of strategic capacity and alignment across the various departments resulting in inconsistency and fragmentation at an institutional level. The several themes adopted and applied for service delivery by the National Government all remain a part of the frame of reference for decision-makers currently tasked with the roll-out of networked infrastructure services in Cape Town. However, in the CCT, principles of privatisation, and especially corporatisation, as mooted in GEAR, have been superficially co-opted as a "half-baked new public management discourse … giving rise to an awkward hybrid: publically managed service delivery with an inclusive bias, wrapped in the language of commodification, markets and cost recovery" (Swilling & Annecke, 2012: 248). Therefore, municipal infrastructure services are delivered by the CCT Utility Departments, driven by these dynamics.

In the case context, it will be shown that the practice of service delivery has been considered a predominantly technical process, rather than the outcome of a number of socio-technical processes, within which political and cultural-institutional processes play out. However, as this chapter shows, despite the assumedly technical nature of delivery, there is evidence of "clashes between policy and implementation …[and]… limited resources and improved quality" (Mc Lennan, 2009: 22) that exerts pressure on the incumbent service delivery model. The tension between policy, planning, and implementation juxtaposed to the tension between limited resources and demand for high quality services will be further revealed in the empirical chapters that follow.

5.2 Cape Town: an overview

Cape Town is world-renowned for Table Mountain, which towers over the city providing an unrivalled aesthetic quality. The city centre and immediate residential surrounds, neatly nestled in between Table Mountain, the mountain spine and the habour, offers a range of world-class facilities: from numerous newly constructed office towers to the quaint European style sidewalk cafes equipped with cheap, high speed internet access to the glistening Green Point soccer stadium. Cape Town is irresistible to tourists and trans-national elites (McDonald, 2008). The city centre and surrounding residential areas, located a short distance away, are populated by upper and middle-income households but remain largely inaccessible for a segment of Cape Town's population. The poor are forced, due to issues of affordability, to reside at the periphery of the city, separated by the dense network of highways and railway lines needed for the daily commute between home and employment opportunities (McDonald, 2008).

Cape Town spans across an area of 2,461 km^2 (CCT, 2009b) and is home to a total population of approximately 3.8 million people (StatsSA, 2012). The expanse of the city has however not been gradual. Over the past four decades the footprint of the city has increased by 40 percent. Much of what is now considered Cape Town was built between 1975 and 2015 (Swilling, 2011). Census data alone reveals that between 2001 and 2011[43] the population of Cape Town increased by 29.3 percent while the average household size decreased from 3.72 to 3.50 (CCT, 2012a). Moreover, 78.4 percent of households have formal houses, while the remaining live in informal dwellings in informal settlements (approximately 13.5 percent) or backyards (approximately 7 percent) while an additional 1.1 percent live in other conditions (CCT, 2012a). Both population growth and in-migration contribute to the increasing informality and consequential service delivery backlog. Coupled together, these trends increase demand for houses, services, and natural resources and environment, which, in turn,

[43] Census data further revealed that between 1996 and 2011, the population of Cape Town increased by 46% (StatsSA, 2012).

exerts pressure on the fiscal capacity of the system. Forecasts, accepted by the CCT, suggest that over a period of 35 years from 2001, the population will grow by almost 60 percent (CCT, 2010b).

The urban footprint therefore has increased, parallel to the population growth. This type of population growth is tightly coupled with a large degree of low-density urban sprawl that follows a "carbon-intensive development model" (Pieterse, 2010a: 15). Much of Cape Town's urbanisation is characterised by a high level of poverty and vulnerability. A significant portion of the population finds themselves below the poverty line and eligible for the CCT Indigent Support Program[44] and free basic services (FBS), which are implemented to ensure basic human rights as prescribed by the South African Constitution (Act 108 of 1996) (RSA, 1996). With only a 49.7 percent employment rate (CCT, 2012a), and an official unemployment rate of 23.7 percent (StatsSA, 2012), Cape Town's economy is in a precarious position. There are few opportunities available to access gainful employment required to shift this group above the poverty line. The economy relies on the financial services, business sector and tourism, yet, the bulk of the population is under-educated. Only 16.2 percent have a tertiary qualification (CCT, 2012a). In the same breath, the poor and working class, who account for 47 percent of households in Cape Town, have a monthly income of R3 200 or less while 14 percent of households have no monthly income (CCT, 2012a). This automatically qualifies them as indigents, and therefore to be considered for indigent support and a property rebate of up to 100 percent. Cape Town's middle class is a mere 31 percent (CCT, 2012a) although, importantly, the middle class in South Africa is still relatively poor with very few assets, generally low skilled, and many remain vulnerable (Visagie, 2013; Burger & McAravey, 2014). Wealth is therefore concentrated with the richest 7 percent of the population that constitute the upper middle class and elite (Swilling, 2006), and in 2010 the household income Gini co-efficient was 0.57 (Western Cape Provincial Treasury, 2011).

[44] An indigent household does not necessarily mean that the house is informal. Therefore there are two valuation methods; property value or household income determines whether FBS or a rebate is applicable. Where the combined household income equals R3 000 per month, households can apply for and become registered as an indigent and in so doing, access FBS's while households with a gross monthly income of between R3 001 and R4 000 receive a 50% rebate on rates. When property value is used as the valuation methods the following applies: Improved property value equal and less than R100 000 = 100% subsidy; improved property value between R100 001 up to and including R150 000 = 75% subsidy; improved property value between R150 001 up to and including R350 000 = 50% subsidy; improved property value between R350 001 up to and including R400 000 = 25% subsidy; improved property value more than R400 000 = no subsidy (CCT, 2012b).

Table 5.1 summarises the quantum of change in the size of the population and the number of households between 2001 and 2011.

Table 5.1: Cape Town population census data between 2001 and 2011

Cape Town	2001 Census	2011 Census	Change 2001 to 2011	
			Number	%
Population	2 892 242	3 740 025	847 782	29.3%
Households	777 389	1 068 772	291 183	37.5%
Av. household size	3.72	3.50		

Source: CCT (2012a: 2)

The implication of urbanisation and demographic growth of this nature is an increase in pressure to provide a variety of (free) social and physical infrastructure. Significantly, the increasing demand for services is by a large portion of the population who cannot afford to pay for them. The pressure to reconfigure the system is evident; the incumbent system will not resolve the human development and sustainability crises facing Cape Town. How to proceed requires an understanding of what processes have taken place that account for the current state of affairs.

5.2.1 Socio-Political context: Cape Town's Municipal Restructuring

To understand the present state of Cape Town, it is necessary to review the socio-political context that has emerged since democratisation in 1994. The liberation movement brought along with it a number of challenges, most notably the urgent need to redress the spatial and economic inequalities that had become deeply entrenched in society and culture as a result of racial spatial and economic planning. South Africa's Constitution is the overarching legislation that guides the activities of the three spheres of government: national, provincial and local. Most significantly, the constitution guarantees socio-economic human rights of all people, secured via the delivery of and access to basic services and infrastructure, irrespective of race, colour or gender, enshrined in the Bill of Rights of the South African Constitution, specifically Section 27.1 a, b, c (RSA, 1996). Table 5.2 describes the role of Local Government as prescribed by the South African Constitution (RSA, 1996).

With the promulgation of the Constitution in 1996 (RSA, 1996), a range of stipulations and objectives meant that local government would be required to undergo a restructuring process.

Restructuring[45] has played a critical role in the democratic transition and was necessary to realise the National Government's redistribution agenda, which favoured those previously discriminated against while encouraging the application of neo-liberal principles to municipal trading services at the local sphere (Jaglin, 2008). The tension between these opposing principles is both stark, and a recurring theme in the municipal restructuring processes after apartheid, as well as the subsequent National Government service delivery agenda. The year 1996 also marked Cape Town's first local democratic elections, during which 61 municipalities, then managed by 17 separate racially based administrations, were reduced to 7 local governing authorities. This was the first step to meeting the requirements of the 1996 Constitution to standardise systems of governance by integrating 'white local authorities' (WLA) and 'black local authorities' (BLA) with the intention of resolving the illegitimacy of WLA and the inefficiencies of BLA (Jaglin, 2004). Areas managed by BLA's were notoriously overcrowded, underdeveloped and with absent essential services while areas managed by WLA's were well run and efficient, with adequate infrastructure capacity to meet the population's demands (Smith, 2004).

Restructuring was done based on the assumption that local government had the financial and technical capacity to achieve the designated mandate of local government, while it was assumed that the major challenge that they faced was managerial, hence National Government opted for a centrally controlled approach (Chipkin, 2002; Mc Lennan, 2009). The integration of administrations alone was however not effective in resolving the malignant conditions within the fragmented Cape Town wherein social and economic disparities were increasing and spatial inequities remained entrenched (Unicity Commission[46], 2000). Division, social dysfunction and the absence of leadership, of which the latter is the most critical, contributed to the lack of progress (Schmidt, 2010). Transformative policy was adopted in parallel to the incumbent service delivery systems, which continued to operate as before, undermining socially orientated intentions (Mc Lennan, 2007). Under these circumstances, insufficient attention was paid to context-specific socio-economic conditions and political networks that determined the implementation and operationalising of policy.

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45 McDonald (2008: part II, chapter 4) offers a thorough discussion of Local Government Restructuring in Cape Town between 1994 and 2000.

46 "The Unity Commission was established in November 1999 as a multi-party political body to supervise the transition to the Unicity for Cape Town, which came into being at the local government elections on 5 December 2000" (Unicity Commission, 2000:34).

The circumstances are particularly pertinent in light of the responses in the literature to *large technical systems* that gain momentum (Hughes, 1989; Summerton, 1994) and become maintained by a particular set of premises that are institutionalised through routine actions that eventually become embedded in the cognitive processes of decision-makers (Geels, 2004). Taking careful note of the deeply embedded realities of well-established socio-cultural patterns and interactions is therefore critical for understanding substantive and real transitions. Moreover, infrastructure is lifted above that which is banal, clearly reflecting the notion of a socio-technical system that is generated and informed through very complex political, social, economic, cultural, technical and environmental processes (Guy et al., 2001).

Returning to the context at hand, during the first few years of democracy, a number of legislation and acts were promulgated to support the new local government system. National Legislature passed the Municipal Structures Act (*Municipal Structures Act 17 of 1998*, 2003), which provided a new structure for metropolitan government for cities in South Africa. Thus, in 2000, the seven separate local governing authorities were amalgamated into a metropolitan institution with an elected government, called the Unicity of Cape Town, now known as the CCT. The Municipal Structures Act enabled the establishment of a centralised power structure that had sole executive and legislative authority in Cape Town (De Wit & Swilling, 2008). Hereby, the responsibility for expanding social and physical services to those previously disenfranchised citizens and segregated parts of the city was transferred to the CCT, specifically the provisioning of basic infrastructure services, a guaranteed human right enshrined in the Constitution (RSA, 1996).

The new structure of local government of the CCT was designed to create a single tax base, sufficient to meet the fiscal requirements of universal service delivery that addressed the spatial fragmentation, pervasive poverty and entrenched inequality issues present (De Wit & Swilling, 2008; McDonald & Smith, 2004; Miraftab, 2004). The standard of services common in white local authority areas would simply be extended to what were previously black local authority areas. Soon thereafter, the Municipal Systems Act (MSA) (*MSA 32 of 2000*, 2000) was promulgated, providing the legislative framework for municipal operations to ensure effective local government. Hereby the central duty of Local Government is "to give priority to the basic needs of the local community … [and] ensure that all members of the local community have access to at least the minimum level of basic municipal services" (*MSA 32 of 2000*, 2000: s73.1.a & c). What is deemed as a *minimum level of basic services* will be discussed in Chapter 6. A full schedule of powers and responsibilities of local governments is listed in Table 5.2. These legislative changes provided local municipalities with the power to become the "hands and feet of the RDP" that delivered key services (RSA, 1994: 18). Hereafter, local government became critical agents of change for post-apartheid South Africa.

Table 5.2: Schedule of powers and responsibilities of Local Government

<table>
<tr><td colspan="2">South Africa's 1996 Constitution (RSA, 1996) as it pertains to local governing authorities:</td></tr>
<tr><td colspan="2">The objectives of local government as defined by the 1996 Constitution are-
a) to provide democratic and accountable government for local communities;
b) to ensure the provision of services to communities in a sustainable manner;
c) to promote social and economic development;
d) to promote a safe and healthy environment; and to encourage the involvement of communities and community organisations in the matter of local government
(Constitution of the Republic of South Africa, Act 108 of 1996)</td></tr>
<tr><td colspan="2">Schedule 4B and 5B of the Constitution (Section 156(1)) describe the relevant local government matters that municipalities have the authority to make and administer policies and by-laws. These matters are specified as:</td></tr>
<tr><td colspan="2">Schedule 4B</td></tr>
<tr><td>- Air pollution
- Building regulations
- Childcare facilities
- Electricity and gas reticulations
- Fire-fighting services
- Local tourism
- Municipal airports
- Municipal planning
- Municipal health services
- Municipal public transports</td><td>- Municipal public works
- Pontoons, ferries, jetties, piers and harbours
- Stormwater management systems
- Trading regulations
- Water and sanitation services limited to potable water supply systems and domestic waste-waster and sewage disposal systems.</td></tr>
<tr><td colspan="2">Schedule 5B</td></tr>
<tr><td>- Beaches and amusment facilities
- Billboards/advertisements in public places
- Cemeteries, funeral palours and crematoria
- Cleansing
- Control of public nuisances
- Control of undertakings that sell liquor to the public
- Facilities for the accommodation, care and burial of animals
- Fencing and fences
- Licensing of dogs
- Licensing and control of selling food to the public</td><td>- Local amenities
- Local sport facilities and markets
- Municipal abattoirs
- Municipal parks and recreation
- Municipal roads
- Niose pollution
- Pounds
- Public spaces
- Refuse removal, refuse dumps and solid waste disposal
- Street trading
- Street lighting
- Traffic and parking</td></tr>
</table>

Source: South African Constitution (RSA, 1996: s156)

During the initial years of being a centralised power structure, the CCT, as the key institution responsible for service delivery, seemed to have had a pair of uncoordinated hands and two left feet, limiting its ability to implement national and local development policies aimed at poverty reduction and economic empowerment. The CCT struggled to find a balance between neoliberal austerity measures, the modernisation of utility services and the delivery of standard networked infrastructure across the city. Additionally, much of the tension that arose in the first several years of the CCT is attributed to a "lack of effective and unifying leadership … [that creates] a strong sense of common purpose among all major interests within the CCT … [and articulated in a] strategic agenda" (Schmidt, 2010: 34). Administrative change-overs involving political clashes between South Africa's dominant party, the African National Congress (ANC), and official opposition, the Democratic Alliance (DA), were frequent between 1994 and 2014. Changes of leadership since the 1996 election resulted in both organisational and institutional changes accompanied by staff changes, translating into the loss of important, knowledgeable employees, and much needed engineering and technical skills, throughout the CCT (Swilling, 2011). This, coupled with attrition, resulted in massive reduction in human capacity across the CCT. There has been a higher degree of political stability since 2006, when the DA claimed majority power over the CCT Council from the ANC, which was solidified in 2009, when the DA won both local and provincial elections with a strong majority. During political scuffles:

> the political parties [were] very sensitive about securing their voting base … [by] [d]rawing stark identity constrasts between … political opponents. This is not conducive to addressing adaptive[47] challenges. Similarily … elected political leaders have focused … on various ways [of] finding technical-delivery focussed answers to the challenges of insitutional reform and service provision (Schmidt, 2010: 41).

Despite political changes and policy shifts, service delivery, synonymous with development in South Africa, has remained a key priority within the CCT albeit wrapped up in differing discourses depending on which political interests are represented at a particular moment. The commitment to service delivery by the CCT has led to the extension of basic services to growing, densifying informal settlements on the urban periphery at an unprecedented scale. In

[47] Adaptive challenges are those problems that cannot be solved with a technical fix that can be provided within a set of procedures. Rather, the nature of these challenges is such that they require an approach that recognises complexity of culture and embraces the process of learning for social change (Heifetz, 1994).

parallel, maintenance of existing services has remained a critical priority for utility departments. Simply, the responsibility for inherently socio-political challenges was transferred to bureaucratic, technical departments, specifically the utility departments, which were tasked with resolving the *technical* challenge of service delivery. A conceptual distinction emerges between two functions of government, the first being politics, which includes the dynamic and fluid realm of politicians, policies, legislature and legislation, and second being delivery, which pertains to banal administration of public services (Mc Lennan, 2007). This disjuncture affects how roles have been perceived and adopted at the level of networked infrastructure management.

The massive growth of the urban footprint and the expansion of networked infrastructure services mean that the managers and officials of infrastructure have been determining and continue to determine the nature and pattern of the development of Cape Town. The political agenda may guide priorities, but much of the decision-making regarding infrastructure is left to assumedly *apolitical* technicians and engineers who are perceived as expert and therefore know how best to configure bundles of networked infrastructure. Swilling and Annecke (2012) argue that the resulting effect is the expansion of services at any cost without a real understanding of the natural resource base that underpins this service delivery, nor sufficient concern for the fiscal implications of the socio-economic conditions. Dominating the institutional discourse is the reference to service delivery as a developmental goal as means to overcome the exclusionary apartheid policies. However, this rationale can no longer be used to frame decision-making and practice. Rather, how to deliver affordable and sustainable services that create inclusive cities must be the priority. As will be discussed in the empirical chapters that follow, the institutional discourse links the overall sustainability of infrastructure to the financial realities, in the narrow sense, of service delivery. Broadening how sustainability is understood and used as a decision-making tool by policy makers, planners and those involved in the operational activities, will be pertinent to socio-technical transitions that shift the development trajectory of Cape Town toward a more sustainable pathway. That being said, much of the debate is focused on the municipal services financing model because of the complexity involved in delivering equitable services to those who cannot afford to pay for them. It is to these issues that the chapter now turns.

5.2.2 The financial conundrum: who gets what, and why?

The MSA sets out the guidelines for development planning, service delivery, tariff structuring and cost recovery, as well as performance management systems and staffing matters. It therefore provides the "core principles, mechanisms and processes that are necessary to enable municipalities to move progressively towards the social and economic upliftment of local communities, and ensure universal access to essential services that are affordable to all" (*MSA 32 of 2000*, 2000: 2) while also stating that municipal services should be as *cost reflective* as possible (*MSA 32 of 2000*, 2000).

That essential services have to be affordable and cost reflective has had consequences for the nature and standard of services delivered. Although the single tax base has enabled the introduction of "intra-urban redistribution" (Parnell, 2005: 22), the constitutional responsibility of service delivery is subjected to the caveat that delivery is dependent on *available resources* (Pape & McDonald, 2002). Pieterse (2010) explains that this caveat is used as the justification for the delivery of lower quality services to those who cannot afford to pay for them. The upper and middle, income households are offered a menu of services that include modern, sophisticated and well-maintained physical infrastructure and social amenities, delivered by well functioning municipal operating systems. In contrast, the poor are offered only the most basic of networked infrastructure that deliver a bundle of FBS and few social services, according to available financial resources.

Local government is responsible for municipal functions, supported by three revenue streams. The first is a share of national revenue from National Government for basic service provisions. The second is accrued from property rates, user charges and levies, usually used to fund operations. The third is a conditional grant transferred to municipalities for additional infrastructure investment for basic services (Patel & Powell, 2008). Cape Town has steadily been receiving a smaller portion of the equitable share allocation from the national fiscus (CCT, 2009c). However, because the CCT relies on transfers from national government to sustain its capital budget, the prospects for future expansion are limited. Crane et al. (2010) do show that utility operators in the departments of energy, water and sanitation, have become more and more strident (since 2004) about the need for economic tariffs for each of the services. This can be interpreted as a cost recovery model that allows for revenue from their own operations to be re-invested into these operations and capital budgets. This is the alternative to heavily cross-subsidising the municipal rates account and corporate services, which undermines the departmental capacity to finance essential maintenance.

Limited financial resources means essential services are considered adequate for the poor, which translates into a system wherein the most basic services are delivered as cheaply as possible, usually of a poor design and poor quality, to those those cannot afford to pay for high quality services (Pieterse, 2010a). The CCT has made significant and important investments into basic service provision in low-income areas; however it is clear that the malignant conditions of poverty and informality will not be resolved by the incumbent investment patterns; especially when "investments in the built environment in Cape Town have been heavily skewed toward middle-and upper income residential areas and business nodes … that benefit capital and elites at the expense of low-income areas" (McDonald, 2008: 167). It is clear that the investment quantum is insufficient for real transformation.

In reviewing the quantum of investment, it becomes evident that over the past decade the CCT has increased the investment in the expansion of networked infrastructure with the aim of realising universal service delivery. In the 2002/2003 financial year the operating budget was R7,4 bn and the capital budget was R1,9 bn (CCT, 2014a). In the 2006/2007 financial year the budget had increased to equal a total of R17,25 bn: the operating budget was R14,23 bn (CCT, 2014b) and the capital budget was R3,02 bn (CCT, 2014c). By 2011/2012 financial year, total operating expenditure increased to R22,14 bn and capital expenditure to R5,09 bn (CCT, 2011a). There has clearly been a considerable increase in the budget in an effort to maintain and extend services in Cape Town, noticeable in the improved *access* to basic water and refuse removal services across the city. Access to improved electricity and sanitation does however lag behind, and a percentage of the increasing number of households are without any access to basic services (CCT, 2012c). This will be elaborated on in Chapters 6 and 7.

A progressive equity model was used to assist the poor, whereby a progressive block is used to make the first block more affordable while prices increase as consumption increases (McDonald, 2008). Rebate policies similarly favour low-value properties and indigents. Rates and tariff revenues from the consumption of water, sanitation, refuse and electricity services have therefore been designed to achieve more equitable service delivery through cross-subsidisation. However, McDonald (2008) argues that this system allows the wealthy to consume at their leisure and pay for world-class infrastructure while the poor can only consume what they can afford and only access the most basic level of service. In this way, the needs of the rich are satisfied while the poor cannot access their equitable share of public resources. According to the CCT 2004/2005 IDP, the Equitable Service Framework takes a broad view of municipal service delivery stating:

> …all residents should receive a universal, basic package of municipal services. The services all communities receive must be affordable on aggregate for the [CCT] as a whole and for individual households. *It follows that only services that can be built (capital expenditure), operated, and maintained (recurrent expenditure) sustainably can be provided…* Communities should have some choice and discretion in determining what range of municipal services they want and can afford. It follows that some areas may opt for a higher level of service for which they are prepared to pay a premium, while other communities may opt for lower levels of services for which they should receive a discount (CCT, 2004: 69, author's emphasis).

Indigent and low income households therefore only consume services above the free basic allocation, when they can afford it, while there are legislative stipulations that limit the amount that local government can increase tariffs and rates on business and wealthy suburbs (McDonald, 2008). The underpinning rationale is the need to ensure tariff packages do not undermine the national economic agenda (RSA, 1996: s229.2.a) or the competitiveness of local urban economic development, especially in a city like Cape Town, which positions itself as a World Class city to attract private sector investment (CCT, 2012c). McDonald (2008) goes on to suggest that these legislative requirements force municipalities to recover revenues more and more from low-income areas, while at the same time becoming dependent on transfers from national government to support capital investments. The CCT has used a range of tactics to ensure cost recovery where, and as far as, possible. Cost-recovery was a priority in the framing of delivery wherein good customers are perceived as those who pay for what they consume and consume according to their ability to pay (Naidoo, 2010). This neoliberal alternative is in stark contrast to what can be considered a socially oriented approach.

The reliance on capital transfers from National Government for new infrastructure investment is concerning, as it remains underfunded while expenditure of the operating budget is based on urgent priorities rather than systematic long-term planning. Moreover, these transfers have been steadily decreasing and trends suggest they will continue to (CCT, 2009c). This is further complicated by the fact that operating budgets are insufficient to maintain and rehabilitate existing investments greater than those for the delivery of the most basic of services. This has had knock-on effects for maintenance and operations of infrastructure networks, crucial for the efficient functioning thereof. Operating budgets have been furthermore more thinly spread, rendering prioritising crucial, which is a major challenge for maintaining working infrastructures. Figure 5.1 illustrates the major risk areas in the infrastructure network. While Chapters 6 and 7 deal with these challenges in greater detail, it is evident that capacity constraints of existing infrastructure must urgently be addressed. However, the way in which this balances out with the CCT's pro-poor agenda does not bode well. The priority of maintaining existing infrastructure networks is prominent. Through discussions with CCT utility managers, it is evident that, regardless of the need to invest in low-income and informal areas, ensuring the maintenance and rehabilitation of infrastructure – meaning that middle and upper-income residential suburb services are delivered as efficiently as possible – is of the utmost importance.

The current concentration of financial resources across the city and the wealth to poverty ratio has implications for the fiscal capacity of the municipality. As the number of indigent households increases, the CCT's ability to accrue revenue through cost-recovery mechanisms is reduced and translates into direct pressure on the service charge tariffs. Moreover, these conditions have translated into the increasing fiscal transfers of financial resources from rate-paying portions of the population to indigents and there are limits to this. Although there is the guarantee of FBSs, the increase in the tariff above and beyond that continues to increase the pressure on poor households that are forced to pay the premium for services when they consume above their allocated share of FBSs.

The budget for the 2011/2012 financial year (CCT, 2011a) is an example of how the CCT allocates budget and accrues revenue. The budget breakdown for both the capital and operating budgets as well as the sources of operating revenue are provided in Figures 5.2-5.5. Through the budget breakdown the spending priorities become clear, as the financial investments are indicative of priorities.

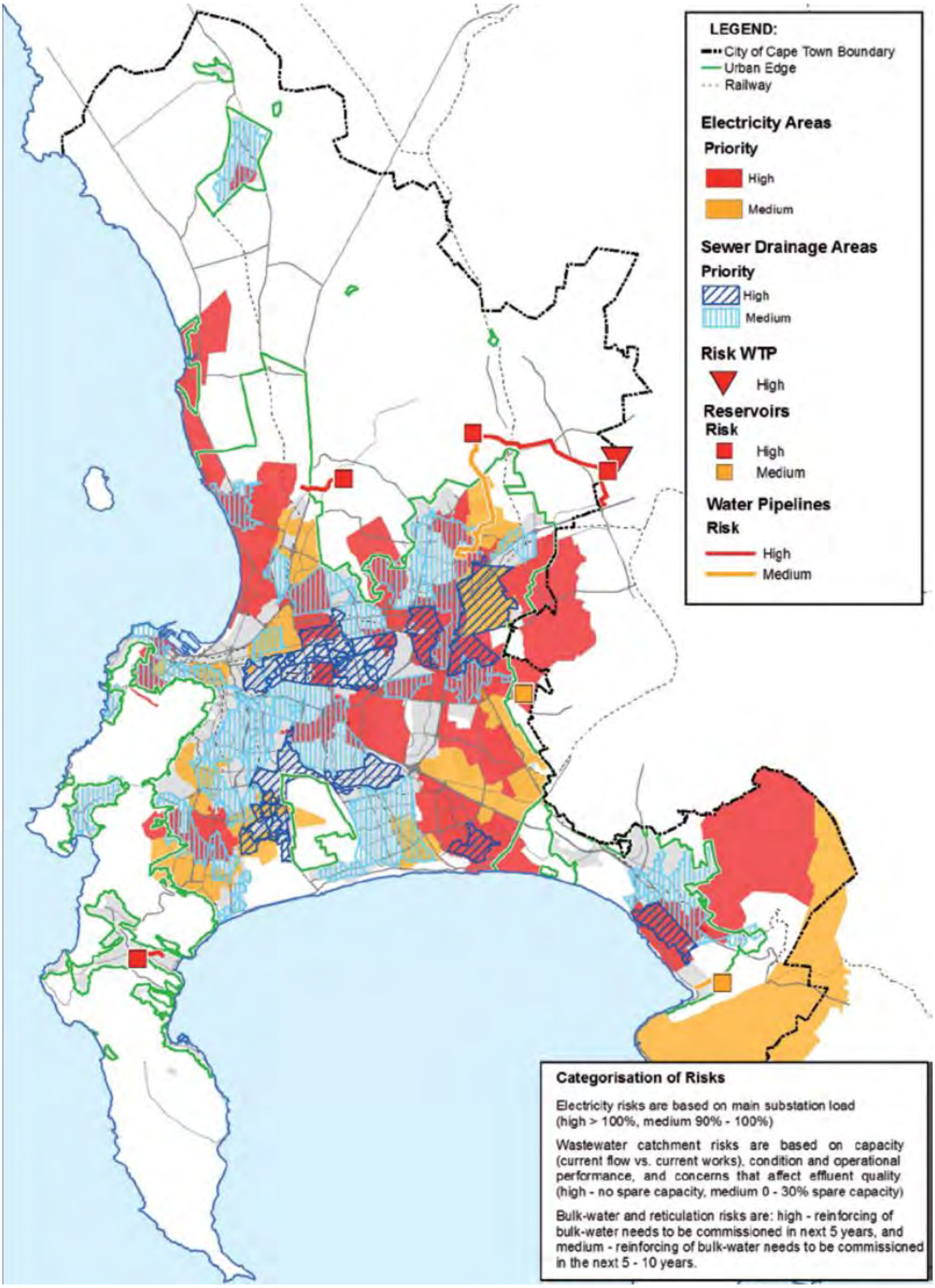

Figure 5.1: Infrastructure risk in the Cape Town Metropolitan
Source: CCT (2012d)

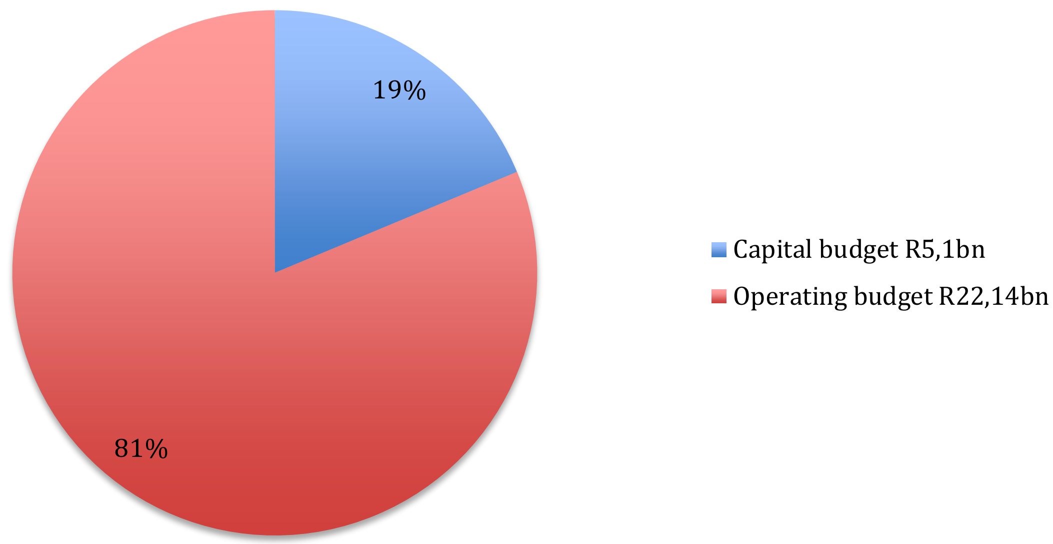

Figure 5.2: Total budget for Cape Town 2011/2012
Source: CCT (2011a)

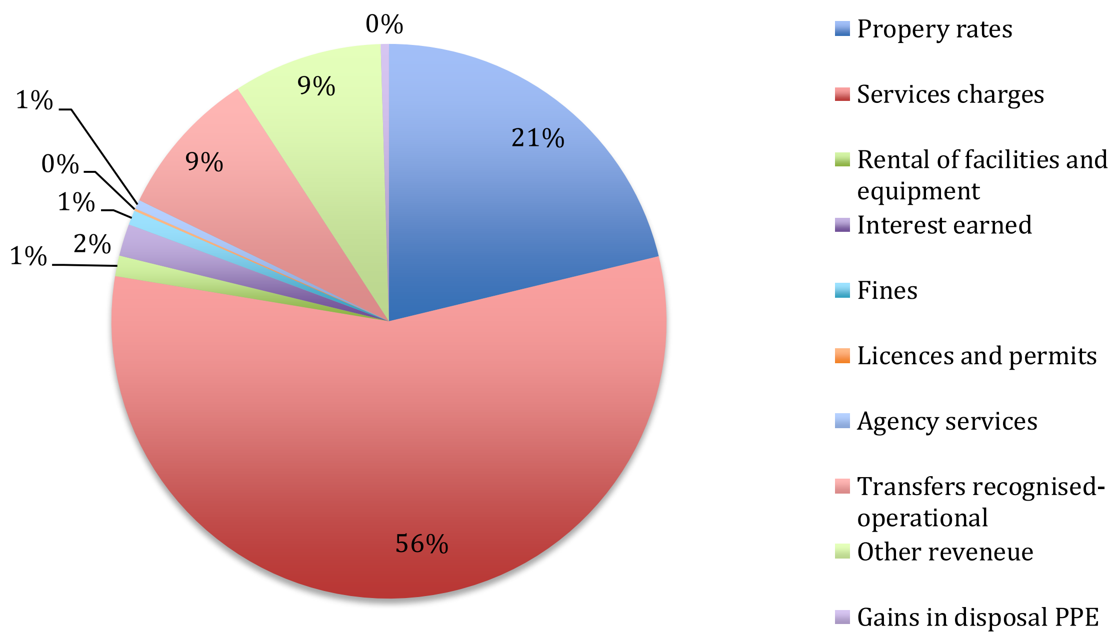

Figure 5.3: Revenue sources for Cape Town 2011/2012
Source: CCT (2011a)

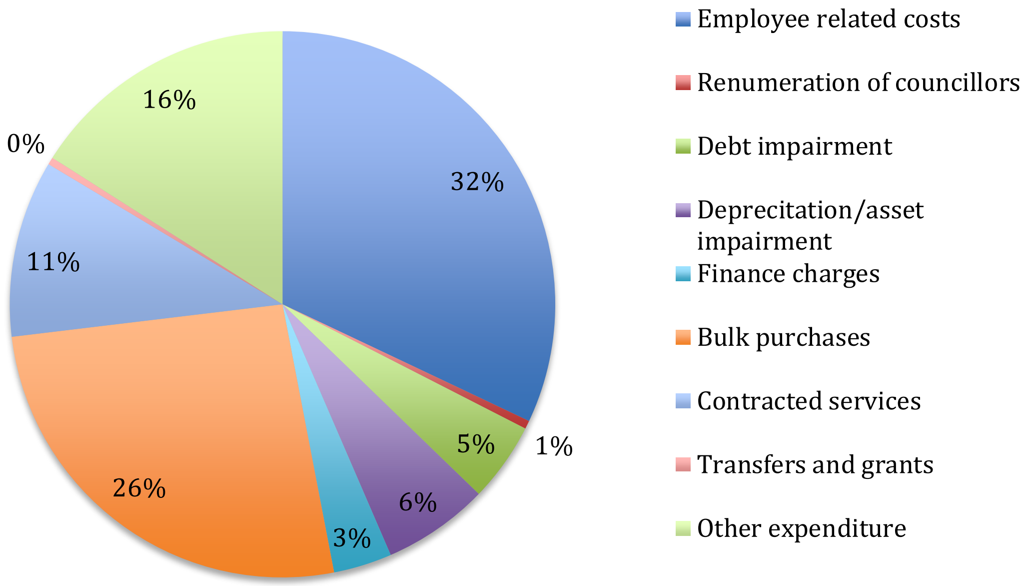

Figure 5.4: Operating budget for Cape Town 2011/2012
Source: CCT (2011a)

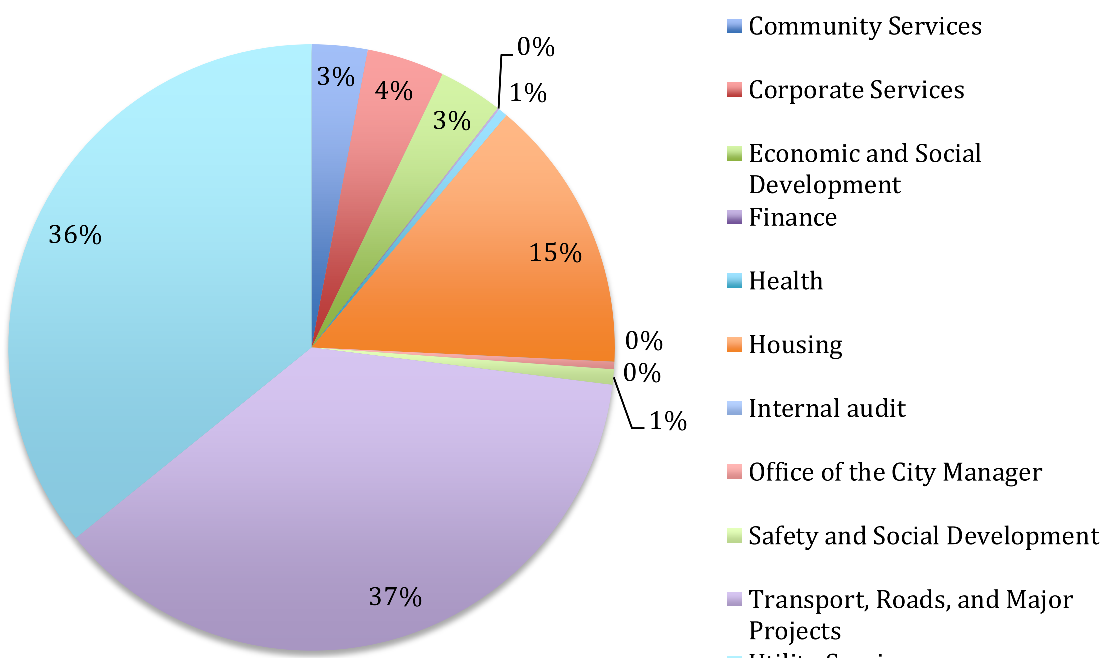

Figure 5.5: Capital budget for Cape Town 2011/2012
Source: CCT (2011a)

Employee-related costs and bulk purchases are clearly the main cost drivers to the CCT, although the structure of the operating budget does not explicitly indicate the amount allocated to particular operational activities associated with networked infrastructures services in the utility services departments, constituted by the Electricity Services (ES) Department, Water and Sanitation (W&S) Department and Solid Waste Management (SWM) Departments. The allocation for operational repairs and maintenance is the outcome of other expenditures such as employee-related costs or contracted services. In total, the allocation for operational repairs and maintenance alone, for the 2011/2012 financial year, equates to R1,8 bn: approximately 8 percent of the operating budget (CCT, 2011a). By comparison, utility services receive a significant portion of the capital budget, a total of R1,08 bn, or 36 percent. The capital budget provides the capital needed for the expansion of basic services; however, investing in higher levels of services requires additional capital, while trends indicate a decrease in the quantum of capital budget (CCT, 2009c). Combined, the total investment for networked infrastructure services is only approximately 10 percent of the total budget, while service charges for the use of those networks accounts for more the half of the CCT operating revenue. The CCT is therefore heavily reliant on utility services for its operational budget and can rely less and less on transfers from national government.

5.2.3 Section summary

The selected means to connect the population to the socio-metabolic flows of the city is unaffordable in the long run. Furthermore, this has not had a major impact in smoothing out resource consumption across the income groups. Despite the progressive nature of service delivery goals and policy developed since the democratic transition, the structure of inequality has not altered dramatically and racial divisions have remained more or less the same. Under-development as result of apartheid still hampers the government's ability to create a stable environment for economic growth in a competitive global environment. This is juxtaposed to the challenge of legitimising service delivery that redistributes resources in a just manner to include citizens previously denied access to standardised, quality infrastructure services, adequate education and fruitful employment (Mc Lennan, 2009). Delivery strategies in this instance are therefore beyond providing services, rather they are concerned with social justice, poverty alleviation and economic growth in a way that confirms citizenry in a new South Africa (Mc Lennan, 2009). Moreover, the networked infrastructure supplied to the edges of the city to connect the urban population to socio-economic metabolic flows, are conventional systems. They are not configured to meet the demands of a natural resource-scarce context, while natural waste sinks are already overburdened. The next section looks to the socio-environmental context of Cape Town as a means to reveal some of the broader environmental issues of service delivery in South Africa.

5.3 Introducing Cape Town's socio-environmental context

One of the most significant, unforeseen impacts of the incumbent service delivery model, and the socio-technical system that supports it, are the detrimental environmental consequences. Cape Town’s natural resource base has been undermined by the particular pattern of resource consumption, facilitated by linearly configured infrastructure bundles. However, this phenomenon is not unique to Cape Town. Numerous South African cities are facing similar challenges, which reflects the need to reimagine the service delivery model as well as the underpinning rationale for service delivery. There is a need to move beyond the modern notion that cheap, convenient and reliable networked infrastructure will resolve the socio-economic challenges present in cities like Cape Town. Rather, for successful sustainability transitions, it is necessary to deliver sustainable urban infrastructure that recognises the importance of social justice and accepts the natural resource limitations of the future.

What becomes clear in South African national policy and legislation, is the emergence of both the strong, revised developmental agenda and a clearer environmental management agenda, the latter being a generally neglected aspect for local government prior to 1994 (Roberts, 2008). Around the same time, during the late 1980s and early 1990s, the sustainability debate had begun to establish greater international recognition while the international ideological debates around resolving ecological crises turned to local governments. Following the acceptance of the Brundtland Report (discussed in Chapter 1) by the United Nations General Assembly, the UN Conference on Environment and Development (UNCED), known as the earth summit, was held in 1992. Here leaders articulated the principles and importance of sustainable development, and the role of local government in activating sustainable development pathways (Roberts & Diederichs, 2002). Furthermore, at the same conference, the Local Agenda 21 provided the blueprint and action for sustainable development to which South Africa was a signatory.

At the level of local government, trends suggest the environmental agenda is of less significance than, and separate to, issues of socio-economic development, often resulting in the perceived need for a trade-off between the two. Immediate priorities emerging from development pressures often result in the (unintentional) exclusion of environmental management from planning and decision-making processes (Roberts, 2008). In this way sustainability and sustainable development are often shrugged off as an environmental issue and the responsibility of environmental management departments (with limited budgets), while economic growth is the key to development, and is facilitated by investments into major infrastructure expansion. Therefore the developmental agenda is largely concerned with the delivery of standardised infrastructure services, with economic infrastructure as a priority. The exclusion of the environment from the socio-economic development agenda has had consequences for the natural environment.

5.3.1 South Africa's natural environment

South Africa faces the serious challenges of a degrading natural environment (summarised in Table 5.3 below). The country's terrestrial eco-systems, main river ecosystems, marine biozones and wetlands, which ensure the supply of ecosystem services[48], are severely degraded and under threat due to over-exploitation (UNEP, 2013). The World Bank shows that in 2010, South African emitted 9.0 CO_2^e metric tonnes per capita compared to the global average of 4.9 CO_2^e metric tonnes per capita (World Bank, 2014a). Carbon-equivalent emissions form the largest portion of South Africa's overall ecological footprint[49], represented by a global hectare (gha), and is now approximately 2.6 gha per capita, just below the global average of 2.7 gha per capita, although significantly higher than the earth's total bio-capacity of 1.8 gha per capita (WWF, 2012). This is not surprising considering the bulk of electricity power is the product of dirty coal-fire power stations and South Africa's kWh of electric power consumption is higher than the international average (World Bank, 2014b). Taking a closer look at resource flows, solid waste generation is shown to be similarly high in South Africa. Approximately 255 kg per capita per annum[50] is generated above the global average, and (largely) disposed of at landfill (Department of Environmental Affairs [DEA],

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[48] Ecosystems provide a series of services from which people derive benefit; these include provisioning services, regulating services, cultural services and supporting services (United Nations, 2005). See the Millennium Ecosystem Assessment Report (United Nations, 2005) for a detailed explanation.

[49] The notion of ecological footprinting draws on the concept of carrying capacity, which is "...the maximum load that can safely and persistently be imposed on the eco-sphere by people" (Wackernagel & Rees, 1996: 50). The ecological footprint represents a measurement of the combined amount of biologically productive land and water required per person or population to meet all the resources that are consumed and absorb waste that is generated (WWF, 2014).

[50] However, the rate of domestic waste generation depends largely on the level of income:
Low income= 0.41kg/per person/day or (0.41kg x 365 days) =149.65kg/person/year;
Middle income= 0.74kg/per person/day or (0.74kg x 365days) = 270.1kg/person/year;
High income= 1.29kg/person/day or (1.29kg x 365days) = 470.85kg/person/year (DEA, 2014).

2014). But this must be read in light of the vast income disparities present, especially as waste generation is positively related to income level. With regard to water resources, low annual rainfall in South Africa coupled with increasing extraction for domestic, agriculture and industrial consumers, places pressure on scarce resources. By 2005, over 95 percent of available freshwater water resources had been allocated, while the quality continues to decrease due to various activities, including extensive mining, urbanisation coupled with poor urban water treatment capacity and the incumbent power generation practices (Oberholster, 2010). It is estimated that national demand will exceed available supply by 2025 due to the high human demand for water (Department of Water Affairs and Forestry [DWAF], 2004; DWAF, 2013). Read together, these figures illustrate that despite the extreme inequality in society, consumption patterns are only marginally lower than the global average. South Africa's population is therefore living beyond the earth's carrying capacity. Admittedly, using the notions of an ecological footprint, carrying capacity and urban metabolism is contested and criticised (Van den Bergh & Verbruggen, 1999; McManus & Haughton, 2006; Golubiewski, 2012) and the purpose here is merely illustrative. South Africa's consumption patterns are unsustainable.

5.3.2 Cape Town's natural environment

Similarly, Cape Town's metabolic system (summarised in Table 5.3 below) is ecologically and financially unsustainable (Crane & Swilling, 2008). The linear flow of resources on which Cape Town is dependent exerts significant pressure on available natural resources and ecosystem services (Crane & Swilling, 2008). As early as 2002, Gasson (2002) demonstrated, using an input-output model, that the urban metabolism of Cape Town equates to a per capita footprint equaling 4.28 global hectares; at this rate the global population would need 2.3 planets to sustain it. Significantly, the majority of the Cape Town population does not enjoy the standard of living that this footprint affords.

In terms of resource consumption, Cape Town's elite, who make up a mere 7 percent of households, consume an equivalent of 14.8 planets while the poorest 51 percent of households live within a 1 planet boundary (Swilling, 2006). This is a clear illustration that Cape Town's urban metabolism is not only unsustainable but highly unequal. Pertinent to this, is the role that infrastructure has historically played in the shaping of consumption patterns. Cape Town's poor households are by and large located in underdeveloped areas that lack adequate infrastructure capacity to cope with the demands of the population, due to segregation policies of the apartheid regime (Smith, 2004). Since 1994, policy at all levels of government has dictated that standardised basic services must be extended to ensure all communities are connected to the urban socio-economic metabolism. This has not proved to be a simple task, and it has become abundantly clear that Cape Town cannot continue to development along its current trajectory.

Table 5.3: Summary of Cape Town's natural resource flows compared to the South African and global average

<table>
<tr><th>Indicator</th><th colspan="3">Cape Town</th><th>South Africa</th><th>Global</th></tr>
<tr><td rowspan="2">Ecological footprint (global hectare per capita per annum)</td><td>Av.</td><td>Rich (7%)</td><td>Poor (64%)</td><td rowspan="2">2.6
(WWF, 2012)</td><td rowspan="2">2.7
(WWF, 2012)</td></tr>
<tr><td>4.2</td><td>6</td><td>0.6</td></tr>
<tr><td>CO2e emissions (metrics tonnes per capita per annum)</td><td colspan="3">7.8
(Lewis & Jooste, 2012)</td><td>9.0
(World Bank, 2014a)</td><td>4.9
(World Bank, 2014a)</td></tr>
<tr><td>Solid waste generation</td><td colspan="3">1.7 kg/capita/day
or at total
2.4 million tonnes of solid waste
(CCT, 2014d)</td><td>Urban average:
2kg/capita/day
(Hoornweg and Bhada-Tata, 2012)
Total average:
255 kg /capita /year
(DEA, 2014)</td><td>Urban average:
1.19kg/capita/day
or
438 kg /capita /year
(Hoornweg and Bhada-Tata, 2012)</td></tr>
<tr><td>Electricity consumption</td><td colspan="3">Approx. 3,500 kWh/capita/year
(Swilling & Annecke, 2012)
or a total of
11874 Gwh (CCT, 2009a)</td><td>Approx. 4603,9 kWh /capita/year
(World Bank, 2014b)</td><td>Approx. 3045 kWh /capita /year
(World Bank, 2014b)</td></tr>
<tr><td>Water Consumption*</td><td colspan="3">82 Kl /capita/yr,
223.3 l/capita/day
or
285.1 million Kl total potable water
(CCT, 2009a)</td><td>235 l/capita/day
(DWA, 2013)</td><td>177 l/capita/day (DWA, 2013)
57kl/capita/yr
(Swilling and Annecke, 2012)</td></tr>
</table>

*Water consumption as reflected here is total water consumption for Cape Town, not only domestic water consumption.

5.3.3 Shifting strategy for alternative futures

In response to the alarming and growing resource constraints and reliance on diminishing waste sinks, the CCT (often in parallel to and conjunction with, National and Provincial Government) has produced a plethora of policy documents and strategic frameworks in order to re-direct (unsustainable and unequal) development. A number of strategies have been developed for several sectors in Cape Town, including Biodiversity Management Strategy

(CCT, 2003b), Coastal Management Strategy (CCT, 2003c), Air Quality Management By-law (CCT, 2010c), Energy and Climate Change Strategy (CCT, 2007c) as well as environmental management and environmental education [51]. The overarching strategy that supports environmental management is the Integrated Environmental Management Plan (IMEP) (2009a; 2003a). It is important to note that strategies and plans relating to environmental management and sustainability are produced by the CCT Environmental Resource Management (ERM) Department and have not neccessarily been widely adopted by the institution as a whole, which is partly why the CCT is unable to effect change and address the environmental challenges described. The intention is to highlight that despite the presence of policy and strategy that reflect an environmental agenda, these are not yet deeply embedded within the day-to-day practice of the Utility Directorate, who manage the networked infrastructure which facilitates the transformation of the natural environment and resources into the urban. Empirical evidence for this will be provided in Chapters 6 and 7.

The CCT explicitly stated the importance of good planning and management practices, including:

> Reducing the city's ecological footprint and introducing sustainable disaster risk reduction measures; [a]dopting a precautionary approach to the use of resources, switching to sustainable patterns of resource use and mitigating negative development impacts; [i]mproving urban efficiency and aligning planned growth with infrastructure provision; [c]reating safe, high-quality living environments that accommodate a range of lifestyles and offer a vibrant mix of land uses. (CCT 2012c: 41)

Moreover, the complex challenges need to be resolved in part through infrastructure-led economic growth (CCT, 2007a). Specifically the CCT has identified that providing infrastructure and improved service delivery is a critical and central aspect of the five year IDP and to this end the CCT has prioritised the delivery of **"sustainable urban infrastructure and services** ... to ensure a high-quality natural environment to complement and stimulate social and economic development. (CCT, 2011b: 3, author's emphasis). Significantly the CCT is seeking to enable this endeavour with the "prioritisation of funds and to achieve the best possible return on public infrastructure investment, linked to the

[51] See the City of Cape Town official website for a list of the various policies, strategies and plans: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Pages/PoliciesandStrategies.aspx.

improvement and maintenance of the CCT's economic and social infrastructure" (CCT, 2012c: 14).

Despite the reference to sustainable urban infrastructure, and the allusion to environmental concerns within the reference to sustainable urban infrastructure, the CCT does not have a clearly articulated definition of sustainability, sustainable development or sustainable urban infrastructure. When referred to in terms of environmental policy and strategy, it is in the context of the management of natural assets through conservation efforts to decrease the risk of economic decline (CCT, 2009a). The premise here is that Cape Town is dependent on its natural assets for long-term economic growth and social development, due to the role these assets play in tourism; without these assets, options for social development are considered basically non-existent (CCT, 2008a). This is a peculiar perversion of the urban sustainability debate that speaks to conservation of the environment rather than really reflecting on infrastructure as the urban operating system, facilitating the metabolic rate, and therefore resource consumption and waste production.

Generally, during interviews with CCT utility officials with the utility management departments, it was revealed that *sustainable* is often used in relation to urban infrastructure. However, this refers to the long-term affordability of delivering specific services and the ability of the department to ensure cost recovery for the required maintenance over the lifespan of that infrastructure system. Therefore, for infrastructure to be sustainable, the cost of providing the service must equal that of the (total accumulated) tariff charged for that service that is reinvested, through the operating budget, into maintenance and rehabilitation. This ensures the technical efficiency of the system to ensure economic competitiveness, enabling the socio-economic system to reproduce. This has wider implications for the relationship between natural resources (largely assumed to be available or substitutable within CCT utility departments) and infrastructure systems (where a high level of sophistication and economic efficiency is preferred), and how investment decisions are made when delivering services.

5.3.4 Implications of incumbent conditions

Taking the above information into account, despite policy directives, the CCT is not embracing sustainability when it comes to utility management, where a proactive crisis management approach is taken over long-term planning for resource constraints (CCT, 2008a). Moreover, despite policy and academic literature describing Cape Town's resource-constrained future, and these concerns having been clearly articulated to CCT Council via a review of the IMEP[52] (CCT, 2008a), very little progress has been made in the effort to shift to a more sustainable development pathway. However this is not to suggest that the CCT has not made major strides in the delivery of services, using the principles of conventional networked infrastructure represented in the discursive domains conceptual frame. Futhermore, the delivery of FBS can be associated with the intention to realise greater levels of social justice. Moreover, the overwhelming impression is that the aim is to support the ongoing status quo wherein the wealthy and middle class retain the comfortable existence afforded by the under-funded low-income and informal areas. The motivation for including the sustainable urban infrastructure debate in the overarching CCT institutional and policy discourse is somewhat unclear.

In South Africa, infrastructure outlays and service provisioning was and still is the primary means to address these socio-economic disparities as the country transitioned from apartheid to a just, democratic society. Considering this in terms of the discursive domain's framework highlights the impact of infrastructure development over time, as cities and towns across South Africa find themselves at different stages of development and respond to challenges differently. This impact will depend on how challeneges are interpreted and responded to. The pace and success of delivery imperatives have much to do with the historical and existing institutional and infrastructure capacity as well as the ability to plan for a somewhat uncertain future. Cities now, more urgently than ever, need a bold, new model for service delivery. Evaluating Cape Town as a case context, using the CCT as an unit of analysis is extremely useful to highlight how cities navigate constitutional obligations, in the case of South Africa, and human rights obligations to deliver networked infrastructure services in a context of fiscal and institutional constraints. To narrow this down to a more detailed analysis of the specific practices of the CCT, the next section is an introduction to the CCT Utility Directorate, and a more detailed description and analysis of the Utility Departments follow in Chapters 6 and 7.

[52] IMEP was adopted in 2001, reviewed in 2008 and repackaged as the IMEP Environmental Agenda 2009-2014, is the overarching environmental policy of the CCT that *should* guide environmental decision-making and is regarded as the means to shift the CCT onto a path of sustainability (CCT, 2008a).

5.4 Introducing the Utility Services Directorate

The Utility Services Directorate lies within the CCT's Section 79 Utility Services Portfolio Committee and is the overarching institutional entity responsible for networked infrastructure. Section 79 portfolio committees are responsible for formulating policy as well as monitoring policy implementation, managed by an executive director who forms part of the executive management team of the CCT. The executive management team acts as the driver for achieving the strategic objectives of the CCT as outlined in the IDP. The purpose and service mandate for the Utility Services Directorate is (i) "to ensure sustainable municipal infrastructure and services (electricity, water, sanitation and solid waste services) that will enable economic development; (ii) to ensure equitable access to basic services for citizens of Cape Town" (CCT, 2010d: 192). The Utility Services Portfolio Committee includes the ES Department, the W&S Department, and the SWM Department, as well as departments responsible for Service Regulation and Logistics, Technical Strategic Support and Project Monitoring. Combined, these departments form the Utilities Directorate, and each is managed by a director, who reports to the Executive Director of Utility Services.

Municipal service departments – those departments that manage networked infrastructure services – are structured as internal *business units*, within the CCT. They are operated by the public entity, but function using the market-related principles of the private sector. Largely influenced by the New Public Management discourse, delivery is considered as technical and performance based, best achieved through managerial decentralisation based on privatisation principles (Chipkin, 2002; Mc Lennan, 2009). Swilling & Annecke (2012) describe this process as the commodification of essential public services. The implication of this type of departmental structuring is a combination of myopia and silo-based operations; a matter that will be discussed in the empirical chapters. The responsibility for the management of the various services rests with the officials within that department or business unit in terms of long-term planning and day-to-day operation and management. While direction is given by elected politicians according to the political agenda, the planning horizon for networked infrastructure is not only much longer than that of a political term, but also highly technical, often beyond the expertise of politicians and councillors. More often than not, priorities, and the vested interests that underpin these priorities, differ.

The overarching strategic objectives of the directorate within the context of the greater organisation and institutional goals are designed and articulated in the IDP. Strategic Focus

Areas (SFA) are identified, under which development objectives are articulated and aligned with Key Performance Indicators (KPI's). However, at an operational level, the departments produce a five-year Business Plan (reviewed annually) aligned with the IDP, outlining annual activities that are incorporated into the Service Delivery and Budget Implementation Plan (SDBIP). The SDBIP outlines specific service delivery targets as well as performance indicators to meet the targets as outlined in the IDP. This is aligned with the five-year IDP cycle, while the latter is reviewed and continually updated every year to ensure consistency.

The five-year IDP for the period 2007/2008-2011/2012 (CCT, 2007a) provides the overarching policy direction for the CCT, which is informed by and in turn informs the Solid Waste Management Plan, Water Services Development Plan and, Electricity Services Plan. Specifically, SFA 2 (of 8) applies to the utilities directorate stating that the strategic intention is to deliver *Sustainable Urban Infrastructure and Services* in which the CCT's objectives include "reducing service backlogs; prioritising bulk infrastructure, and developing an integrated approach to infrastructure, service planning and budgeting" (CCT 2007a: ii). Additional objectives of the utilities directorate are to provide: i) universal access to services (water and sanitation, electricity and refuse removal); ii) develop demand management programs; iii) the conservation of natural resources; and iv) the effective management of Cape Town's infrastructure and resources. The activities of the directorate are governed by certain legislative parameters.

5.4.1 Legislative parameters

There are two pieces of legislation that apply directly to and determine the activities of the Utility Directorate. The first is the Municipal Systems Act (MSA) (*MSA 32 of 2000*, 2000), and the second the Municipal Finance Management Act (MFM) (*MFMA 56 of 2003*, 2004). Because the delivery of municipal services is governed by the MSA and MFMA, the utility departments use this legislation as the basis of decision-making. Importantly, these two Acts along with the Municipal Public-Private Partnership Regulations finalised in 2005, govern and regulate the establishment of partnerships. Many officials interviewed explained that while fiscal and capacity constraints represented a major barrier for purposive interventions, establishing partnerships with external organisations, to provide capital, capacity and technology, is particularly onerous due this suite of legislation.

5.4.1.1 Municipal Systems Act

One of the most pertinent aspects of the MSA (*MSA 32 of 2000*, 2000) is the provision it makes for the type of service delivery mechanism that should be adopted by local government; in other words, whether or not a service should be delivered by an internal (public) or external (private) service provider. The legislation prescribes a series of complex processes that must be followed to determine a particular service delivery mechanism, described in sections 76-86 of the MSA. De Visser broadly summarises the processes stipulated by the act in four steps: "(i) an initial review of the way in which the municipality currently provides the service; (ii) a process for considering an external service delivery mechanism (culminating full council approval); (iii) a feasibility study; and (iv) competitive bidding" (2012: 123). While this process is meant to streamline procurement and ensure efficient service delivery, it is perceived by officials to be a major constraint to innovative projects.

5.4.1.2 Municipal Finance Management Act

The MFMA and the Public Finance Management Act (PFMA) (*PFMA 1 of 1999*, 1999) are considered important regulatory frameworks, not only because they prescribe modern budgeting, accounting and financial management principles to give effect to the constitution, they are also considered a regulatory constraint by CCT officials, especially the MFMA (National Treasury, 2013). The MFMA is designed to ensure what it calls "secure, sound and sustainable management of the financial affairs of municipalities … [that align with National] Treasury's norms and standards" (*MFMA 56 of 2003*, 2004: 2). While the tone of compliance and transparency, as a strong theme throughout the legislation, is necessary, the intention to prevent corrupt and incompetent officials from taking advantage of the system creates a strict environment within which the building and improvement of infrastructure and service delivery is policed, rather than enabled, by one piece of legislation (Corporate Governance Framework Research Institute, 2009). The interpretation of the MFMA, along with the onerous processes it prescribes, hinders the willingness of officials to develop innovative service delivery packages, especially due to the clauses that pertain to partnerships between private and public entities (De Visser, 2012; Corporate Governance Framework Research Institute, 2009).

The intention is not to describe the legislation in detail, but rather to highlight the implications of the act for service delivery at the local level. These implications will be discussed further in the empirical chapters that follow.

5.5 Conclusion

This chapter provided an introduction to the case context, highlighting a range of socio-economic and ecological challenges, within a messy and complex system, that are continuously reproduced in the city. Guided by the legislative and regulatory framework, the technicians who manage Cape Town's infrastructure structure activities around the principle of technological and economic efficiency of the system. The lattice of frameworks, plans and policies adds up to a set of clearly defined formal rules, determined nationally and locally, which limit the discretion of officials to act outside of status quo. Moreover, they are influenced by a particular set of assumptions that have become institutionalised over time, due to historical conditions juxtaposed to modern notions of infrastructure configuration and service delivery.

That being said, this chapter also introduced an emerging trend in the CCT that speaks to a range of discursive domains described in Chapter 2. The discursive domains have provided the legitimating discourse for officials to act in ways that represent emerging alternatives within the well-established institutional routines that reproduce the urban system. What follows in Chapters 6 and 7 is an overview of the departments that constitute the Utility Directorate. The intention is to demonstrate the underlying driving forces and institutional practises that account for the dynamics at play. More importantly, these chapters present a picture of how the discursive domains described in Chapter 2 are institutionally mediated. The conceptual frame described in Chapter 3 offers a means to unpack and reveal these institutional practises. The extent to which the objectives of the emerging policy discourse is successful in effecting change within the CCT, and how this impacts the prospects and relevance of sustainable urban infrastructure in Cape Town will be explored in the analysis in Chapter 8.

6. The City of Cape Town's Utility Departments

This chapter is divided into two parts. The first part speaks to networked electricity infrastructure and introduces the CCT Electricity Services (ES) Department. The second part speaks to water and sanitation infrastructure and introduces the CCT's Water and Sanitation (W&S) Department. These parts are structured in the same way. First, there is a discussion around what more sustainable urban infrastructure might look like, considering the discursive domains that make up the conceptual frame in Figure 2.6, which is followed by an overview of the utility department that manages the particular networked service. There is specific attention paid the organisational structure, the logic that underpins the service delivery model and where within the department there are innovative responses to resource constraints. This chapter therefore describes the two supporting cases, onto which the case of the Solid Waste Management (SWM) Department is built in Chapter 7.

6.1 Introducing electricity services infrastructure

Securing a supply of energy and electricity is crucial both for the reproduction of the global economy and ensuring the developmental rights of households of the global south where access is extremely limited. However, the future supply of electricity and energy must be aligned with the environmental imperatives of the 21st century.

Conventional energy, which drives the global economy, has been derived from the combustion of finite fossil fuels since the industrial transition. The combustion of fossil fuels for energy accounts for 56 percent of anthropocentric GHGs and is a major contributor to accelerating climate change. Current atmospheric concentrations of CO_2 are 39 percent (390ppm CO_2) above that of preindustrial levels (Moomaw et al., 2011). To remain within the IPCCs (2007) recommended temperature increase, GHG emissions would need to stabilise within a range of 445 to 490 ppm CO_2. Renewable energy (RE) technologies are generally low carbon and, as such, have been identified as a critical component in the effort to stabilise GHG emissions. Fossil fuel-based energy emissions range from 469 to 1001g CO_2/kwh while RE emissions range from 4 to 46g CO_2/kwh (Sathaye et al., 2011). Significantly, bioenergy can be used to *avoid* those GHGs, which are the by-products and residues of urban metabolic processes. From an environmental standpoint, it is clear that RE technologies are preferable.
Harnessing energy from renewable sources is the foundation of a sustainable urban energy and electricity system, necessary for a sustainable energy transition. By incorporating the

principles described in Chapter 2, namely decentralised or semi-centralised systems that are modular in nature and can supply electricity of a different level of quality to users with different needs, it is possible to envision a pathway toward configuring energy systems that are 100 percent renewable (Girardet, 2010). Systems designed using these principles can include direct solar energy, a virtually inexhaustible energy source in the form of photovoltaic or concentrated solar power. Electricity can be generated from direct solar energy in two ways. The first is by using a photovoltaic (PV) cell that converts energy directly into electricity (Arvizu et al., 2011a). The second is the harnessing of solar thermal energy, using concentrated solar power (CSP), to produce high-energy that is then converted into electricity (Arvizu et al., 2011a). Each of these has a different potential for impact, depending on the sector, while their applicability is dependent on the context[53]. These technologies offer a suitable alternative for cities attempting to retrofit or build new electricity networks. Although there are both advantages and disadvantages, the potential for social benefit is extremely high in terms of providing a secure source of electricity for 1.4 billion people who currently do not have access, as well as a safe source of energy for 2.7 billion people's home cooking and heating needs (Arvizu et al., 2011a).

Direct solar energy has the highest technical potential, meaning that it has the fewest barriers to implementation (Arvizu et al., 2011a), but is limited by its inherent variability (Arvizu et al., 2011b). Therefore, a balanced, diversified and integrated mix of RE technologies is necessary to maximise usefulness and ensure energy security. Wind energy, in conjunction with solar, offers an opportunity to further decrease in GHG emissions. This technology has been successfully deployed in a number of countries worldwide, and is both economically and technically capable of continued expansion[54] (Wiser et al., 2011). Typical wind turbines have an energy production capacity of at least 1.5 MW. Although the contribution of this source of energy will vary depending on the regional conditions, the global technical potential ranges from 70 EJ/yr (19,400 TWh/yr) calculated onshore to 450 EJ/yr (125, 000 TWh/yr), which includes on and off shore (Wiser et al., 2011). Considering Weisz and Steinberger's (2010) finding that the global consumption of primary energy is 500 EJ/yr, these findings are particularly compelling for investment. Other sources of energy for an integrated system can be found *in situ*; for example, capturing gas from solid waste landfills and sewerage offers an

[53] For an explanation of these technologies see Arvizu et al., (2011b) and Beatty (2010).

[54] In 2009 wind energy's contribution to meeting global electricity demand equalled 1.8% and it is considered highly possible and feasible to increase that number to 20% by 2050 through ambitious efforts (Wiser et al., 2011).

under-exploited solution for cities that are burdened by large quantities of waste, generally found in developing regions (Arvizu et al., 2011a).

The generally modular, and decentralised nature of these RE systems, makes them a desirable option when considering an alternative for unconnected developing areas. RE reduces the cost of importing energy sources while securing, to a degree, supply (Arvizu et al., 2011a). Mini-decentralised power plants or autonomous energy supply systems are an alternative to expansive transmission networks seen in developed regions and cities (Sims et al., 2011). While the independence that these systems afford is a benefit for consumers, the challenge of variability and predictability is acute, so too is the need to minimize overall costs where alternatives currently (generally) have higher capital requirements than centralised networks (Sims et al., 2011). Hedging against this requires hybrid systems and energy storage capacity to increase the flexibility of the system, as well as demand-side interventions to provide reliability (Sims et al., 2011).

This is by no means an exhaustive list; rather, the intention is to demonstrate the possibility of reconfiguring networked infrastructure systems; particularly, reconfiguring networked infrastructure systems in a way that reduces the demand for virgin, non-renewable resources and the negative environmental impact that occurs as a result of the processing natural resources. The opportunity offered by RE systems however remains under-utilised. Inertia around implementation is partly due to the reliance on the flows from the natural environment, which is a higher risk than having the stock-piled resources used in conventional energy systems (Sims et al., 2011). In this way, electricity supply has largely been taken for granted. A core aim of this research is to understand what additional conditions might account for the inertia around the uptake of alternatives at an institutional level.

6.2 City of Cape Town's Electricity Services Department

Electricity distribution has long been considered the backbone of service delivery in South Africa and plays an important role in achieving comprehensive, inclusive service delivery (Jaglin, 2013). For the CCT ES Department, inclusive service delivery means the provision of basic services and also free basic electricity[55] (FBE) as well as the efficient collection of user

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[55] Households on the highly subsidised two block inclining tariff, who use an average of 450 kWh or less per month, including any free basic electricity, qualify for free basic electricity. The CCT tier one tariff allocates 60 kWh per month free basic supply for users who consume less than 250 kWh per

charges. Despite the CCT's success in connecting almost the entire population to the electricity grid, networked infrastructure remains divided, and "low income communities [who are still stuck in the spatial arrangements of the apartheid vision] are struggling with energy poverty[56], and wider unequal socio-environmental conditions" (Silver, 2013: 126). Low income households are burdened by the high cost of electricity and therefore often unable to access electricity services, a basic tenent of human development. Comprehensive delivery is further disrupted by a combination of supply shocks, and rehabilitation and delivery backlogs that result in a system of prioritisation in which trade-offs are inevitable. There is evidence that various urban actors and networks within the CCT are attempting to reconfigure electricity (and energy) networks "with varying levels of finance and success" (Silver, 2013: 126) although interventions are not necessarily purposive in nature, nor are they the intention of the ES Department.

In an effort to understand the prospects and relevance of sustainable electricity networks in Cape Town from an institutional perspective, this section seeks to unpack how ES is interpreted and understood within the CCT, but particularly by the ES Department and the Environmental Resource Management (ERM) Department. The focus here is to reveal those institutional arrangements that allow or inhibit purposive change and under what circumstances purposive change might emerge.

6.2.1 Overview of the electricity services network

The configuration of Cape Town's electricity network is considered unsustainable (Crane & Swilling, 2008; Spencer, 2010). There is insufficient generation and storage capacity within the Cape Town Functional Region to provide electricity, and therefore the city is dependent on resources beyond its boundaries, which makes Cape Town reliant on *imported* electricity. The Electric Supply Commission of South Africa (ESKOM), South Africa's parastatal electricity utility company, produces and supplies the bulk of Cape Town's electricity at coal-

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month on average. The CCT tier two tariff allocates 25 kWh per month of free basic supply for users who consume more than 250 kWh per month but less than 450 kWh per month on average. Eskom consumers on the other hand who purchase less than 250 kWh per month on average on one of the Homelight tariffs (so excludes anyone who may be on the Homepower tariffs) will receive 50 kWh per month free (CCT, 2013e).

[56] "A household that spends more than 10% of their net income on energy is regarded as energy poor or in energy poverty" (Department of Energy, 2013: viii).

fired power stations[57] in the Northern Province and Mpumalanga. A vast interconnected transmission system expands across South Africa to ensure a secure supply of electricity, but results in enormous technical and financial inefficiencies (Ward & Walsh, 2009). It must be noted that this is a structural phenomenon. Electricity generation is regulated at a National level by the National Energy Regulator of South Africa (NERSA), and therefore production and pricing is tightly controlled.

The CCT is the service authority, and customers receive electricity from both the ES Department and ESKOM as service providers. There is "little cooperation between the two ... [making] city-wide planning difficult" (Spencer, 2010: 137). The ES Department administers the bulk of the distribution, providing approximately 72,5 percent of electricity supply through both traditional, use-then-pay systems and pre-paid meters (PPM) to 60 percent of consumers in Cape Town while ESKOM provides electricity to the remaining 40 percent of consumers (Swilling, 2013). Significantly, ESKOM services mainly newly developed and growing areas where the majority of residents are low income (Jaglin, 2009; CCT, 2012e). Moreover, ESKOM has always focused on facilitating capitalist growth as a fundamental business model (Gentle, 2009). As the *other* electricity service provider, it has exerted pressure on CCT to privatise electricity distribution, which would diminish the CCT's social welfare agenda and equate this essential public service of electricity distribution to the "selling of commodities" (Swilling & Annecke, 2012: 257). However, privatisation has been consciously resisted[58] because the CCT uses the significant (yet decreasing) "revenue surpluses generated through the sale of electricity to cross-subsidise low-income users and other public services" (Leeuwendaal, personal interview, 2013, October 14) in the endeavour to provide universal coverage and access. It is useful to reflect on the inconsistency of this arrangement with the Constitution (RSA, 1996: s156), which provides that the CCT ought to reticulate electricity as described in table 5.2. Therefore, as the CCT resists privatisation, ESKOM's grip on the existing regime *locks-out* the possibility of the provision of an integrated system that may support higher levels of social justice. Figure 6.1 shows the areas of electricity supply for each provider.

[57] Coal-fired power stations produce over 90% of South Africa's electric power and 98% of the electricity that is sold in Cape Town is imported from the Eskom national grid, and therefore generated from coal-fired power stations (Silver, 2013; Spencer, 2010; Jaglin, 2009).

[58] An account of the CCT's successful efforts to avoid the adoption of Regional Electricity Distributor is offered by Swilling (2014).

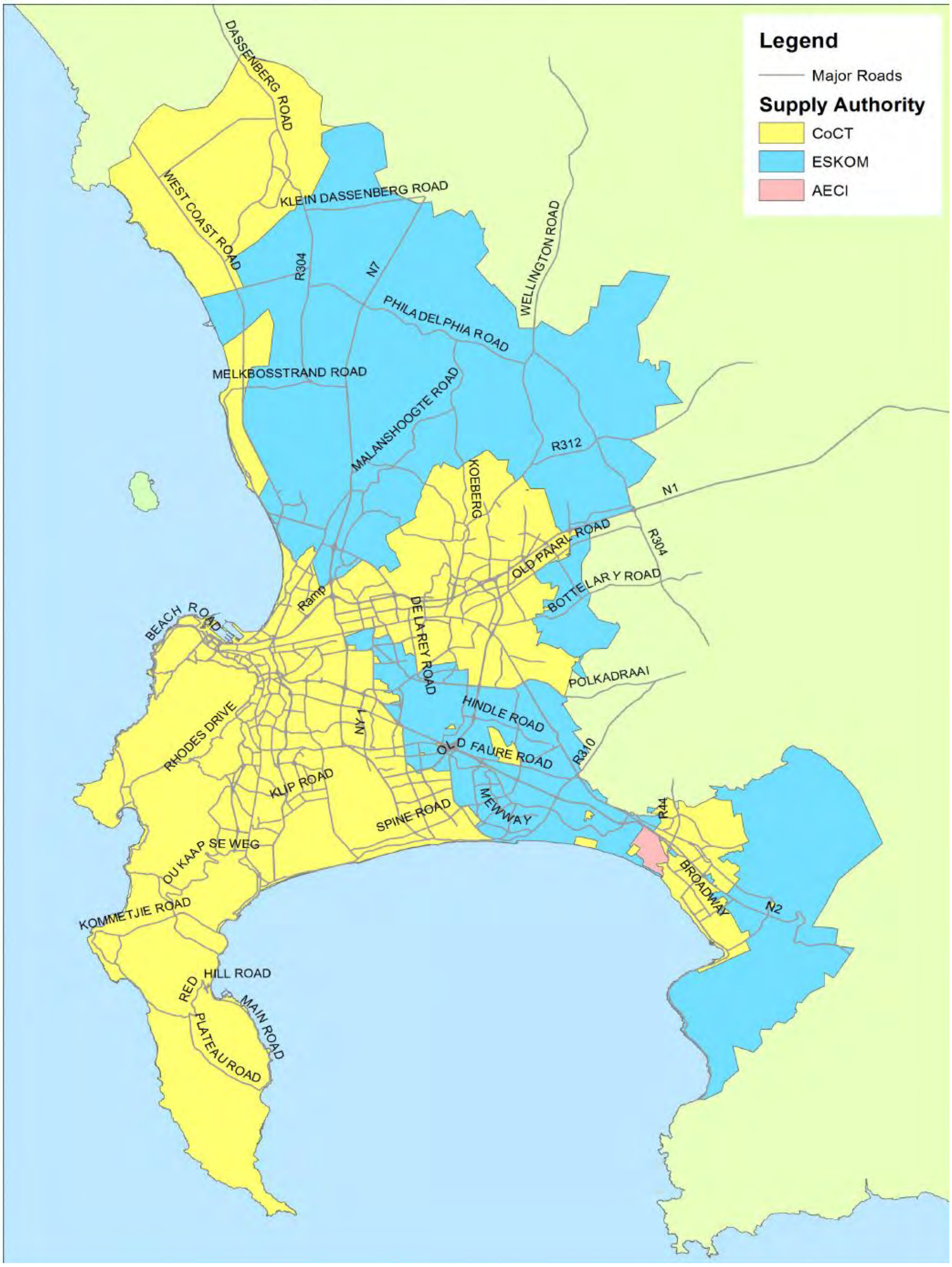

Figure 6.1: Electricity distribution supply areas for ESKOM and the CCT
Source: CCT (2012e)

The bundle of infrastructure that is used to generate electricity for Cape Town is made up of a combination of coal, nuclear, hydro and gas-turbine power. Table 6.1 summarises the installed electricity supply capacity in Cape Town. The majority of electricity is sourced from non-renewable energy sources, specifically coal-fired power stations in the North that transmit electricity via 400kV lines delivering a maximum of 2600MW, or 50 percent of total supply capacity to Cape Town (Spencer, 2010; Sustainable Energy Africa (SEA), 2007). Cape Town does have an element of renewable energy, but it is still far less than 1 percent of the grid-based supply. This is from the Darling Wind Farm[59] (DWF), and privately owned solar hot-water heaters and solar panels installed by households and business, a practice actively encouraged by the CCT. The minor contribution of renewable energy and the introduction of electricity-saving measures signals a shift in the CCT's view of the electricity system and more specifically the role of electricity consumption; however, not from within the ES Department. How this shift has emerged and its perceived consequences by the ES Department will be unpacked as this section unfolds.

Table 6.1: Summary of installed electricity supply capacity

Operator	**Source**	**Total Contribution**
Eskom	National transmission lines (coal)	2600
	Koeberg Nuclear Power	1800 MW
	Palmiet Pumped Storage	400 MW
	Acacia Gas Turbines	171 MW
	Open gas turbines	1050 MW
City of Cape Town	Steenbras Pumped Storage	160 MW
Independent Producer	Darling Wind Farm (DWF)	5.2 MW (10 MW capacity)
	Privately owned solar water heaters[60] (10 000) in CT	4.2 MW

Source: CCT (2007d); SEA (2007); Spencer (2010); Swillling & Annecke (2012)

[59] The Darling Wind Farm (DWF), South Africa's first commercial wind farm, is an independent power producer (IPP), privately owned and supported by funding from the Danish Government, the State owned Central Energy Fund and the Development Bank of South Africa, and has been in operation since 2008 (CCT, 2010e).

[60] This is an estimated figure by the Energy Efficiency and Climate Change Unit although the Department are currently using GIS to survey the number of SWH heaters in Cape Town (Roux, personal communication, 2014, November 29).

There are a number of refurbishment and maintenance challenges due to ageing of equipment on the entire distribution system, including the network and switch gear necessary for transmission (CCT, 2011c). The entire high voltage system requires some expansion as well as rehabilitation, as does the switch gear in the medium voltage distribution system (CCT, 2011c). Cape Town currently faces a R1.6 billion backlog in the refurbishment and maintenance of electricity infrastructure across the geographical area, which includes a R326 million backlog for electrification (CCT, 2011c). In spite of these maintenance and rehabilitation backlogs the ES Department has made some inroads towards achieving its mandated goal of universal service delivery. While there is a 100 percent electrification rate in formal housing developments, there is still a backlog in informal areas and backyard dwellings in formal areas. Between 2001 and 2011, the number of households with access to electricity for lighting and cooking increased from approximately 84 percent to 91 percent (CCT, 2012a). But the backlog remains, despite major capital investments in areas where deficits are concentrated and in growth corridors, made possible by the Integrated National Electrification Programme, the private sector and the CCT capital budget (Jaglin, 2009). The way in which this department has managed to extend *almost* universal access to the electricity network, is however also the way in which it limits innovation and systemic change. These results, which look impressive on paper, have been achieved thanks to the high level of experience, expertise and knowledge of *modern* electricity distribution held within the department. However, the department is far from delivering sustainable and inclusive infrastructure, due to wider socio-economic inequalities, and seems unable to identify what exactly that means for its role as a service provider. This is partly due to the internal operations of the department and partly due to the external conditions of dual delivery.

The overview of the network has introduced the context within which the ES Department maintains the delivery of services to Cape Town's residents. Wrapped up in this, is the historical role of electricity consumption as a means to generate revenue for the CCT, which is largely how the ES Department perceives its role, rather than as the provider of an essential public service. The Utility Services Directorate receives a substantial portion of the CCT budget while at the same time contributes approximately 10 percent of the revenue generated through surpluses[61] in electricity sales to the rates account (Leeuwendaal, personal interview,

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[61] The significance of electricity revenues to overall municipal revenues is illustrated by the fact that revenues generated through the sale of electricity in 2008/2009 accounted for 27% of total municipal revenues (PDG, 2011). Moreover, the margin generated on electricity sales results in a surplus of 22%

2013, October 14). The entire system relies on cross-subsidisation to achieve inclusive service delivery in Cape Town and offset non-revenue generating services. However, this has become counter intuitive as explained below:

> The electricity grid is always being improved by [the ES Department] and they have great capacity to balance the grid. [But at a more fundamental level] we have to have a new business model for [the] ES Department and the CCT needs a new revenue model. We tax [electricity] consumption [as] we are dependent on it for income for the CCT … [but] consumption is **structurally decreasing** (Ward, personal interview, 2013, December 10).

The model of delivery is based on the ES Department constructing what it considers to be realistic and realisable tariff packages to accrue revenue for the CCT, while the efficient collection of user charges is vital to balance the CCT budget. Furthermore, the ES Department places significant emphasis on cost efficiency, maintaining a philosophy that the "bottom line is cost recovery" (Leeuwendaal, personal interview, 2013, October 14) to ensure that the "department never has to compromise on essential maintenance" (Trollip, personal interview, 2013, November 7). Largely, this helps to fend off the "enormous pressures from suburban residents to keep their electricity infrastructure world class … [by investing] much more in suburban areas than they do in townships" (McDonald, 2009: 16).

A creative combination of increased meter reading, pre-payment systems and service terminations has been employed to ensure adequate credit control and cost recovery (McDonald, 2009; McDaid, 2009). In the past, the CCT responded to non-payment and illegal connection by manually cutting off users, only reconnecting them once debts and reconnection fees were paid (McDaid, 2009). However, this is largely no longer necessary, due to the installment of pre-payment metres (PPM), "used by approximately 67 percent of domestic electricity consumers" (Leeuwendaal, personal interview, 2013, October 14). The installation of PPM has implications for revenue management and collections ratios, as well as the consumer's control of consumption. By transferring the action of cutting off supply to an automated system, the provision of electricity becomes de-politicised (McDiad, 2009). But, as argued in Chapter 2, these systems are not apolitical. Rather, the vested interests of the ES Department and the CCT, on which these socio-technical systems precariously balance, are revealed here to be the collection of user revenue rather than social development.

relative to the CCT operating expenditure in that same year. Therefore, the sale of electricity has significantly enhanced the ability to manage revenues and credit control (Jaglin, 2013).

However, the landscape within which the ES Department acts has shifted. Issues of climate change in parallel to supply shocks have resulted in a crisis that forces the CCT to review its approach to service delivery. However, while the incumbent regime holds onto the existing system, other departments within the CCT find themselves taking up the initative to intervene for purposive change.

6.2.2 Interventions for improved electricity services

There is a growing policy discourse within the CCT that considers energy efficiency (EE) critical for improving energy security, electricity supply and reducing GHG emissions, and this is clearly expressed in the IDP (CCT, 2012c). Since 2006/2007, electricity supply shocks, load shedding and rolling blackouts have plagued South Africa, and as a result Cape Town's electricity consumption has decreased beyond the 10 percent target set out in the IMEP, introduced in Chapter 5 (CCT, 2009a). Moreover, since then there have been several purposive interventions and initiatives that seek to reduce electricity consumption.

Prompted by the risk climate change poses to Cape Town's rich biodiversity[62] and natural fauna and flora, juxtaposed to its vulnerability to limited energy capacity, the ERM Department has begun to develop strategic responses to the threat of climate and energy vulnerability. The CCT is the first governing authority in South Africa to develop a Framework for Adaptation to Climate Change (CCT, 2006b) and implement a city-wide Energy and Climate Change Strategy (CCT, 2007c), followed by the Energy and Climate Action Plan (CCT, 2010f). The action plan is managed and coordinated by the Energy and Climate Change Unit in the ERM Department. In 2008, as recorded in council minutes, momentum gathered around this issue due to the recognition by the Executive Council that the CCT's "07/08 IDP Document [does not] make mention of this broad subject [of energy efficiency and climate change] or its function areas" and goes on to say "that [this] must be addressed as a matter of urgency in order to express, with weight of emphasis, the CCT's political and administrative vision in relation to this matter" (CCT, 2008b: 1375).

Energy Efficiency for a Sustainable Future that focuses on energy security and carbon mitigation as the eighth SFA was subsequently agreed upon and included in the IDP. The Council furthermore created a "new political structure, [which was] given a high profile" (CCT, 2008b: 1386) for the *Energy Efficiency for a Sustainable Future* SFA. The

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[62] "The cape floral kingdom is a true global hotspot of bio diversity, being the smallest and richest on earth, while having the highest number of threatened plant species of any city in the world. Cape Town lies witin the Cape Floristic Region, A UNESCO World Heritage Site" (CCT, 2010f: 03).

Section 80[63] Energy Committee that reports directly to the Executive Mayor was thus established. Currently, this SFA has its own work stream and political support through the CCT Executive Management Team (EMT), Energy and Climate Change Subcommittee (consisting of CCT officials) and the Energy and Climate Change Committee (a political committee consisting of both councillors and mayoral committee members). This provides actors within the Energy and Climate Change Unit with the legitimacy to drive reform processes across the institution, not only in the ERM Department.

It is interesting that *Sustainable Urban Infrastructure and Services,* as the second SFA of the IDP, has no such support. Rather, the responsibility falls directly to the utility departments alone. However, it is not surprising, considering that climate change has fast become fashionable within international policy discourse and political agendas. The CCT's vision to be "a sustainable, **world-class** African City" would be impossible without what the CCT calls "a clear set of policies and strategies for sustainable growth and development" (CCT, 2007c: 5, authors emphasis) that hook into international policy discourse around topical issues. The desire of the CCT to be on the cutting edge of policy fashion is rivalled only by their preference for being among the first developing world cities to develop such a policy (CCT, 2007c). The international sustainable urban infrastructure policy discourse has only recently increased in *mobility*, gaining traction over the past several years, and through *mutation* processes is reproduced, depending on the spatio-temporal charater of a particular context, to use Peck and Theodore's (2010) metaphor. However, due to nonlinear processes of reproduction of incomplete policy packages, the conceptual notion remains inchoate in the CCT and politicians and officials have a limited understanding of the notion of sustainable urban infrastructure as a discourse (Peck & Theodore, 2010). This phrase now represents a range of ad hoc policy and strategies guiding infrastructure investment in Cape Town, but in the absence of political oversight and support for comprehensive, integrated activities to drive reform.

The ES Department has described, in various departmental sector plans (CCT, 2011c; CCT 2012e; CCT, 2013b), its role in promoting the use of renewable energy in accordance with the Energy and Climate Change Strategy. The aims of the department are as summarised below:

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[63] Section 80 committees are appointed by Council to assist either an executive mayor or an executive committee to ensure efficient performance of a function of local government (CCT, 2011b).

> To promote the use of green electricity generated at the DWF; to promote and facilitate the implementation of other renewable generation systems; to ensure the department is up-to-date with national legislation regarding renewable energy; investigate and identify practical and feasible options for the supply of electricity from sources other than ESKOM, e.g. independent power producers (CCT, 2011c: 12).

Other responsibilities of the ES Department, together with the ERM Department, are the promotion of demand-side management (DSM) and EE. Realising successful outcomes for these aims have however not been actively sought by the ES Department, despite the several attempts by the Energy and Climate Change Unit to improve electricity savings and efficiencies. For example, the DWF project was intended to spark additional renewable projects, but despite the positive initiative, the project has failed rather spectacularly. Momentum for any real change has been stifled by several factors. From a technological perspective, the system is operating at only 50 percent of its technical capacity and is financially unsustainable; “the price of electricity was determined and secured prior to it becoming operational but did not take into account the [electricity] price escalations since 2007” (Jones, personal interview, 2012, October 10). It has furthermore been suggested that the management and maintenance of the DWF is wholly inadequate for such a sophisticated system; issues from poor location to poorly maintained operating systems are evident (Roux, personal communication, 2014, November 29). Another major reason is the lack of budget allocated to the Green Energy Branch, in the ES Department, for functions beyond direct operations. The small staff cohort and the general complacency of the Branch Head to motivate for the DWF's on-going functioning are revealed in the excerpt below from an interview:

> Green Energy is a branch in the ES Department. But [the head] has no budget for additional staff … even though he is in the department, he has not asked for it. But this is very much to do with having a champion and making your mission loud and proud. If you are going to sit on your mission and find all the problems why you can’t do things, you are not going to access to money... [Green Energy] is an incredible opportunity for change in Cape Town. The individual in charge is [extremely capable and is highly skilled] ... but cannot see his mission as a change agent (Ward, personal interview, 2013, December 10).

Another example of ES Department’s complacency toward the issues is that of the Department of Energy’s (DoE) Municipal Energy Efficiency Demand Side Management (EEDSM) programme. Through the Division of Revenue Act (DoRA) (*Division of Revenue*

Act 10 of 2014, 2014), and DoE's EEDSM programme, in 2009 a grant was made available to the CCT for EE retrofits[64] within municipal infrastructure and council operations (Mohamed, personal interview, 2014, June 4). These interventions included the retrofitting of street lighting and traffic lighting as well as municipal buildings to reduce energy consumption. The accumulated electricity savings are displayed in Figure 6.2. However:

> originally [the grant] went to the ES Department but it is that problem of paying the ES Department to reduce their revenues and they were not interested. EE is absolutely not their core business. They don't have a champion and they don't care about [EE]. So the [ES Department] mismanaged the money … after which the whole program was moved over to [the ERM Department] who now receive additional budget for the EE Campaign under the Energy and Climate Change Unit who manage the allocations, business plans and reporting.… [Needless to say] there is a bumpy relationship between the EDS and the ERM (Ward, personal interview, 2013, December 10).

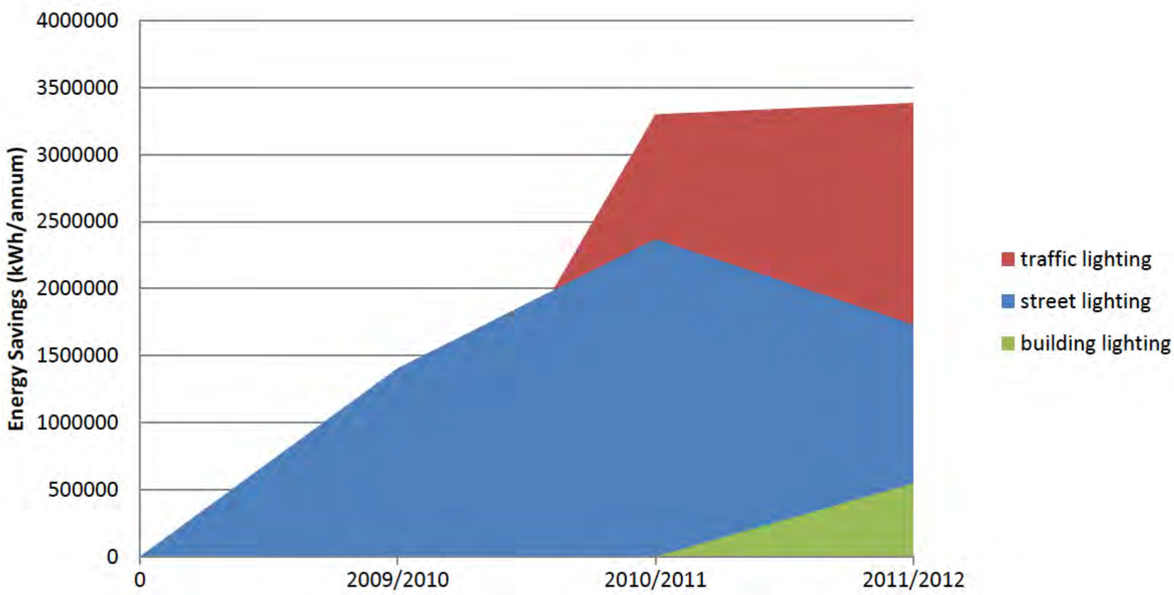

Figure 6.2: Cumulative energy savings from DORA projects
Source: Mahomed (2012)

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[64] "By 2011, all the of traffic lights had been retrofitted … the CCT hasn't taken that in cognisance that the traffic department has changed its whole business model … the way it does maintenance has changed and it all of a sudden has spare capacity because LEDs doesn't need as much maintenance as what incandescent and halogens, which traffic light used to have, might require. That whole model has changed which [illustrates how] innovative that department is … there are technical challenges but the department is able to managed this" (Mohamed, personal interview, 2014, June 4).

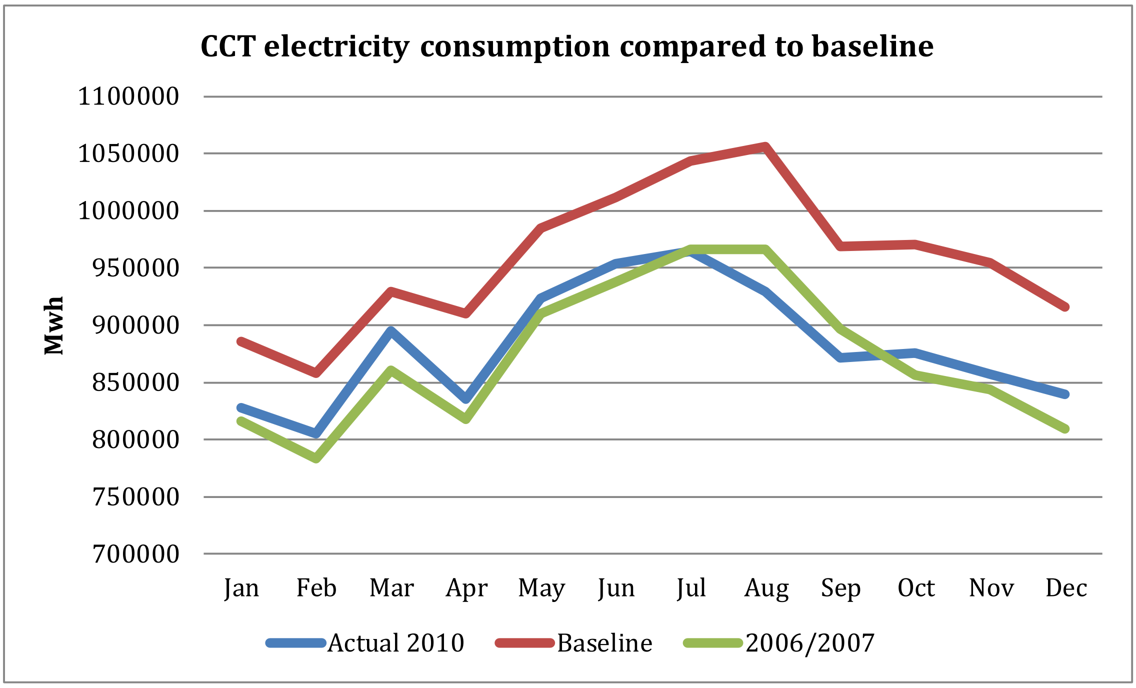

Figure 6.3: Electricity consumption in Cape Town
Source: CCT (2013b)

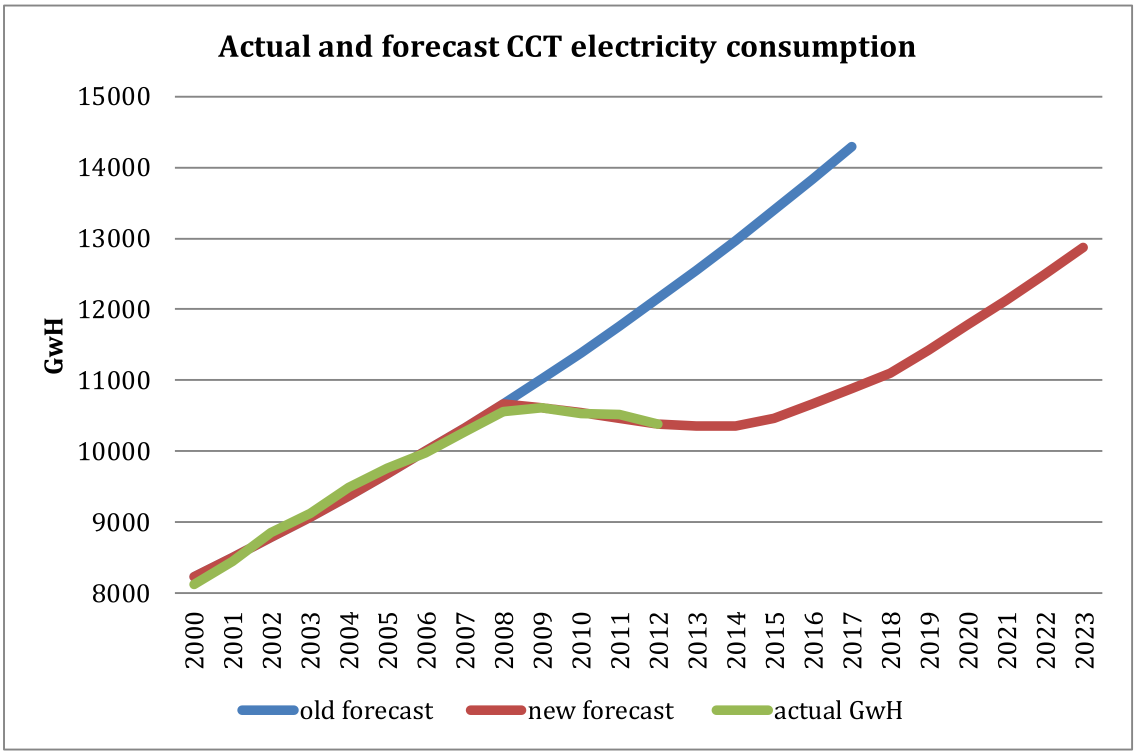

Figure 6.4: Trends in electricity consumption in Cape Town
Source: CCT (2013b)

In addition, the ES Department (begrudgingly) allocates R5 million per year to the Electricity Saving Campaign, also managed by the ERM Department, which is an initiative that seeks to decrease electricity consumption. The ES Department is of the opinion that "promoting energy efficiency is somewhat counter-intuitive as the ES Department is interested in the sale of electricity" (Leeuwendaal, personal interview, 2013, October 14) as "the sale of electricity is considered the saving grace" (Jones, personal interview, 2012, October 10) for the ongoing functioning of the CCT.

Diminishing returns due to EE and energy saving interventions is exacerbated by the fact that electricity consumption has diverged significantly from the forecast trends over the past several years. While original forecasts assumed a constant growth rate of 3.3 percent per year, decreases in consumption since the 2007/08 financial year resulted in electricity consumption flat-lining, as illustrated in Figures 6.3 and 6.4 above. Although it is likely that consumption will increase over the medium term, infrastructure planning is done based on the forecast consumption and, therefore, assumed revenue generation. This has translated into a "decline in average electricity consumption, and therefore sales, in the order of 1.4 to 2 percent each year" (Leeuwendaal, personal interview, 2013, October 14). Declines like this directly impact the financial stability of the ES Department. Historical growth in electricity sales allowed for tariff increases to remain relatively low while still allowing the CCT to make a profit; however, the decrease in demand has changed the game.

Significantly, it is unclear what accounts for the decrease in demand for electricity. Some attribute the change to the "implementation of energy efficiency and electricity savings programs by the CCT, articulated in the IMEP [CCT, 2003a; CCT, 2009a] and the Energy and Climate Change Strategy" (Mohamed, personal interview, 2014, June 4). However, this is more likely to be in response to the price increases and the generally high elasticity of electricity, especially in low-income households as an outcome of the global economic recession and rolling blackouts, than in response to purposive electricity saving interventions (Roux, personal communication, 2014, November 29). The blind spot here is that an increase in the price of electricity affects the poor households more than middle and high-income households. Moreover, higher tariffs and supply volatility are likely to persuade large energy users to invest in small scale decentralised embedded generation and EE retrofits. This is becoming more and more common across Cape Town.

In response, the ES Department is actively pursuing an effort to decrease its budget allocation to the ERM Department. "The argument used in the request to decrease the budget for [electricity savings] is based on the rationale that the campaign cannot be a CCT Council priority when portions of the population remain unconnected to the grid, electrification is the priority" (Roux, personal communication, 2014, November 29). CCT officials and the Executive Council cannot ignore the fact that electrification can instantly improve living conditions in the order of 15 to 20 percent, which makes it politically important (Annecke et al., 2005). The tension between electricity savings and efficiency gains for environmental sustainability, and the use of revenues to cross-subsidise social services is highly political in such a context where inequality is so prevalent. However, the social agenda is subverted by the volatility of electricity prices and the effect that has on the poor. "Ultimately, it is the urban poor who will suffer the consequences as energy prices rise at rates well above inflation" (Swilling, 2013: 11).

6.2.3 Internal tensions that inhibit cooperative and integrated change

Considering the 'bumpy relationship' between the ERM Department and the ES Department, it is clear the marginal shifts in how electricity services are perceived do not come from the ES Department. Rather, it is through interventions from other departments and urban actors[65]. At the same time the inertia within the ES Department means that change is resisted. The Head of the Energy Efficiency and Climate Change Unit suggests, "while some managers in the [ES] department are supportive of electricity saving [initiatives] ...if you go higher, to the director or assistant director, they are sort of freaking out [about diminishing revenues]" (Ward, personal interview, 2013, December 10). This sentiment opens up questions around why the ES Department is reluctant to consider experimenting with alternatives.

The internal dynamics of the ES Department disrupt the delivery of sustainable and inclusive infrastructure. When examining data (CCT, 2014e) representing the employees of the ES Department categorised by position, business area and the date the individual joined the CCT, a specific pattern emerges. A significant number of officials within the department who are highly skilled[66] and in senior positions joined the CCT between 1970 and 1999. What this

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[65] Silver (2013) offers a thorough analysis of emerging processes that demonstrate how various urban actors are reconfiguring energy networks in innovative ways.

[66] Positions such as: operational district manager, technical specialists, manager of infrastructure management, high voltage operational manager, manager of electricity supply, coordinator of distribution system development, head of distribution, manager of finance and commercial, and head of engineering (CCT, 2014e).

shows, is a group of highly competent engineers and professionals, who ensure the system functions, and have been working within this particular context for a long time, delivering conventional services. But it is common for these individuals to resist change:

> Many white [officials] who sit [in the ES Department] just say why you can't do things. [They are] grumpy old men who are worried about their power being undermined and who just see barriers…people in fairly senior positions have often only ever worked for the CCT and so they have little experience of the private sector or NGO sector, which makes it difficult for people to think differently (Ward, personal interview, 2013, December 10).

Moreover, the core competencies of the organisation are located firmly within these individuals who are "unwilling to part with a very particular way of doing things and they are not willing to engage in real skills transferal" (Trollip, personal interview, 2013, November 7). As a result, there is very little flexibility in how this service *should* be and *is* rolled out, determined by the department stalwarts within a powerful centralised agency. The "senior management conduct affairs as if they were part of a mini-empire" (Trollip, personal interview, 2013, November 7), where the method of network maintenance and expansion is an established system, that has adapted very little over the past 30 years.

> There are two different kinds of people in the CCT. Some people are extremely rule bound and feel that you can't do anything unless it is business as usual and it has been done before. [They] see the CCT as an established system and considers 'how it works' to be just that, how it works with no room for change. The other kind see the system but don't consider it as immutable because there is definitely a history of change and take advantage [of small wins]...but work toward a larger goal (Ward, personal interview, 2013, December 10).

The rules and logic that govern this regime are clearly well defined and are constantly reproduced by rule-bound actors. Yet, those pockets of innovation cannot be ignored. While there is evidence of small wins within the sector, there is also evidence of *pushback* from the ES Department described above. What then is the prospect for such interventions, generally at the margin of the system, to cohere in a manner that manifests deeper change processes?

6.2.4 Section summary

There are evidently institutional tension both within and external to the ES Department. This case study section has offered an overview of the ES Department, with reference to the ERM Department. The intention has been to demonstrate the status quo of the ES with an eye on the prospects for re-orientating the system toward a more sustainable development pathway. This section has shown that the ES Department is increasingly concerned with improving the security of supply through load management, rather than overall load reduction. Moreover, it has shown that the business model of the department is largely reliant on revenue generation for the ongoing management of the system, which renders the CCT vulnerable to changes in price, implemented by ESKOM, and future consumption patterns. Therefore, the institutional culture of the department is focused on maintaining the status quo despite the CCT's policy to promote EE and electricity savings. Moreover, the ES Department is stuck behind the walls of its mini-empire while the CCT is shifting, at least in policy, from the conventional service delivery approach toward a more sustainable agenda that seeks to incorporate renewable energy sources and improve efficiencies. These reforms are driven by the ERM Department. The ES Department however has a greater degree of power to secure certains budget allocation arrangements, which renders the ERM Department unable to access adequate budget for project implementation. In addition, the working relationship between the two departments is poor, which does not bode well for future collaboration, despite their mutual mandate to save electricity and drive reform in the sector.

Morever, this is not to suggest that the ERM Department is well on its way to initiating a transition in this sector by institutionalising a new service delivery model. While there is evidence of successful interventions from the Energy and Climate Change Unit, the configuration of those interventions is not necessarily in alignment with sustainable urban infrastructure, represented as the ecological restoration and social justice discursive domain. Caught up in the efficiency discursive domain, the ERM Department is currently unable to present a case that will alter the service delivery model. In the meantime, the service delivery model of the ES Department is geared toward militating against the continued success of these interventions, while the status quo of delivery remains the same. It is unlikely that the ES Department, bounded by a set of rules that govern the regime, will re-orientate activities toward supporting sustainability-orientated innovations. The following section introduces the W&S Department in an effort to further reveal the prospects and relevance of sustainable urban infrastructure. First, however, there is an introduction to water and sanitation infrastructure.

6.3 Introducing water and sanitation infrastructure

In the natural environment, water moves continually through a hydrological cycle, a process that transforms and replenishes the earth's water reserves. In direct contrast, conventional networked infrastructure that holds no baseline commitment to sustainable urban infrastructure, conveys water resources through urban areas without consideration of this balanced cycle. Conventional urban water systems have three main components (Bry Sarté, 2010; Moffatt et al., 2011). There is a supply component in which water is captured and stored in dams, treated to a potable level at large Water Treatment Works (WTW) and distributed throughout the urban system via an extensive, big pipe network to consumers. The collection network, the second component, transfers grey and black water, via another extensive big pipe network to Wastewater Treatment Works (WWTW) where it is treated to a minimum standard and discharged directly into natural water bodies present in the urban system and wider in the functional region, which are expected to purify the treated by-product. While the hydrological cycle does this naturally, the generally low standard of treated wastewater and the quantity that is returned creates an imbalance that degrades the natural process. The third component is the storm-water system, which collects storm water from impervious urban surfaces laden with pollutants and discharges it directly into the natural environment (Bry Sarté, 2010; Moffatt et al., 2011). Consequently, the capacity of the natural cycle is diminished, intensifying the degradation of eco-system services. Furthermore, the water treatment and distribution system is energy intensive and incurs substantial losses due to the distances water is carried across urban territories that are prone to leaks and bursts. Much of what is stated here is represented by Cape Town's hydrological system, which will be described in the following section.

The negative ecological implications of existing urban water management practices suggest that an alternative is nessecary. Moreover, in a high growth period, such as the ongoing urban transtion in the global south, meeting the conventional standard of supply and treatment becomes an economic impossibility (Bieker et al., 2010). Nelson (2008) promotes the idea of decentralised technologies, which include water efficiency and conservation, stormwater retention and reuse, and decentralised[67] wastewater treatment, reuse, and resource recovery.

[67] Libralato et al. (2011) explain that the concept of decentralisation has been interpreted in different ways and is determined by a plant's treatment capacity or the population equivalent that is serviced. Furthermore, while decentralised plants operate locally, they are not always small, but rather they reflect the matter of scale (Libralato et al., 2011).

These interventions aim to preserve scarce resources as well as restore the integrity of the water cycle. Interventions to augment supply in established systems include desalination (powered by renewable energy), rainwater harvesting, and water reclamation, based on the assumption that the quality of water required is only treated to that required level (Jacobsen et al., 2012). This depends on configuring semi-centralised or decentralised, integrated water and wastewater treatment systems that support Integrated Water Resource Management (IWRM). Significantly, IWRM is based on the principle that water resources should be coordinated and managed to encourage equitable, economic and social welfare (Wu, 2008). It seeks to balance the "use of resources for livelihoods and conservation of the resource to sustain its functions for future generations, and promotes social equity, environmental sustainability and economic efficiency" (Wu, 2008: 78). What follows is an attempt to understand the prospects for implementing these types of alternatives in Cape Town with a focus on the institutional dynamics of the CCT's W&S Department.

6.4 The City of Cape Town's Water and Sanitation Department

The CCT W&S Department has made progress in the roll-out of basic services, and inroads towards setting up the foundations of an *efficient* urban water system. However, the realities of un/under-serviced and over-crowded areas, polluted water bodies in and around the city and the degrading urban environment illustrate the major gap between what are considered progressive policy and strategies, and implementation (Pan, 2011). A myriad of challenges face the W&S Department in their effort to deliver water services. Obstacles include: the significant service delivery backlog in basic sanitation services, relative unaffordability of services, high water demand and consumption, an overloaded wastewater treatment system and substandard effluent discharge, the financial sustainability of services and the absence of adequate human capacity to address the pressing challenges (Crane & Swilling, 2008; Pithey, 2007; Swilling & Annecke, 2012; Winter, 2010; Salga, 2011). Ageing and dilapidated infrastructure threatens not only the security of supply but also the ability to manage the trade-offs between allocated budget for rehabilitation and refurbishment, and network expansion aligned with urban population growth and backlog eradication (Crane & Swilling, 2008; Pithey, 2007; Swilling & Annecke, 2012; Winter, 2010; Salga, 2011).

In an effort to intervene and resolve these challenges, the W&S Department have commissioned a number of studies and reports over the past decade; most important, the Western Cape Water Supply System (WCWSS) Report (DWAF, 2007). While these reports are illustrative of the technical capacity of the system, they are less clear on the overall sustainability of water resources, and the delivery of water and sanitation services. The notion of sustainable urban infrastructure is absent from internal planning and strategy documents as well as discursive frames of CCT officials, despite the explicit reference to it in the IDP (CCT, 2007a). Moreover, the Water Services Development Plan (WSDP) (CCT, 2007e; CCT, 2011d), the guiding strategy for the department, does reference the need to ensure sustainable services. Winter (2010: 103) states that "it is therefore sobering that measures for determining sustainability are not discussed in two of the most comprehensive water reports of recent years". This is true across the utility departments.

The W&S Department is addressing the interrelated challenges of sustainable water and sanitation service provision in an ad hoc, disparate way. Although, there are indications that combined, these interventions may accumulate and cohere to support a more sustainable development pathway, it remains to be seen whether this will take root for systemic change. The remainder of this section reviews and unpacks the technical conditions that exist, as well as institutional and socio-economic conditions that reinforce the status quo. The section begins with an introduction to the policy and corporate parameters.

6.4.1 Policy and corporate parameters

South Africa's water planning architecture is designed by the Water Services Act (*Water Services Act 108 of 1997*, 1997) and the National Water Act (NWA) (*National Water Act 36 of 1998*, 1998), which, combined, have been lauded as a particularly progressive water legislation, because it translates the concept of IWRM into an implementable policy[68] (Schreiner, 2013). The intention is to create more equitable municipal water services, as part of post-apartheid reconstruction, and achieve sustainable water resource management (Koldeweij, 2013). The Department of Water Affairs (DWA) acts as the custodian of water systems while the NWA describes the principle of cooperative governance across institutions and spheres of government, wherein the management of water resources is carried out at the lowest appropriate level, via catchment management agencies (Schreiner, 2013). The CCT together with the Department of Water Affairs (DWA) and ESKOM own the WCWSS, although it is operated by the CCT and DWA in an integrated way (CCT, 2013c).

[68] For a critique of South African water legislation see Schreiner (2013). She contends that the inherent complexity of the national legislation governing water does not suit the current South African context, consequently limiting implementation.

Theoretically, strategic planning[69] is achieved across the spheres of government by a set of aligned strategies at each level of government (Koldeweij, 2013). At the municipal level, the W&S Department is made up of technical and non-technical branches. The Bulk Water Branch is responsible for the treatment of raw water to a potable standard, the Waste Water Treatment (WWT) Branch is responsible for the treatment of wastewater and the Reticulation Branch is responsible for all reticulation, both water and sewerage. The Water Demand Management (WDM) Branch provides planning and policy obligations. In addition, there are four support branches. Figure 6.5 represents this in an organogram.

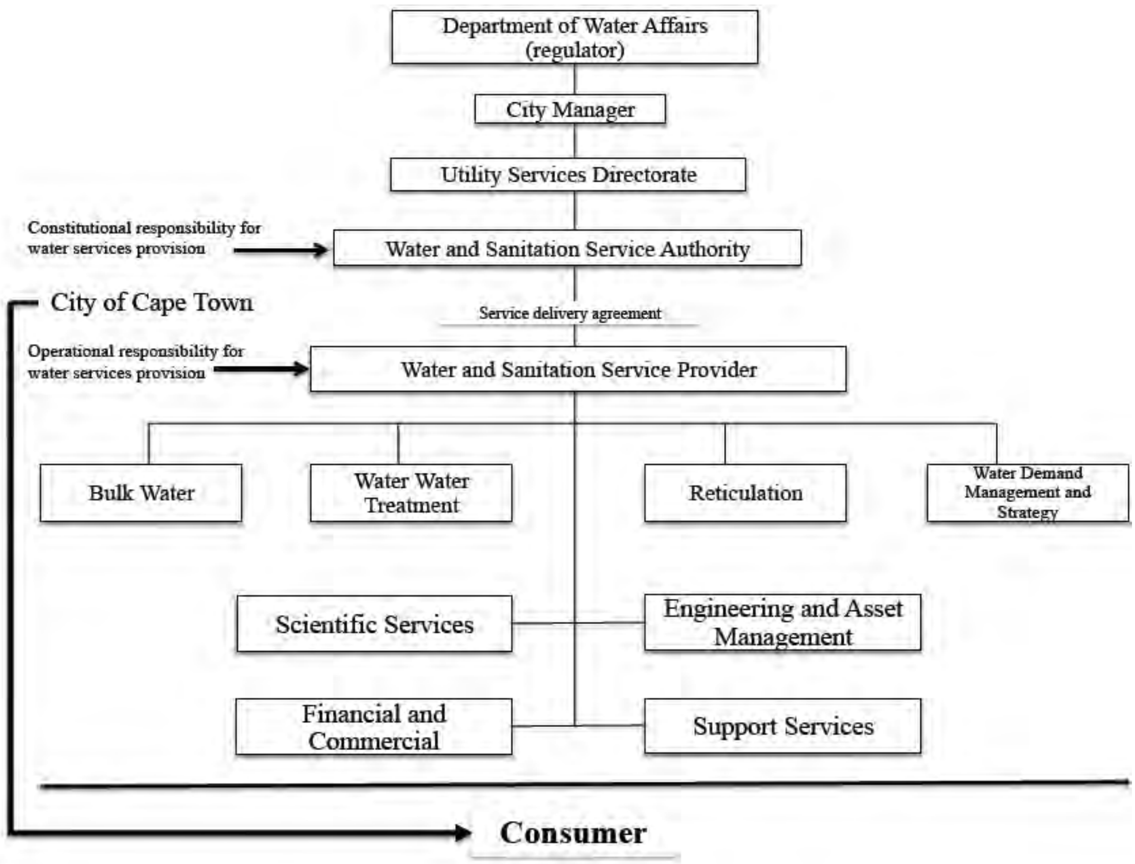

Figure 6.5: Structure of the Water and Sanitation Department

Source: CCT (2013c)

[69] At the municipal level, the Water Services Development Plan (WSDP), a requirement of the Water Services Act, provides the business plan for the delivery of water services within a municipality's area of jurisdiction, and therefore guides decision-making within the water services department. The WSDP is aligned with the Western Cape Water Reconciliation Strategy Study (WCWRSS), thus providing the Provincial Level of strategic planning, as it provides the long term water supply and demand for the area and the schedule for supply augmentation schemes and direction for local government demand management interventions. These two strategies are then located within the overarching National Water Resource Strategy (NWRS). See Koldeweij (2013) for a detailed acccount.

6.4.2 Water Supply

The expansion of Cape Town's footprint exerts pressure on both the WCWSS and the infrastructure network that conveys water and wastewater. An overwhelming majority (99%) of Cape Town's water is surface water, collected during winter months from catchment areas outside the municipal boundaries and stored in dams and reservoirs (CCT, 2011d; CCT 2013c). The remainder, a mere 1 percent, is collected from the Atlantis Water Resource Management Scheme (AWRMS) (CCT, 2011d). Figure 6.6 is an illustration of the WCWWS footprint.

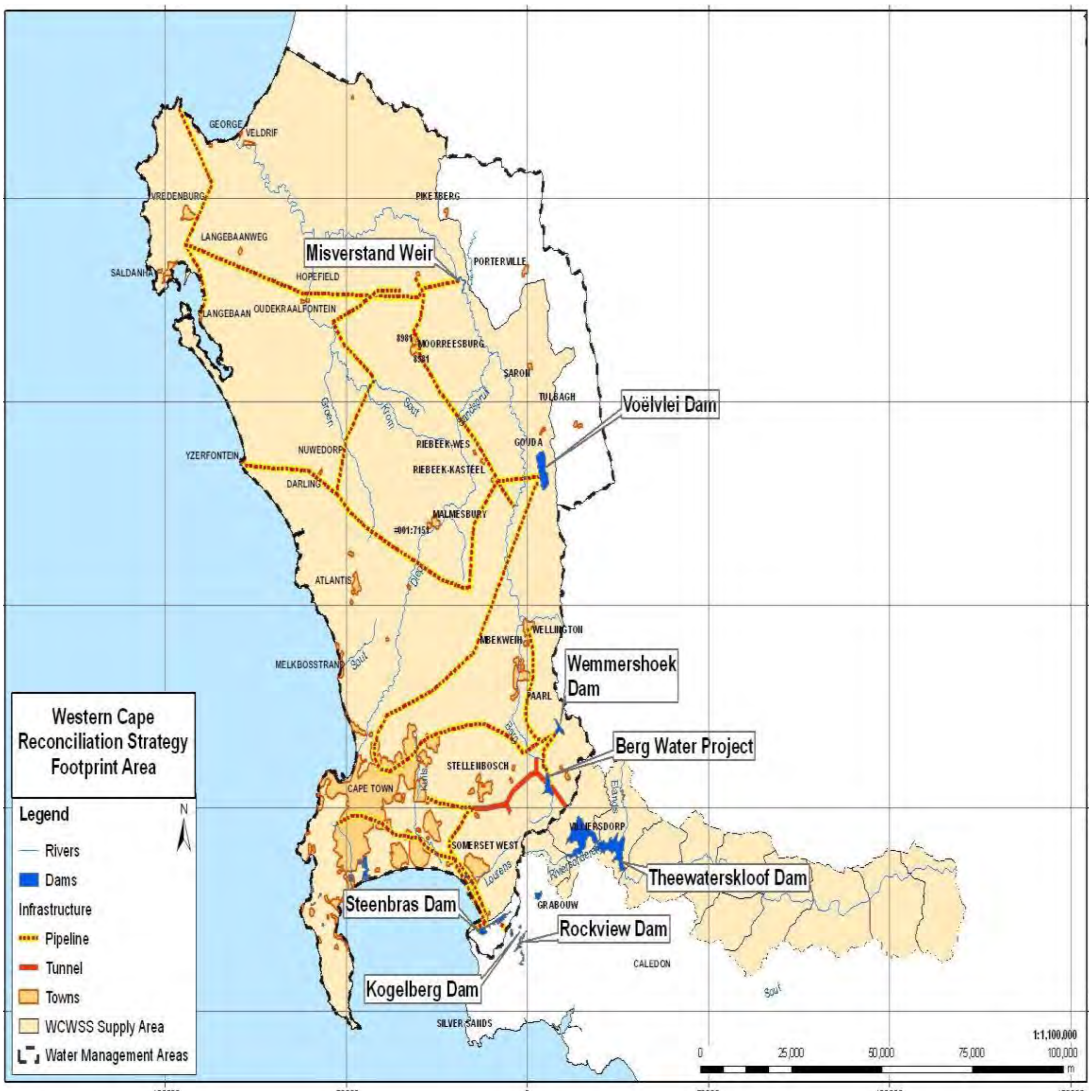

Figure 6.6: Cape Town's water resources
Source: CCT (2010g)

AWRMS is a sustainable supply of water that uses an artificial recharge and recycling system. The scheme draws water from the Atlantis, Witsands and Silwerstroom Aquifers, for domestic and industrial consumption. While it only accounts for a small percentage of Cape Town's total raw water resources, it meets approximately half of the water demand of the Atlantis area, in the northern part of Cape Town. It is an important but limited local urban water resource that is returned to the original source, via artificial recharge basins. A percentage of the treated effluent from the Westfleur WWTW's and urban storm water runoff is used (i) as a barrier against saltwater intrusion, (ii) to artificially recharge the aquifer and (iii) to augment total yield from which potable water is abstracted (DWA, 2010a). Generally, ground water resources remain an under-exploited opportunity in Cape Town. The Table Mountain Group (TMG) Aquifer Feasibility Study and Pilot Project is underway to determine the potential for development of the group aquifer as a potential supply in the future. However, based on the findings of this chapter it is more likely that the department will fall back onto large-scale conventional systems, which depend on rainfall catchment.

Table 6.2 summarises the storage capacity of the WCWSS as well as the fluctuation in the total water storage. In June 2012 the total storage was 57 percent of total capacity, while only two years prior, in June 2010, the total storage capacity occupied was 84.9 percent. What this table does not show is that in 2006, dam levels were at a twelve year low of 26 percent of total storage capacity (CCT, 2010g). Fluctuations demonstrate the variances of the water catchment capacity of the WCWSS [70] and the limitation of this approach to ensuring sustainable water supply, due to the reliance on rainwater catchment and the lack of diversification.

Evidence suggests that the effects of a changing climate are already being felt in Cape Town. The city has experienced irregular and heavier rainfall (which limits the absorptive capacity of soils, resulting in water runoff and erosion), while it is anticipated that higher temperatures and wind speeds will be more prevalent, increasing surface water evaporation and thereby decreasing available water (DWAF, 2004; CCT, 2006a). It is assumed that climate change will reduce the yield capacity of the water system by 5 percent over the next 25 years (CCT, 2010g). However, these facts seem absent from the frame of reference of departmental

[70] Of the 556 million m^3 total annual yield of the WCWSS, the CCT receives 398 million m[70]; 73% is supplied by DWA schemes, of which Theewaterskloof and the Berg River contribute approximately 50% to the total yield while the CCT contributes 27% via its operated schemes, the Wemmershoek and Steenbras dams supplying the bulk (CCT, 2010g).

officials and technicians. There is no specific departmental stance on these issues from the director or branch heads, rendering officials inactive and stuck in a decision-making mode that favours short-termism, wedded to the existing model for delivery (Koldeweij, 2013). Long-term planning is consequently inadequate and medium term challenges (such as drought conditions) are dealt with in a reactive manner, through restrictions, for example. Moreover, there is a "general lack of understanding and awareness of [climate] vulnerabilities among practitioners" (Koldeweije, 2013: 47), which is confirmed in a statement by the Head of Bulk Water who feels "lucky that there is no evidence of climate change in in the Western Cape yet" (Rhode, personal interview, 2013 November).

Table 6.2: Storage capacity and total storage of the WCWSS

Major Dams	**Bulk Storage: June 2008-2012**						
99% of total system capacity	Capacity Ml	Cap. less dead storage	% 2008	% 2009	% 2010	% 2011	% 2012
Wemmershoek*	58644	58544	64.3	74.7	69.4	72.1	48.0
Steenbras Lower*	33517	33517	58.3	64.7	63.9	58.5	53.2
Steenbras Upper*	31767	29267	74.7	94.2	79.6	59.8	74.1
Voëlvlei**	164122	156022	62.7	76.8	81.7	62.0	46.5
Theewaterskloof**	480250	432022	78.6	92.3	85.7	71.6	57.0
Berg River**	130000	125800		73.1	100.3	79.2	71.0
Total Stored			561514	760015	762852	692478	511763
Total Storage	898300	835400	768300	898300	898300	898300	898300
% Storage			**73.1%**	**84.6%**	**84.9%**	**70.1%**	**57.0%**

Source: CCT (2013c: 62), CCT (2013c), CCT (2013c)
*Owned by the CCT
**Owned by the DWA

Population and economic growth trajectories, coupled with the impacts of climate change, indicate that Cape Town will be the first city in South Africa whose demand will exceed potential yield (DWAF, 2004). Figure 6.7 illustrates water supply and demand trajectories in Cape Town. However, this is not an unprecendented phenomenon and Cape Town has a history of water-supply shocks. After the 1994 amalgamation, a number of institutional and administrative shifts took place, and the CCT inherited a service delivery model from the apartheid administration (Swilling & Annecke, 2012). The CCT was tasked with extending the system, based on the principle of efficiency and standardisation, with the goal of full cost recovery across Cape Town. Wealthy consumers were able to continue to consume as they had always done, while a considerable part of the historically excluded population was connected to water services and to a tariff system that was based on the principle of a consumption-based charge (Smith, 2004), which is regressive (Swilling & Annecke, 2012). Moreover, the spatial dynamics of post-apartheid Cape Town meant that the poorest parts of the population are located in extremely dense informal settlements with a history of disinvestment in infrastructure. Logic dictates more water will be consumed due to higher household density and dilapidated infrastructure prone to bursts and leaks (Smith, 2004). An unconstrained water demand placed pressure on both the quality and availability of water resources within the WCWSS, as well as the infrastructure network mediating these resource flows (Winter, 2010). This tension required the development of water resource management interventions.

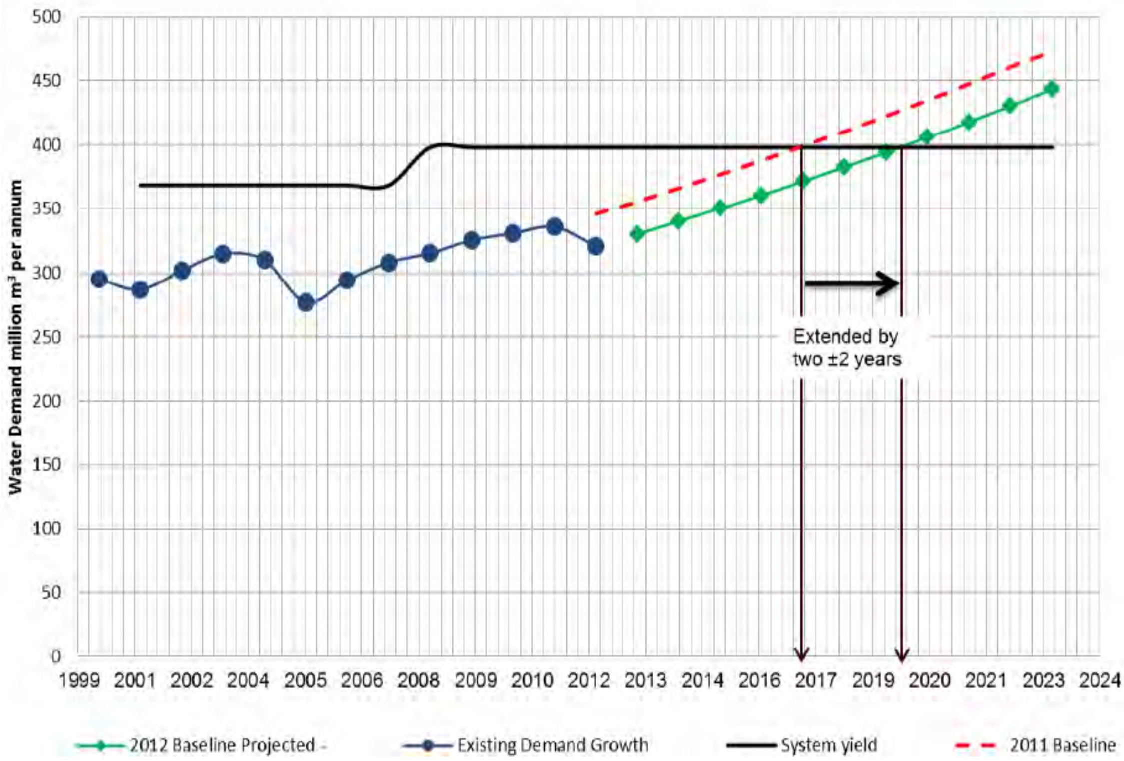

Figure 6.7: Cape Town's water demand trajectory compared to availability
Source: CCT (2013c)

6.4.3 Water resource management interventions

Recurring drought conditions between 1999 and 2005 highlighted the inherent vulnerabilities of Cape Town's water supply, leading to a shift in how water resource management has been perceived by the W&S Department. Initially, the implementation of water restrictions applied during drought periods coupled with a series of awareness campaigns decreased water demand significantly (Winter, 2010). Water restrictions, however, do not change behaviour in the long term; rather, as was seen in Cape Town, consumers respond to restrictions in the short term but consumption rates return to original levels as soon as restrictions are lifted (Winter, 2010). To address the challenges in a systemic way, two fundamental strategic changes were made.

Firstly, to address the unsustainable regressive tariff system, the CCT introduced the stepped tariff that allowed poorer households to benefit from free water and reduced tariffs as long as water consumption was kept below the prescribed minimum (Jaglin, 2008; Swilling & Annecke, 2012). This was a positive step, considering Allen's (2001) dimension of social sustainability, which also encourages higher levels of social justice from an affordability perspective, in that it reduces the burden on poor and marginalised households. Secondly, the *Long Term Water Conservation*[71] *and Water Demand Management*[72] (WC/WDM) *Strategy* was finalised and implemented (CCT, 2007f). Subsequently, WC/WDM has become a central focus of W&S Department as strategy to secure supply in the short-term. The WC/WDM Strategy is designed to achieve a balance between water resources available and water demand. "Interventions are typically low in cost with little logistical effort intended to reduce both water demand and non-revenue losses[73]" (Basholo, personal interview, 2013 October 31). Free basic water is a component of non-revenue and will be elaborated on in section 6.4.4. The droughts:

> prompted the need to focus on saving water, and minimisation of water wastage and losses…. The long term WDM strategy was born … it highlighted strategies, key projects and plans ... [to reduce] water losses, waste and misuse and … manage it (Mackay, personal interview, 2014 September 17).

The publishing of the WC/WDM strategy in 2007 can be considered as a concrete shift in the CCT's approach to managing finite water resources. Both hard (technical) and soft

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[71] Water Conservation is the minimisation of loss or waste, with emphasis on care and protection of water resources and the efficient and effective use of water (CCT, 2007f).
[72] Water Demand Management is the adoption and implementation of a strategy that seeks to influence the water demand and usage in order to realise greater economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability (CCT, 2007f).
[73] Non-revenue water consists of unaccounted for water (UAW) and unbilled authorised consumption (free basic water).

(awareness and education) interventions are used to delay the need for augmentation. Soft interventions are directed towards schools and other public facilities with a focus on training and raising awareness of the importance of water efficiency. These are considered interventions that promote WC. In addition, a range of hard or technical interventions, considered as WDM interventions, have been implemented. The installation of water demand management devices help customers determine a level of consumption, and thereby manage water bills while improving the CCT's ability to collect revenue and maintain administrative efficiency. This is considered critical for equitable and sustainable service provision, from the perspective of the W&S Department, because it allows residents to monitor their own consumption and not find themselves in debt. The CCT is therefore following the trend, identified by Von Schnitzler (2008), where both the water and electricity sectors encourage the use of PPM as a means to connect the urban poor to networked infrastructure services, as well as disconnect. Disconnection due to a lack of funding or access to credit speaks to "the increasing enclosure of basic necessities" (Von Schnitzler, 2008: 900). This is not the case for wealthy consumers, who consume first via world-class infrastructure, then pay.

The reticulation network accounts for the bulk of water losses as a result of pipe leaks or bursts. So the "most important intervention is an extensive pressure management programme that reduces leaks and bursts, complemented by a pipe replacement" (Basholo, personal interview, 2013 October 31). The Head of the WDM Branch explains:

> [T]he WDM strategy ensures the *sustainability* of water supply to Cape Town. By introducing WDM measures you prolong your investment in … and increase the lifespan of infrastructure. Lower pressure [means] leaks and bursts are fewer … losses are less and non-revenue water reduces. This reduces the need for replacement or rehabilitation (Basholo, personal interview, 2013 October 31, author's emphaisis).

Combined, these interventions have been successful[74] in the reduction of non-revenue generating water demand. In addition to these interventions, progress has been made in the effort to expand treated effluent re-use as part of the WDM Strategy. This is an increasingly important component of the W&S Department's intention to reduce non-revenue water.

[74] There has been significant success with WC/WCM strategies which effected a water demand of 27% less than the unconstrained rate in 2000. That being said, the existing pattern was laughable and completely unsustainable due a combination of structural issues (Swilling & Annecke, 2012). Savings through water leakage reductions equal 13.4 million m^3 water per year or R80 million per year (Meyer et al., 2009).

Approximately, 10 percent of the total annual volume of treated effluent is re-used in Cape Town, of which 35 percent offsets potable water demand (DWA, 2010b). Treated effluent re-use has been on the department's agenda for some time, as confirmed below:

> Treated effluent feasibility studies began in 2003.... The strategy prioritised certain WWTW with [adequate] capacity and a potential demand within the vicinity.... From then treated effluent has been rolled out steadily. The focus is on large users like industry, golf courses and school fields, [while] there are large estate style developments that use treated effluent (Mackay, personal interview, 2014 September 17).

By all indications, there is significant potential for expanding this system to offset the demand for potable water, where water of a lower quality can be utilised for lower quality requirements. This is explicitly proven in the most recent water reconciliation report, focusing on the re-use of treated effluent and the potential to augment water supply in Cape Town (DWA, 2010b). Not only does it make financial sense, it makes environmental sense. However, the dire condition of WWTWs and sewerage reticulation systems hinder the expansion of this network.

The wastewater (or sewer) infrastructure network has two main components, wastewater treatment and wastewater reticulation, which includes the effluent reuse network. The capacity of the WWTW infrastructure in certain areas is dire. Most cause for concern is the sewerage reticulation system, which is operating beyond capacity and prone to breakages (CCT, 2011d). Of 27 WWTWs, 4 are operating at capacity and another 5 are operating beyond the design capacity (CCT, 2011d). Significantly, a wastewater quality compliance assessment[75] indicated that six of the plants have "very poor performance … [and] need targeted intervention toward gradual sustainable improvement" while three of the plants are in a "critical state … [and] need urgent intervention for all aspects of the wastewater services business" (DWA, 2011). Treated effluent of a poor quality is discharged into Cape Town's rivers and estuaries, eventually making its way into the sea, but not before contaminating the natural environment. Therefore, raw water accessed from beyond the city regional boundaries is not returned to the original source (CCT, 2013c).

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[75] The quality of the WWTW, as determined by the DWA Green Drop monitoring system, is poor. The CCT has a municipal green drop score of 86.8% while 11 of the WWTW received Green Drop status during the most recent assessment cycle (DWA, 2011).

WDM interventions, combined, are designed to extend the network lifespan through engineered solutions in the most financially efficient way available. This extends the lifespan of both the network and available water resources, which "may allow the next water resource scheme to be deferred to approximately 2029" (CCT, 2013c: 19). Reducing water demand is a critical aspect of sustainable IWRM. But it also reduces sustainability to a set of efficiency-related issues, which are inadequate for systemic transitions toward more sustainable urban infrastructure configurations. While demand-side interventions are focused on efficiency gains, supply-side interventions are limited to conventional infrastructure.

Several investigations and pilot studies into supply augmentation have been conducted by the W&S Department, in partnership with the DWA, to determine the potential future water resource mix. These include additional surface water schemes, treated effluent reuse, groundwater exploitation and the desalination of sea water (DWAF, 2007). While the intention is to reduce the reliance on surface water and diversify the resource mix, there is a lack of attention to the long-term sustainability transition of the water system. The Director of the W&S Department states:

> [A]s an engineer, I am naturally excited about many of the **large infrastructure build** projects we have on the horizon – an example is a R1.7 billion bulk water supply scheme including the new 500Ml/d water treatment works, two 300Ml reservoirs and large diameter pipeline from the Berg River Dam, which will be constructed over the next eight years … beyond [conventional bulk water supply schemes], we are looking at new technologies to supply water, and it is interesting to be breaking new ground for Cape Town in studies looking at large scale groundwater abstraction, water reclamation for non-potable and potable use, and the desalination of sea water (Flower, 2014, author's emphasis).

The cost of these large infrastructure projects as augmentation schemes, which align with conventional infrastructure and, potentially, the efficiency discursive frame, limits the options for investment in more sustainable urban infrastructure. Not only are the escalating maintenance costs placing pressure on water and sanitation tariffs, but as augmentation schemes become a greater priority over the next several years, the capital requirement will increase while tariffs will again be reviewed and increased to cover the cost of augmentation (CCT, 2013d). Consumers will be locked into the same consumption patterns for the lifespan of these "large infrastructure build projects" (Flower, 2014). An official from the WDM Branch explains the department's perspective:

> Cape Town is growing and developing, like it or not, there is going to be new industry and commercial users. With our current water we can supply but until when? We don't want to wake up one day and say we never thought about building a dam. Your look onto the whole thing must be open-minded. We understand the benefits of having a dam. It's not a matter of if we need it, but rather when do we need it (Mackay, personal interview, 2014 September 17).

Even though reference is made to the potential efficiency gains of alternative technologies, "WDM ... is a new concept, [and shifting] from the old hydraulic mission of the old engineers that we need to build more dams and bigger infrastructure to a more water efficient ... approach, doesn't happen overnight" (Siyengo, personal interview, 2014 September 17). The most probable scheme, to ensure security of supply by 2019, "in the order of economic priority is the raising of Voëlvlei dam (DWA), wastewater reclamation, groundwater (TMG Aquifer) and desalination" (CCT, 2013c: 39). Groundwater harvesting and water reclamation have however been a low-priority agenda for at least the past decade and have gained little traction within the department. Moreover, underpinning the logic of the department is the recognition of Cape Town as a developing city and therefore the provision of modern infrastructure is an important component of how the CCT markets the city as an investment destination.

Combined, interventions have significantly contributed to reducing water demand, offsetting the urgent need for augmentation that was arising in early 2000. Since the implementation of the WC/WDM Strategy in 2007, significant savings have been accrued through pressure management, which reduces non-revenue water, and the reuse of treated effluent. Moreover, together these interventions demonstrate a shift toward more integrated responses, outlined in the WC/WDM strategy compared to the traditional short-term intervention through water restrictions. However, it is evident that the W&S Department prefers conventional practice, and interventions are in response to short and medium-term priorities of demand reduction. This is counter-intuitive, considering the operating budget is almost entirely self-funded and heavily reliant on cost-recovery, accrued through the increase in tariffs and decrease in non-revenue water[76]. The more efficiency gains increase and non-revenue water decreases, the

[76] Pressure management has been effectively used to reduce water losses in Cape Town. The total savings are approximately 13.4 million m3/yr which represents approximately R80 million/yr @ R6.20 per m3 (Approximately USD 8 million/yr) (Meyer, Engelbrecht & Wright, 2009).

less capacity the department has to accrue savings in this way. As the population continues to increase and Cape Town experiences economic growth, so the demand for water increases. The longer-term challenges of water supply are therefore likely to be addressed by conventional technologies. Supply augmentation is inevitable (Rhode, personal interview, 2013 November 4) and therefore so is the adjoining expensive capital infrastructure investment. The fiscal constraints rather than sustainability imperatives will drive interventions. This has implications for the financial sustainability of this service which exacerbates the department's need to constantly make trade-offs between network expansion, maintenance and/or rehabilitation, depending on priorities; either technical or political:

> Across the departments, the priority of rehabilitation lies with the technocrats and officials responsible for operations and maintenance, but the priority of network expansion generally lies with the politicians and councillors (Palmer, personal interview, 2014 January 15).

Capital is accumulated through national grants and subsidies as well as external loans. "The CCT's ability to raise funds has improved, and [the] high credit rating allows us to get more loan funding" (Rodkin, personal interview, 2013 October 13), which is complemented by the fact that the CCT is "generally well-functioning and wealthy based on its user charge collections rate" (Coetzee, personal interview, 2012 October 4). The financial planning is structured to be relatively forward looking, balancing service provision, maintenance and cost recovery over a three year budget cycle coupled with a ten year budget, outlined in the master plan, which provides cushioning for additional required expenditures (Koldeweij, 2013). However, "operating budget allocation is made on a priority basis, [significantly only] allocating funds as it becomes affordable using the Asset Management Plan (AMP) as a guide" (Saayman, 2013b). There is clearly a gap between what is planned and what is implementable, and the system is remedially driven. Budget constraints impact the ability of the department to address requirements set out in the AMP adequately. When a part of the system is not deemed a priority, "alternative solutions, like pressure management, are used instead of pipe replacements. In this way [the W&S Department] can prioritise select areas where the infrastructure has really given up" (Basholo, personal interview, 2013 October 31).

Overall, during interviews, little to no attention was paid to the socio-economic factors associated with the delivery of sustainable urban infrastructure and its link to consumption patterns. Significantly, Koldeweij (2013) finds that although WDM management policies are an important component of broader strategic plans for the CCT, little attention is given to the broader consumption trends over the past century, and what accounts for the variances in water consumption. In other words, in the residential water use sector, the links between household membership, income and the price-elasticity of water, and consumption have not been sufficiently explored. This is a major concern, considering the W&S Department is relying on WDM to provide services by reallocating inefficient existing capacity to new consumers (CCT, 2007f).

6.4.4 Services levels and consumption variances

Water consumption trends by sector have, for the past several years, been much the same with some minor variances in the percentage allocations. Residential users account for the largest proportion of water consumption, approximately 50 percent. Non-revenue water, consisting of unaccounted for water[77] (UAW) and unbilled authorised consumption (free basic water[78]), accounts for approximately 20 percent of the water demand in Cape Town. Figure 6.8 is a representation of water consumption by sector in Cape Town. Within the residential consumption category, there is a significant disparity across socio-economic groups.

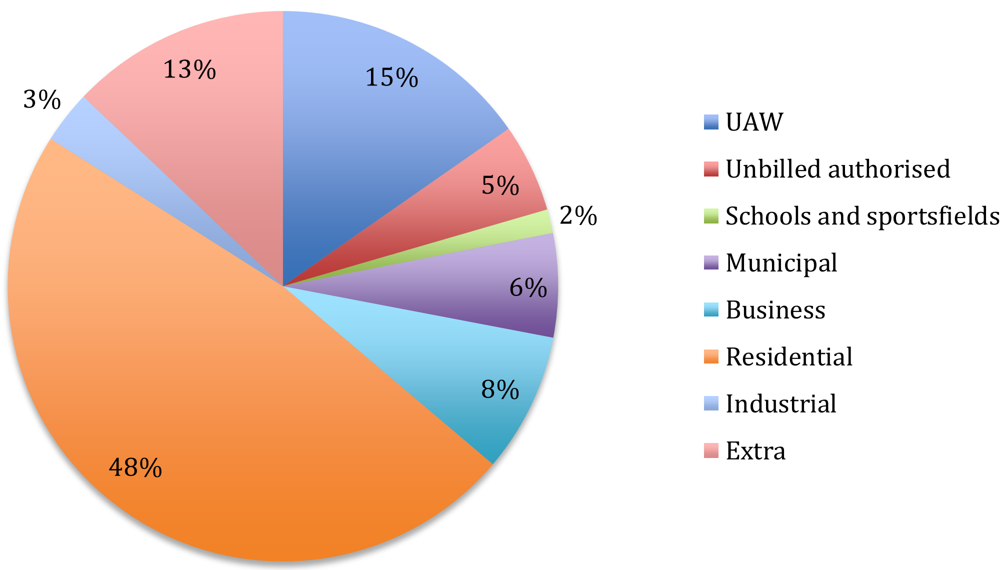

Figure 6.8: Water consumption by sector in Cape Town
Source: CCT (2013d: 33)

[77] UAW is water that enters the system but is lost somewhere along the way due to leaks, breakages or burst mains, collectively called 'technical' losses.
[78] The Water Services Act (Water Services Act 108 of 1997, 1997) stipulates 25 litres of potable water per person per day must be supplied.

Although the CCT actively draws attention to its success in the delivery of basic services, boasting universal coverage, the results of the most recent census tell a different story. *Access to services* is a relative term, because of how *access to services* is defined and the fluctuation in the number of informal households. Table 6.3 reveals the plight of informal households and backyard informal households who are the recipients of basic, generally communal services. While services may be delivered, the condition and quality of that service cannot only be determined in quantitative terms, i.e. the number of facilities delivered. According to the CCT, communal public services have "high maintenance costs due to [necessary] frequent cleaning and repair or replacement due to vandalism [and theft]" (CCT, 2011d: 68). Moreover, there is a general reluctance to invest in informal settlements, which are perceived by some CCT officials to be temporary rather than a permanent feature of the urban landscape, which partly accounts for the dire state. The conditions of sanitation services in informal areas are elucidated by findings of two social audits[79] conducted by the Social Justice Coalition (SJC). It appears that the absence of sufficient budget to ensure the routine monitoring, cleaning and repairs of communal sanitation facilities accounts for the ongoing sanitation crisis in informal settlements (Silber, 2011; Robins, 2014). "Using a toilet is the most dangerous activity for people living in an informal settlement", infringing on both the health and safety of communities (SJC, 2013: 7). Communal services are too few, inadequate, unhygienic and undignified.

Table 6.3: Comparison between National and CCT basic service standards

	National Standard	**City of Cape Town Standard**
Water	A basic water supply facility within 200m of dwelling, delivering at least 25 *l*/person/day at a minimum flow of 10 *l*/min in the case of communal water points, or 6 000 litres of water per month per formal connection (in the case of yard or house connections).	Ditto but with an added minimum specification of at least 1 tap per 25 households and communal stand must be within 100 metres of a household[80].

[79] A social audit is a tool used to measure and report on funds allocated to benefit a particular community. The intention is to increase transparency and accountability of local government while including the voice of the intended beneificaries of funds and services (SJC, 2013).

[80] However, the national census data does not reflect the additional provisions provided by the CCT.

	National Standard	City of Cape Town Standard
Sanitation	Easy access to a safe, reliable, private toilet facility which is protected from the weather, ventilated, low smell, hygienic, minimises the risk of spreading diseases and enables safe treatment and/or removal of human waste and wastewater in an environmentally sound manner including communicating hygiene.	Ditto but with an added minimum specification of at least 1 toilet per 5 households.

Source: CCT (2011d: 63)

Formal households have access to metered, uncontrolled water, connected to the house or to a yard water tap. This amounts to 75 percent of total households in Cape Town. Just over 88 percent of households are connected to a networked water-borne sanitation system, i.e. flush toilet[81] (plus 2 percent who have a flush toilet with septic tank) (CCT, 2012a). The remaining households are serviced with a variety of sanitation technologies (CCT, 2012f) as summarised in Table 6.4. Informal settlements are largely serviced by communal standpipes, arranged so that 1 standpipe serves 25 households, and a total of 15.2 percent of households are serviced in this way (CCT, 2011d). However, inadequate drainage around standpipes results in significant health risks associated with stagnant grey water. It is the norm that informal or low income households consume just over the amount allocated as FBS; on average between 25 to 32 litres per capita per day (CCT, 2013d). WDM devices and prepaid meters ensure the quantity of supply while enabling the CCT to decrease non-revenue water. This is compared to formal households, who consume over four times more water than those living in informal settlements; in 2012 the average was 145 litres per capita per day (CCT, 2013d). This is a clear illustration of the water consumption disparities in Cape Town, summarised in Table 6.4. The more severe sanitation backlog is evident, as explained below:

[81] This is not to suggest that the researcher promotes the idea that all informal households must necessarily be connected to the existing network. There are numerous technologies available to connect these households to dignified, decentralised sustainable sanitation systems (see Pan, 2011). However, it does illustrate the disparities across socio-economic classes.

> The total capital requirement over the next 5 years from 2010/11 to 2015/16 to primarily cover sanitation backlog eradication is estimated at R432.5 million [as increase from R236 million over the 2009/10 to 2013/2014 period] allowing for a 5 percent household growth. Part of the funding is also required for the replacement of black buckets as well as to cater for additional service demand growth in informal settlements due to the influx of people. R12.8M is required to resolve the water backlog and provide for the anticipated growth in demand (CCT, 2011d: 9).

Low-income households, who consume the least water, are expected to increase their consumption as economic growth and development continue, while high consumers are expected to decrease consumption, as the combination of efficiencies and behaviour change begins to become more common. Although efficiency improvements have become evident in Cape Town, consumption for the low income and indigent population has not increased to an adequate level. The manager of one reticulation catchment area explains that there are political and social challenges associated with service delivery:

> There are huge challenges in informal settlements. The levels of services [the CCT] provides are … statutory. People are expecting higher levels but we cannot [deliver] because there are statutory [stipulations] that prevent us from doing so (Rodkin, personal interview, 2013 October 13).

The SJC however argues that despite statutory stipulations, statutory obligations are not being met by the CCT (SJC, 2011). There are negative social consequences as a result. The Mayoral Committee Member for Utility Services, Councillor Ernest Sonnenberg claims that in informal settlements, the ratio of toilet to household is 1:3.2 (CCT, 2015). But, as represented in Table 6.5, combined, more than 125 000 households do not have access to decent toilet facilities, which translates to almost 500 000 people. The 2011 *Toilet Wars*[82] (Robins, 2014), revealed the shocking and dire sanitation conditions in informal settlements, where it is not uncommon for more than 100 households to share one communal facility (Silber, 2011). Evidence of these conditions is described in the *Khayelitsha 'Mashengu' (chemical) Toilet*

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[82] During South Africa's 2011 local government elections, images of open toilets and accompanying inadqaute sanitation facilities were rampantly distributed across a multiplicity of media and social media platforms. This became the narrative of the election, highlighting the limits of the incumbent model used to realise the envisioned democratic transtion. These debates around social injustices, 20 years after apartheid, were reported as the Toilet Elections and Toilet Wars in the media (Robins, 2014).

Social Audit (SJC, 2013). This audit reports that although the CCT paid a private service provider, through a service delivery agreement to **deliver** and **maintain** 346 temporary chemical toilets, 25 percent of these were missing. Of those identified on site, 68 percent were damaged and 54 percent were in an unusable condition (SJC, 2013). The SJC has played a central role in using the sanitation crisis, represented as the Toilet Wars, as a window of opportunity to gain political support for critical maintenance and management of crumbling sanitation facilities, described as "an assault on the dignity of … [poor, powerless] South Africans" (Robins, 2014: 498).

The type and number of installed sanitation facilities in informal settlements is detailed in Table 6.6. The chapter now turns to how the SJC has situated itself as social movement that facilitates engagement between civil society and local government about an extremely political and personal issue: the right to relieve yourself in a dignified manner. Through this lens it is possible view the overarching arena of contestation around informal settlements.

Table 6.4: Access to water and toilet facilities in Cape Town

Access to Piped Water	No hh	%	Access to Toilet facility	No Hh	%
Piped water inside yard	801744	12.3%	Bucket system	48510	4.5%
Piped water outside yard: <200m	99770	9.3%	Chemical toilet	12341	1.2%
Piped water outside yard: >200m	130952	2.7%	Pit toilet	4122	0.4%
No access to piped water	7218	0.7%	Other	10699	1.0%
			No access to toilet facility	29068	2.7%

Source: CCT (2012a: 13)

Table 6.5: Per capita consumption of domestic water in Cape Town

Level of Service	Consumers	Av pop. per stand	Total pop	*l*/capita/day	Total M*l*/day
Informal- inadequate	27655	6	165930	25	4.15
Informal- basic	1108	6	6648	25	0.17
Informal- intermediate	68640	6	411840	32	8.91
Informal- full	46420	6	278520	32	8.91
Formal- full	924748	3	2877087	153.67	442.11
Total	**1068572**		**3740025**		**468.52**

Source: CCT (2013d: 37)

Table 6.6: Basic sanitation technologies installed and informal households serviced (June 2013)

Type of toilet facility	No. of toilets	% of total toilets	Service Ration	No. houses serviced
Chemical	5129	12.73%	5	25645
Container	4223	10.48%	5	21115
Bucket	957	2.38%	1	958
Porta-potti	17834	44.26%	1	17834
Full flush	10620	26.35%	5	53100
Other	1532	3.8%		5551
Total	**40296**			**124203**

Source: CCT (2013c: 35)

The SJC is a member-based organisation comprising civil society organisations in Khayelitsha, an informal settlement in Cape Town – home to approximately 700 000 people (SJC, 2011). The SJC, since its inception in 2008, has persistently lobbied the CCT to meet the basic human rights of citizens enshrined in the constitution, and brought the issues of sanitation to the fore through the Clean and Safe Sanitation Campaign (CSSC) in 2010. "Informal settlements are viewed as temporary … [which] underlies a lot of the reason for a lack of planning and resources" (Kramer, personal interview, 2015 July 3). The main concern was articulated as the lack of financial resources to ensure the maintenance, monitoring and cleaning of communal sanitation facilities in informal settlements, many of which had fallen into disrepair. Through a combination of public protests, prevalent during the first year of the campaign and culminating in the Toilet Wars, active citizenship, political engagement, political lobbying supported by scientific and academic research as well as real-life testimonials, the SJC exerted enough pressure on the CCT to be awarded an audience with the the CCT Mayor Alderman Patricia De Lille and other senior managers. After a series of consultations, culminating at a sanitation summit hosted by the SJC in September 2011, the CCT, and specifically the mayor, agreed to consider the inclusion of a Janitorial Service for informal settlements to address challenges identified by the SJC (CCT, 2012g). This was after the CCT realised that service delivery does not automatically equate to access to adequate and dignified services, also proving that the particular configuration of a socio-technical system can undermine developmental efforts. This is extremely pertinent to the endeavour to understand the prospects and relevance of sustainable urban infrastructure in middle-income cities such of Cape Town.

Soon thereafter, the CCT Mayor announced the allocation of financial resources for the implementation of a daily Janitorial Service in informal settlements, proudly introducing the initiative as a first for South Africa (CCT, 2012g). In the mayor's words:

> "the service includes the daily cleaning of flush toilets, standpipes and surrounding areas, doing minor repairs of flush toilets and reporting all instances where more extensive repairs are needed … The introduction of the janitorial service came about as a result of discussions between the City and the Social Justice Coalition. **Through mutual co-operation and a genuine desire to improve service delivery, an innovative and practical initiative has been found**. The City will continue to engage with civil society and community organizations that are willing to assist in finding solutions that benefit all residents of Cape Town (CCT, 2012g:1, author's emphasis)

Signalled by the "budget allocation, [which] goes to the heart of where priorities lie ... [and] to the heart of how things can be dealt with and change" (Kramer, personal interview, 2015 July 3), the announcement of a Janitorial Service can be considered a major victory in the effort to improve living conditions in informal settlements, representing a shift in the CCT's approach to sanitation. It reflects how through sustained activism, engagement and deliberation a positive outcome can be realised, that promotes engagement between local government and civil society while at the same time giving a voice to the marginalised. Furthermore, the CCT's willingness to engage on these types of important issues though partnership opens up opportunities for future engagement (Overy, 2013).

Positive gains were not long lived. Despite a commitment from the CCT and the mayor to develop a plan for the roll-out and implementation of the Janitorial Service, no such plan or policy was provided (SJC, 2014). The SJC argues that the provision of a policy document and operational plan would support the effective roll-out and implementation of the service (SJC, 2014). Without such alignment from an institutional perspective, the intervention remains a poorly conceived techno-fix. This provides further evidence of the CCT's lack of willingness to plan appropriately in informal settlements. Indeed, there is an implicit reluctance to planning and, as a result, interventions "are all done haphazardly to manage crisis, and are now failing" (Kramer, personal interview, 2015 July 3).

Indeed, the results of the social audit of the Janitorial Service for Communal Flush Toilets in Khayelitsha, *Our Toilets are Dirty* (SJC, 2014), are illustrative of the fact that the service has been poorly managed and is largely ineffective. The second social audit reports that (i) the quality of the service is extremely poor, toilets are serviced irregularly and many toilets are locked, limiting access; (ii) the maintenance is inadequate, as minor faults are not fixed and major fault not reported; and (iii) systems are ineffective and equipment inadequate, which hinders ability to provide services and affects the health and safety of janitors (SJC, 2014). In this way the issue of the right to sanitation has been reduced to a technical problem of removing human waste, distorting the issue of social justice, by which everyone has equal right to dignified and healthy living conditions.

On the other hand, the CCT believes that the failure is due to:

> Ongoing disagreement in the community about recruitment, which results in failure to recruit janitors, lack of support from community leaders, excessive vandalism from community leaders, threats to the safety of CCT staff hampering monitoring of the services, [and] faults not being reported immediately by janitorial workers (CCT, 2015)

Where the city blames vandalism, the community blames inadequate planning and sustained budget allocation. The détente since the Toilet Wars, between the CCT and the SJC, supported by community members has broken and opportunities for future collaboration is now in jeopardy. The programme has already been scaled back and budget allocations are already being diverted back into established expenditure cycles (CCT, 2015). The competing evidence provided by the CCT and the SJC has created a highly contested and political set of circumstances that now informs the narrative of communal water and sanitation services in Cape Town. That being said, the lessons are clear. There is significant value in activating this kind of community participation process that empowers community members to engage critically with government decisions delivered in a top-down fashion, rather than being passive recipients (Overy, 2013). Herein lies the SJC's theory of change (Overy, 2013). The question that remains unanswered is how this process could have effected the configuration of sustainable urban infrastructure that supports the attainment of higher levels of social justice aligned with the restoration of ecological systems. In other words, whether it could concieveably be configured to enable access to fulfil a socio-economic right while ensuring affordability in a way that would enhance livelihood strategies through the provision and modalities of service delivery. Implementing the Janitorial Service successfully is considered to be a *more* sustainable infrastructure configuration because it speaks directly to the issue of inclusive service delivery by offering access to a safe, clean and dignified sanitation system. If the socio-technical system is configured and delivered appropriately the quality of this system can be equated to the quality of conventional sanitation, albeit a different standard. Yet this alternative configuration does not rely on an unsustainable, large technical conventional system mired by inefficiencies. The benefits of transitioning to an alternative configuration were introduced in chapter 2 and section 6.3 of this chapter. Cape Town is a not only balancing precariously on socio-economic tight rope, but is located within water scarce region. These factors must be taken into account when considering the backlog in service delivery and the future configuration of networked infrastructure - this is applicable to all services.

6.4.5 Section Summary

Significantly, the W&S Department has not interrogated what sustainable urban infrastructure might mean to how operations are managed and how substantial capital investments are made. Not only does the roll out of the Janitorial Service process illustrate this but, according to current planning, long-term issues of water scarcity are to be resolved using conventional practice, despite the changing climatic conditions. Futhermore, the existing model of service delivery is determined by the existing networked infrastructure system, which is reinforced on a daily basis. The presence of the WC/WDM Strategy has taken the place of *sustainability* as an imperative in and of itself; and considering how the notion of sustainability is framed by the WC/WDM, the conclusions drawn about sustainable water resource management are ineviatable:

> The current limited water resources threaten the sustainability of Water Services in Cape Town. WC/WDM can extend the assurance of supply of the existing water resources and go a long way in reconciling future demand and supply (CCT, 2007f:19).

There is a lack of comprehension of the overarching, interrelated challenges of sustainable water and sanitation service provision in the present context, while the notion of sustainable urban infrastructure is absent from internal planning and strategy documents as well as a frame of reference for officials interviewed. No coherent departmental vision emerged during the fieldwork. While ‘what’ system vulnerabilities are present within the system seem to be fairly well known and commented on, there is less of a understanding of ‘how’ these vulnerabilities may affect Cape Town, and no attention is paid to the consequences in the broader socio-economic sense.

The W&S Department has two key objectives: firstly, compliance with national standards, and secondly, the provision of world class services to middle and high-income customers while low income consumers are forced to use poorly constructed and maintained facilities, originally designed to be a temporary solution for temporary settlements. In this way, the available capacity is focused on realising stipulated targets while little attention is paid to thoroughly conceptualising and framing *what* sustainable urban infrastructure could mean for the CCT beyond the obligation to extend access and ensure maintenance of the central network. There is a general reluctance to recognise that informal settlements will be a relatively permanent feature of the urban landscape, thus limiting necessary routine and consistent investment in informal settlements. The role of external pressure in the delivery of services, and thereby access in urban socio-economic metabolic flows, via community organsations and social movements is revealed here as an important condition for sustainable urban transitions.

6.5 Conclusion

This chapter introduced two departments in the Utilities Directorate, the ES Department and the W&S Department. The brief overview and analysis offered an introduction to the status quo, with specific reference to the supply and demand for services, the nature of service delivery and the state of the infrastructure network, while weaving through a narrative that speaks to the dynamic institutional culture that structure activities. In each of the cases it is evident that during the period under analysis the departments contended with supply pressures, with specific moments of crisis emerging that demonstrate the inappropriateness of the incumbent service delivery model. How each of these departments has responded to these moments of crisis is pertinent as it is demonstrative of the prospects and relevance of sustainable urban infrastructure for the case context.

The next chapter explores these dynamics in more detail through an in-depth description of the SWM Department in an effort to answer the research questions. The analysis presented in Chapter 8 will look across the cases and extract generalisable conclusions in an effort to address and respond to the research questions outlined in Chapter 1.

7. Solid Waste Mangement

This chapter provides an in-depth case study of the Solid Waste Management (SWM) Department. The previous chapter provided an overview of the ES Department and the W&S Department. Insights provided in that overview become more explicit in this chapter, while it also offers empirical evidence for the arguments made in the analysis provided in Chapter 8. This chapter starts with an introduction to sustainable waste management practices, which is followed by an introduction to the CCT SWM Department. The chapter unpacks the status quo of, and current approach to SWM in Cape Town with an eye on the technical, financial and institutional flows that underpin the reproduction of the system. The intention is to demonstrate how processes within the SWM Department are illustrative of a transition to a more sustainable delivery approach. It focuses on the period since the establishment of the Cape Town Metropolitan in 2000, until 2012. It also demonstrates the obstacles and resulting inertia that the department contends with. The causes of the inertia offer insight into the prospects for the institutional uptake and embedding of more sustainable urban infrastructure. The evidence assists in achieving the overarching goal of this research, namely to understand the relevance of growing sustainable urban infrastructure literature and policy discourse in a middle-income city like Cape Town.

Competing forces within the institutional arrangements, that on the one hand enable change and on the other resist change, are revealed in this analysis. Using the conceptual frame developed in Chapters 2 and 3 to unpack this tension, this chapter illustrates the presence of capability within the department that renders itself open to innovation for systemic socio-technical change. In the search for evidence to answer the research questions, a key part of the research was to identify where (relative) innovation within the department is present. More importantly, to identify if innovators are able to make their agenda mainstream within the organisation and in this way adopt a new way of doing things, to re-orientate the organisation for a paradigmatic shift onto a more sustainable development trajectory by adopting a new service delivery model.

7.1 Introducing sustainable solid waste management practices

The implementation of sustainable SWM infrastucture network is a vital component for overall urban sustainability. The quantity of waste produced in cities has increased significantly, in parallel to urbanisation, industrialisation and a consequential increase in income, associated with an increase in consumption (Hoornweg & Bhada-Tata, 2012). Conventional waste disposal systems are based on the premise that waste is a negative externality, reducing the system to a number of separate parts. It relies on a vast network of roads, specialised transport vehicles, waste transfer stations, incineration facilities and landfill sites (Chalmin & Gaillochet, 2009). Disposal of waste at landfill is responsible for significant GHG[83] emissions as well as downstream pollution with substantial negative ecological implications (UN-Habitat, 2010b).

Low collection rates and uncontrolled landfilling is common in developing cities of the global south, where high-density, low-income informal settlements are a common phenomenon (UNEP, 2011). Factors that contribute to the inadequacy of conventional SWM practises in these contexts include steep, narrow and unsurfaced roads that are inaccessible to conventional collection vehicles, which are commonly used regardless of their general inadequacy, and limited space and number of refuse storage containers (Marshall & Farahbakhsh, 2013). Invariably, refuse is dumped at inapproriate locations, resulting in negative ecological and health externalities.

As a means to address the challenges of conventional SWM in both formal and informal settlements, Integrated Solid Waste Management (ISWM) has been introduced. ISWM is a holistic approach and the alternative to the modern understanding of solid waste, which is viewed as a technical problem and seeks to identify an engineered, technical solution (Van de Klundert & Anschutz in Marshall and Farahbakhsh, 2013). ISWM is an integrated management approach that takes into account the various stakeholders, technical components, socio-institutional dynamics, and environmental concerns with the objective of realising a balance between environmental improvements, economic efficiency and social acceptability (Thomas & McDougall, 2005). In this way ISWM, importantly, recognises SWM as a socio-technical system and ongoing process that is context specific. The best system for a particular context will be locally determined (McDougall et al., 2008). Joos et al., (1999) show that while the technical and economic aspects of SWM are important, the role of public acceptance and participation, and consumer behaviour are equally important.

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[83] The impact of methane (CH_4) released from landfill sites is up to 20 times greater than that of CO_2 (UN-Habitat, 2010b).

The most important aspect of resolving the challenge of waste disposal in the future is avoidance through the redesign of products and changing patterns of production and consumption. This decreases the need for virgin materials while reducing the associated harmful emissions generated through production, eventual collection and disposal processes (Hoornweg & Bhada-Tata, 2012). Solid waste as a by-product of socio-economic activities is however inevitable, and many of the interventions are beyond the ambit of control of municipalities and local governments in the global south. How local authorities respond to and manage solid waste production is therefore the focus here. The technology used for SWM needs to be configured to minimise environmental impacts associated with those aspects which contribute most to GHG emissions and other negative externalities; specifically the organic fraction of waste, collection vehicles that collect waste across vast urban spaces and the configuration of disposal methods.

The recongifuration of conventional disposal practices, such as landfilling, has become possible through a series of breakthroughs in technologies for collection, reprocessing, and extracting organic waste, mineral and materials, while technologies for harnessing energy from organic waste and gas-capturing from landfills have advanced substantially (Bogner et al., 2007; UNEP, 2011). However, failing to completely separate waste streams at their source, especially organic from inorganic (which is then categorised further, depending on composition characteristics), significantly reduces the capacity for successful sustainable waste management (McDougall et al., 2008). Consequenlty, sustainable waste management is impossible without large-scale public buy-in. Moreover, the technological application is highly contextualised and therefore depends on the local, regional and national drivers of waste management and GHG mitigation (Bogner et al., 2007).

There is a range of technologies that accompany these interventions that enable more sustainable socio-economic metabolic flows, including: starting with the separation at source for material recovery and recycling; accumulation of bio-waste for composting; bio-waste accumulation for anaerobic digestion and waste-to-energy conversion; capturing methane gas for energy generation or flaring; and controlled incineration for energy conversion. SWM interventions[84] are purposely described in brief, because of the contextual nature of ISWM. Evidence does suggest that there is no perfect combination of interventions that will yield a

[84] For a comprehensive overview of the various ISWM interventions options and technologies see McDougall et al. (2008).

desired sustainability imperative aspired to by all cities (McDougall et al., 2008; Marshall & Farahbakhsh, 2013; Thomas & McDougall, 2005).

This chapter seeks to determine what the ISWM policy agenda means for a city like Cape Town. The SWM Department is faced with a number of challenges, but what is interesting for the purpose of this research is how it has responded to these challenges.

7.2 Solid waste management in the CCT

SWM in Cape Town is an interesting case study for closer examination when enquiring about the prospects and relevance of sustainable urban infrastructure in middle-income cities of the global south. Considering the conceptual frame describing the discursive domains developed in Chapter 2, the CCT SWM Department demonstrates potential for a transition from an unsustainable SWM system toward a more sustainable urban infrastructure system. Generally, there has been a shift in the way solid waste is perceived, understood and managed within the department from before the amalgamation in 2000. This is particularly reflected in the policy framework. Prior to the amalgamation, environmental problems were considered to be disconnected from local SWM practices (Ferrara et al., 2008). Historically, municipalities referenced in Chapter 5, which now make up the CCT, used both formal and informal SWM procedures such as uncontrolled incineration and illegal open air dumping, resulting in numerous uncontrolled landfills, the effects of which the Disposal Branch are still dealing with (Naude, personal interview, 2013, November 28). But the SWM Department effectively manages waste collection and disposal with sophisticated technical efficiency aligned with a well-constructed legislative framework for waste management in South Africa.

7.3 Solid waste specific policy framework

The South African national government provides the policy and legislative framework for SWM that meets the conditions laid out in the Constitution of South Africa, Act 108 of 1996 (RSA, 1996). The overarching national legislation is described in the Constitution, wherein Section 24 of the Bill of Rights states that:

> Everyone has the right –
> a) to an environment that is not harmful to their health or well-being; and
> b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-

i) prevent pollution and ecological degradation;

ii) promote conservation; and

iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development (RSA, 1996).

The Local Government Municipal Systems Act (MSA) (*MSA 32 of 2000*, 2000) and Municipal Finance Management Act (MFMA) (*MFMA 56 of 2003,* 2003) frame and dictate the statutory obligations of local government. In addition to this, a list of sustainability-related policies and strategic frameworks provide the legislative parameters for the SWM Department. The plethora of waste-specific policies in the national, provincial and local sphere demonstrates the increasing awareness for appropriate SWM processes. This is summarised in Table 7.1. The principles of SWM are captured throughout legislation, policies and plans in various forms.

Table 7.1: Summary of the South African legislative framework for waste management

Legislation, policy/framework, strategy	**Source**
National Government	
Constitution 108 of 1996 – Bill of Rights.	(RSA, 1996: schedule 5b)
DWAF – Waste Management Series: Minimum Requirements (trilogy of policy)	(DWAF, 1998)
Deapartment of Environmental Affairs and Tourism (DEAT): White Paper on Integrated Pollution and Waste Management for South Africa	(DEAT, 2000)
National Waste Summit: Polokwane Declaration	(DEAT, 2001)
National Environmental Management: Waste Act 59 of 2008. [Commonly referred to as NEMWA].	(*National Environmental Management: Waste Act 59 of 2008*, 2009)
National Domestic Waste Collection Standards, under NEMWA.	(DEA, 2009)
National Waste Management Strategy.	(DEA, 2011)
National Environmental Management: Waste Amendement Act 26 of 2014.	(*National Environmental Management: Waste Amendment Act 26 of 2014*, 2014)

Legislation, policy/framework, strategy	Source
Provincial Government	
Western Cape Health Care Waste Management Act 7 of 2007.	(*Western Cape Health Care Waste Management Act 7 of 2007*, 2007)
Western Cape Health Care Waste Management Amendment Act 6 of 2010.	*(Western Cape Health Care Waste Management Amendment Act 6 of 2010,* 2010)
Provincial Integrated Waste Management Plan.	(Department of Environmental Affairs and Development Planning [DEADP], 2012)
Local Government	
Integrated Waste Management [IWM] Policy (MC 08/05/06)	CCT, 2006c
IWM By-law (MC 15/03/09)	(*IWM By-Law* C/15/03/09, 2009)

Although prior to 2008, local governments were responsible for SWM without adequate national support or guidelines, the passing of the NEMWA (*NEMWA 59 of 2008*, 2009) signalled a shift. It stipulates a set of standards that local municipalities have to abide by, based on the principles of *reduce, reuse and recycle*. "The CCT has been proactive in its effort to ensure it is aligned with national legislation to meet its service delivery mandate" (Ladouce, personal interview, 2013, November 28). This will become evident in following sections of this chapter.

7.4 Status quo of solid waste in Cape Town

As the service authority and service regulator, the SWM Department provides services across the metropolitan municipal area. The SWM Department is structured so that branches are individually responsible for cleansing, collections and disposal. Each branch performs a function that requires different skills, technologies and disciplines for the "on-site handling and storage, collection, transfer and transportation, processing and disposal" of solid waste (Mouton, 2013: 9). The CCT has a fairly sophisticated and efficient technical capacity to address issues of waste generation using conventional technology. Technical capacity refers to the ability of the SWM Department to perform its designated function (DEAT, 2007).

Over one million households are serviced either directly by the department or a contracted-in service (CCT, 2012h). All formal households receive a weekly kerbside service from the

Collections Branch, the cost of which is recovered through the collections tariff, revised annually. The tariff for formal households in 2012/13 was R85.21 per month (CCT, 2013e). The flat service charge for solid waste removal for formal households, regardless of income, does not take into account the additional inputs; for example fuel for longer distances in low density, hilly areas where high-income households are generally located in Cape Town. As the cost of delivering services continues to increase, those with less ability to pay bear the greatest burden of inadequate service delivery, while the environment absorbs the cost. In the case of indigent households, determined by the household income threshold, this service is provided free as a basic service enabled by national grants. Informal settlements receive a weekly door-to-door collection and/or general area cleaning services managed by the Area Cleaning Branch (CCT, 2012h) but delivered by the private sector (Overy, 2013). This FBS is delivered at half the cost of formal services, costing approximately R38.40 per month, depending on the number of households and informal settlements present in any given month, including the cost of disposal (Diedericks, personal interview, 2014, September 4). The commerce sector receives a service from the SWM Department or from contracted private sector companies whereas the industrial sector, which produces hazardous or special wastes, is serviced by the private sector only as dictated by policy (*IWM By-Law C/15/03/09*, 2009). The Collections Branch transfers waste either to transfer stations or directly to landfill, both managed by the Disposal Branch. Currently, there are three landfill sites operating in Cape Town: Coastal Park, Visserhok and Bellville South[85] (CCT, 2013f).

Although the service-delivery model is structured to ensure the entire population receives a weekly service, be it in a formal or informal dwelling, the level and type of services are not the same. Informal households are serviced through community-based contracts that run over a three-year period. Households are allocated two blue bags, to be collected once a week, and deposited at communal skips, which are retrofitted shipping containers. The model is based on a system that appoints a supervisor and local workers who collect waste from a number of households within a particular boundary. Within that boundary, contractors are also responsible for street cleaning, picking up litter and the removal of illegally dumped waste. Another contractor then collects the deposited waste and transports it to landfill. However, it is often the case that waste is left uncollected or dumped in the vicinity around the skips (Pan,

[85]The Bellville South site was scheduled to be prematurely closed due to "close proximity to residential areas and the risk of contamination to the underlying Cape Flats aquifer" (Mega-Tech, 2004: 7-120). Because approximately 30 hectares of the site is unlined, however, its operating permit was then extended to 2013.

2011). Similar to the case presented in the case of the W&S Department, "the services are not being adequately monitored … by the CCT's project manager to ensure compliance" (Ladouce, personal interview, 2013, November 28). The resulting environmental pollution is inevitable. So is the contact that residents have with the accumulated waste. "Significant improvement [can be made] by [simply] addressing the underlying systemic issues such as the location … and design of communal skips" (Pan, 2011: 110) and improvements to monitoring and management systems. Yet, "what [SWM Department] has been doing in informal settlements has not changed for years. It's exactly the same" (Diedericks, personal interview, 2014, September 4). Moreover, the CCT is quick to blame the community for bin theft and littering (CCT, 2012c) rather than accept mutual responsibility.

Dominant waste streams in Cape Town include household recyclables, organic and garden waste, other trade waste and builders' rubble (Akhile Consortium, 2011). Table 7.2 provides a summary of the waste streams taken to landfill, while Figure 7.1 and Figure 7.2 depict the mass and volume of the various waste categories. These figures illustrate which categories are the largest culprits in terms of airspace consumption and where minimisation interventions are most needed.

Table 7.2: Composition of waste streams landfilled (mass vs volume)

Category of waste	**Volume**	**Mass (tonnes)**
Builders rubble	10%	22%
Household packaging	21%	15%
Other trade waste	13%	18%
Household greens	21%	6%

Source: Akhile Consortium (2011)

There have been changes in both the SWM Department and the waste sector. Waste disposal per capita increased significantly between 2000 and 2007 as a result of an increase in economic growth, the expansion of the building and demolition industry, population growth rate and accurate record keeping (De Wit, 2009). Moreover, the delivery of services to previously excluded portions of the population, which can be seen as a significant achievement in the delivery of inclusive urban infrastructure and services, increased the amount of waste requiring disposal. Following economic-related market trends and a series of purposive interventions in the form of limited waste recycling initiatives, total solid waste disposed at landfill tapered off towards 2008, as illustrated in Figure 7.3. Therefore, despite the expansion of waste management services, the tonnage of waste disposed of at landfill has decreased.

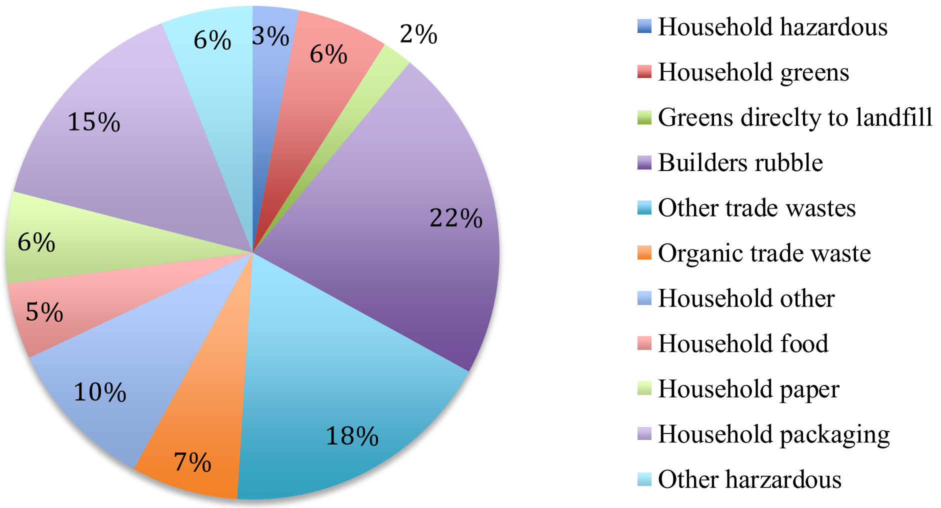

Figure 7.1: Characterisation of waste landfilled in terms of mass (tonnes) (2008/2009)
Source: Adapted from Akhile Consortium (2011)

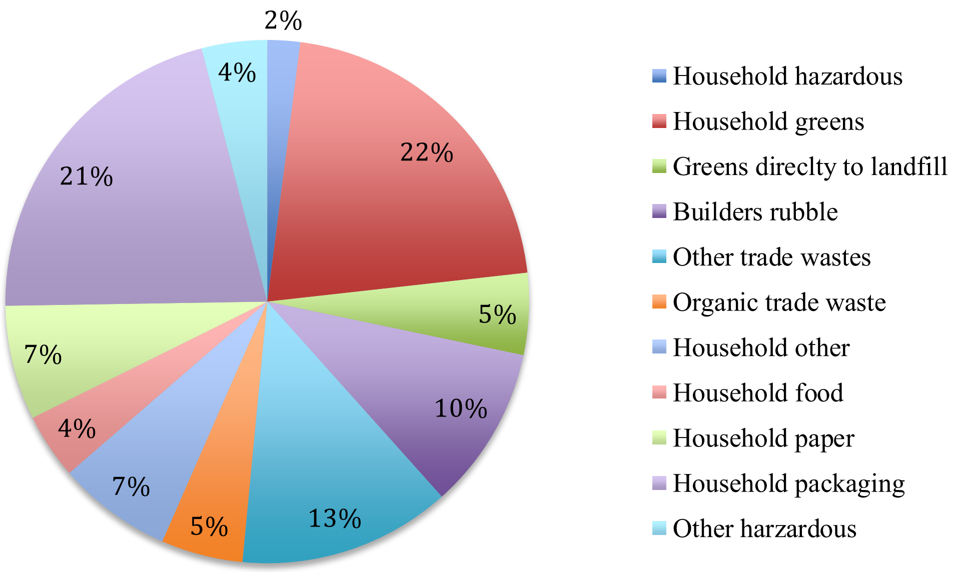

Figure 7.2: Characterisation of waste landfill in terms of volume (m^3) (2008/2009)
Source: Adapted from Akhile Consortium (2011)

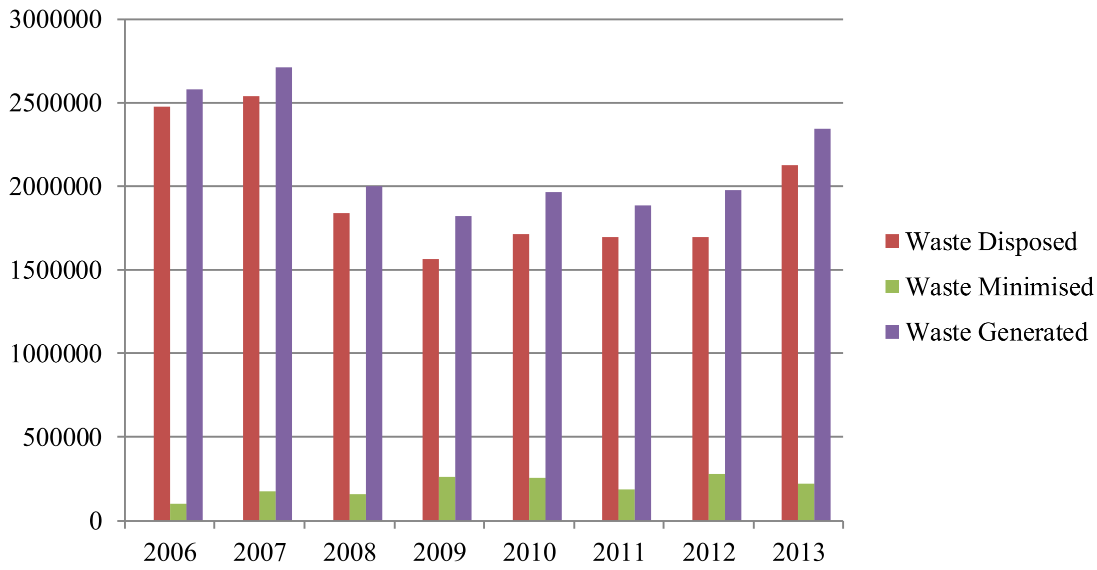

Figure 7.3: Solid waste data recorded at CCT facilities and CCT initiated waste minimisation programmes
Source: CCT (2014f)

Between 2009 and 2012, approximately 25 percent to 30 percent of the waste that was generated annually, was diverted from CCT landfills (CCT, 2013g). In the 2011/2012 financial year, 12.3 percent was diverted through waste management initiatives of the SWM Department (CCT, 2012h), while the rest was diverted by the commercial and industrial sector for reuse and recycling (Akhile Consortium, 2011).

These changes illustrate decoupling. There is a relative decrease in waste generation and an increase in waste diversion from landfill in the solid waste sector in Cape Town (Swilling & Annecke, 2012). Fluctuations in waste disposal and diversion are to be expected; however, this trend is starting to reverse as illustrated in Figure 7.3. The factors, either within the department and CCT or externally, that account for the changes remains under-explored in this context. Understanding how these changes have come about is particularly interesting, considering that in 2006 the head of the Disposal Branch at the time stated: “there is nothing we can do to reduce waste – in fact, we’re only expecting volumes to increase – but we can stabilise the flow of it” (Haider in Pollack, 2006). The following sections focus on what accounts for changes, and the prospects for shifting toward a more sustainable development trajectory from hereon.

7.5 Change and inertia in the SWM Department

Evidence shows fluctuations in the quantity of solid waste generated between 2006 and 2013 in Cape Town. External socio-economic factors and market volatility, as well as internal forces account for fluctuations. Competing priorities within and between the SWM Department branches, and the structure of formal and informal institutions are just some of the factors that influence the system, but they are important factors. As a starting point for understanding changes, this chapter tracks the department-specific changes to policy and strategy between 2000 and 2012. The chapter then shifts its focus to a series of purposive interventions that demonstrates a baseline commitment to more sustainable infrastructure configurations, carried out by the SWM Department. It focuses specifically on the institutional arrangements of solid waste services, exploring the procedures adopted by the organisation in an effort to understand the incumbent system.

7.5.1 Policy changes in the SWM Department

During the period after the first democratic elections, significant adjustments were made to address the historical legacy of extreme institutional fragmentation and differentiated service delivery, described in Chapter 5. The amalgamation allowed for a centralised power structure to emerge, ensuring all SWM functions were managed and regulated by a central SWM Department (Swilling & Annecke, 2012).

Internally, the SWM Department of the CCT is guided by the SWM Sector Plan, a statutory requirement of MSA (*MSA 32 of 2000*, 2000), and reviewed annually. This sector plan, now known as the Integrated Waste Management (IWM) Plan, articulates the operational and support strategies of the department and acts as the implementation vehicle to "manage and minimise waste to ensure [the delivery of] sustainable and affordable services" (CCT, 2012i: 1). The sector plan incorporated IWM as the result of the council resolution to adopt the IWM Policy (CCT, 2006c) in 2006 and the complementary IWM By-Law in 2009 (*IWM By-Law* C/15/03/09, 2009). Together, this marks a significant shift in the approach to municipal SWM.

The shift in the approach to municipal SWM was not a simple process, nor was it spontaneous. Following the amalgamation, and strategic intention to standardise services across the city, the SWM Department became increasingly concerned with the inadequacy of landfill airspace for the amount of waste generated. This concern is understandable. In 2000, Cape Town had seven operating landfills, but by the mid-2000s, only three remained in operation[86], placing significant pressure on the solid waste infrastructure system. Two of those remaining have had close brushes with decommissioning. Bellville South's landfill permit stipulated closure by 2013, but the lifespan has been expanded to 2016, while the Visserhok landfill site's footprint was doubled in size, creating Visserhok North to ensure capacity until at least 2020 (Novella, personal interview, 2014, October 22). Figure 7.4 shows the supply of and demand for available airspace as of 2010, including a planned but unconfirmed new regional site, which will be discussed in greater detail in section 7.5.4.1. It became clear that without major socio-technical changes to the system Cape Town would run out of landfill airspace.

In addition to limited airspace, legislative requirements at the national level began to shift as early as 2000[87], forcing the department to review its approach to SWM. Moreover, "in early 2000s the department was making decisions without reliable … or comprehensive information, … the [department] was under pressure to provide a coherent policy package for SWM" (Van Vuuren, personal interview, 2013, July 15). These circumstances pointed to an impending crisis in the waste sector, resulting in a series of reponses from the department:

> The SWM Department took a long term view of the challenges it was facing and pending changes, and in terms of process, a plan[88] was formulated to (i) draft policy for adoption by Council, directly linked to the legislation (the National policy, but NEMWA was still in the making), then (ii) draft a by-law that would reflect the same, but which would be enforceable after promulgation [of NEMWA] (Coetzee, 2014).

The plan, developed by the Integrated Strategy and Policy Division in the Planning Branch had at its core two goals; the first was to resolve the airspace crisis and the second was to meet pending legislative requirements. The latter would see local governments obliged to implement minimisation activities. These two factors are not only compatible but offered an opportunity to meet both goals with one solution.

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[86] Gordon's Bay landfill site closed in 2003; Brackenfell landfill facility reached capacity in 2005, although it remained open as a drop-off facility; Swartklip closed prematurely due to its close proximity to the Cape Flats ground water aquifer (Megatech, 2004); Faure landfill site closed in 2006.
[87] These changes are noted in the White Paper on Integrated Pollution and Waste Management for South Africa (2002) and the Polokwane Declaration (2001).
[88] These were Council driven processes in terms of legal mandate and thus funded by Council (SWM) budget (Coetzee, 2014 pc).

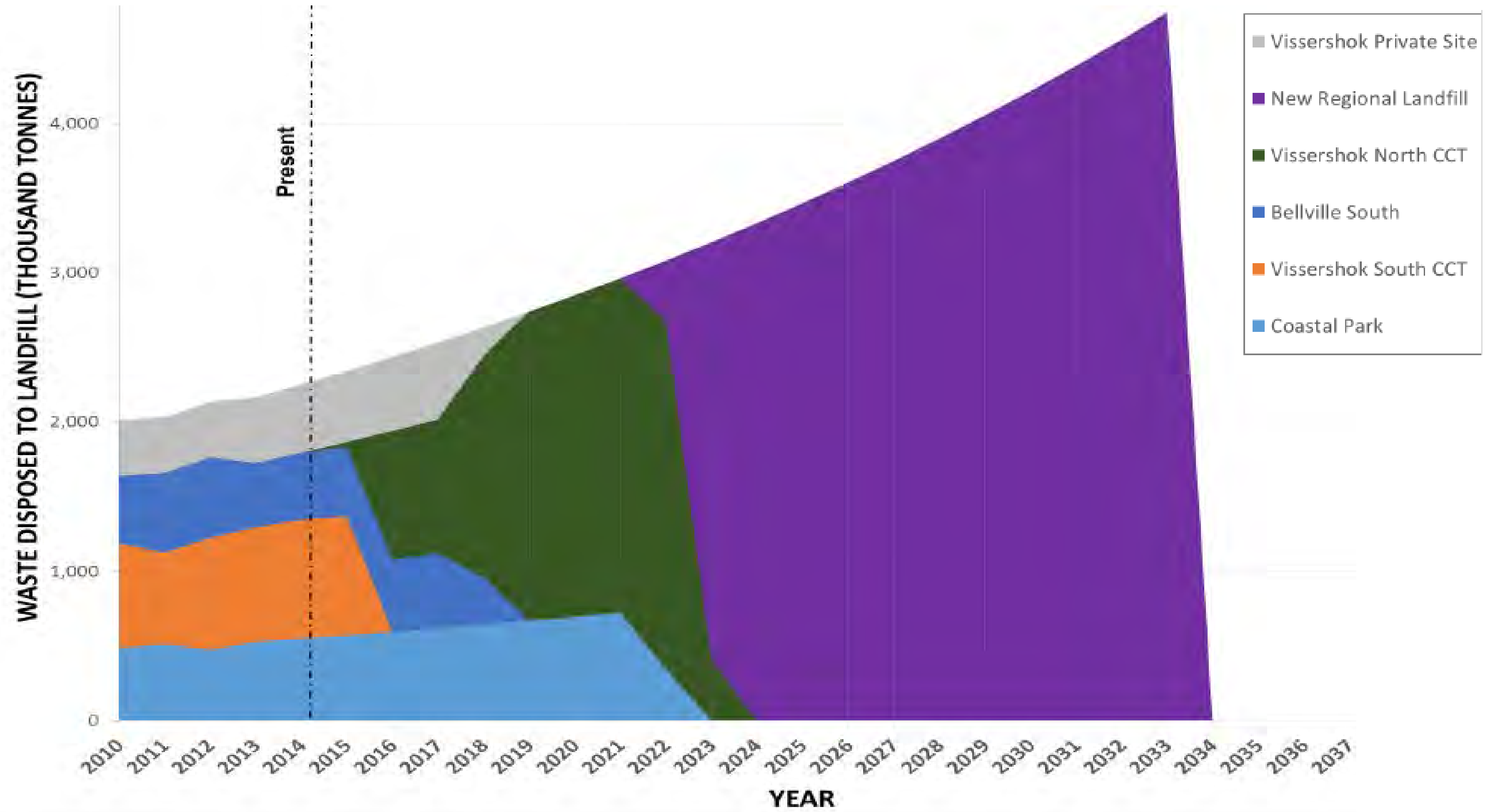

Figure 7.4: City of Cape Town Airspace Model
Source: Lindgren (2015)

What follows is a description of a series of processes that played out between 2000 and 2012. For the purposes of academic inquiry, it is necessary to question whether the local crisis and emerging national pressures were strong enough to impose real systemic change, wherein the SWM Department adopts a new model of service delivery so as to shift the development trajectory toward a more sustainable pathway. From these finding it is then possible to discern what might trigger, occasion and sustain sustainable urban infrastructure transitions in relation to what is know from the literature, as discussed before.

7.5.2 Locating momentum for change processes in the SWM Department

The Integrated Solid Waste Management Plan (IWMP) Status Quo Report[89] (Mega-Tech 2004)[90] provided the base from which the department began planning for SWM in the future, in terms of policy. The outcome of this assessment was a tome, holding a thorough repository of information that otherwise would remain uncollated, and locked in respective branches and department actors holding extensive knowledge. Many of the employees have been in the SWM Department or the CCT for a number of years, or decades in some cases, and as such have unique knowlegde and experience of the system (CCT, 2014e). The IWMP Status Quo report provided the departure point for the first phase of departmental strategy to address the collective challenges emerging in a context where, historically, the legislative goal was to clean, collect and dispose, to a legislation that obliged the municipalities to divert waste from landfill.

The IWM Plan was preceded by a feasibility study that made technical recommendations for SWM. This report, compiled in 1999 by USA consultants Mega-Tech, and funded by the USA Trade and Development Agency, is titled *Feasibility Study toward an Integrated Solid Waste Management Plan for the Cape Metropolitan Area* (Wright-Pierce, 1999). Commonly referred to as the Wright-Pierce Report (1999), it has had an astonishing impact on the long-term planning of the SWM Department. The Wright-Pierce Report (1999) was so influencial because it highlighted the shortcomings and knowledge gaps in the waste management system

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[89] The Status Quo report included an overview of the incumbent waste management systems, and analysis of the waste streams as well as a socio-economic profile of the population (see Mega-Tech, 2004).

[90] This report was funded by USAID, a foreign investment agency working in the field of poverty alleviation and democracy. The perception from the SWM department officials: "like most foreign export and investment agencies needed to get a foot in the door and at the time were offering funds for preliminary investigations (pre-feasibility studies, such as the one completed in 1999, known as the Wright Pierce report, and the subsequent 2004 report). Remember the White Paper preceding the NEMWA was published in 1999, so the USA used that as an opportunity to lay the foundation for possible further, more material work that would lead to export of technology and services. Indeed, they also funded work for National Treasury, which included the production of a case study for what is now the PPP Regulations Guideline (circa 2005)" (Coetzee, 2014).

as the result of historical institutional fragmentation. It also highlighted the diminishing airspace in the Cape Town functional region, and it made the recommendation that the SWM Department pursue the construction of a regional landfill site, which would be fed by satellite refuse transfer stations. By adopting this approach, the short-term urgency for transfer and disposal facilities would be relieved. It also suggested the introduction of minimisation stategies to offset the increasing operational cost the department would encounter in transporting waste. The recommendations of this report were not only accepted and assimilated into the long-term IWM Plan but into the institutional language and culture.

The IWMP Status Quo Report (Mega-Tech, 2004) used the Wright-Pierce Report (1999) as the basis for its analysis. Recognising the SWM Department's decision to construct a regional waste disposal facility as a long-term strategy, the IWMP Status Quo Report, using a cradle-to-grave approach, was concerned with offsetting the high cost of transporting and disposing waste at a remote facility by improving waste minimisation initiatives, which would be required by legislation anyway (Mega-Tech, 2004).

Indeed, these reports represented two extremely compatible cases for SWM and are now commonly used as the reference and rationale for "the inevitable need for a landfill site which [according to the Disposal Branch] is the only viable option for Cape Town as a third world country with spare land available" (Hall, personal interview, 2014, June 3). However, this option has come up against several obstacles, because suitable land comes at a high premium in Cape Town and democratic processes of public participation have delayed plans for implementation. Despite these factors, the strategy to develop a regional landfill site has not been deviated from, reflecting an absence of reflexivity within the department. At the same time, the Planning Branch continued to follow its longer-term plan to develop appropriate policy and strategy to support ISWM and purposive interventions for a system change.

The drafting of the IWM Policy[91] started in 2005 and was adopted as policy of Council in May 2006 (CCT, 2006c). The IWM Policy was based on what was articulated in the draft national legislation and therefore had all the elements required by the national legislation when the NEMWA (*NEMWA 58 of 2008,* 2009) was (eventually) promulgated. This represents a shift, three years ahead of national legislation, in principle to an ISWM approach,

[91] Basis of the report is the National White of Integrated Pollution and Waste Management, which preceded NEMWA.

with the goal of sustainable SWM that held at its core the principle of waste minimisation described as follows in the policy:

> Waste minimisation forms the core of the National Waste Management Strategy to ensure that health and environmental impacts can be minimised, and landfill airspace can be optimized to keep increases in tariffs sustainable over the long-term. Waste minimisation is defined as any activity that can prevent or reduce the volume, resource and environmental impact of waste, which is generated, treated, stored or disposed of (CCT, 2006c).

The IWM By-law was informed by and gives effect to the IWM Policy, to meet requirements of NEMWA, and was adopted by Council (*IWM By-Law* C/15/03/09, 2009) and promulgated in the Provincial Gazette. While the by-law conforms to the legal minimum as determined by national legislation, the CCT by-law had one stricter caveat in that "any and all service providers involved in waste management must be registered and receive approval from the CCT to operate within the industry and as such comply [with legislation and regulation]" (Coetzee, personal interview, 2013 July 19). This secured the SWM Department's authority for not only administrative integration but a standardisation of services when previously "the level and standard differed from area to area in accordance with historical (racially distorted) administrative practises" (Swilling & Annecke, 2012: 272). The by-law therefore has both a social and environmental agenda. However, the CCT has extremely poor monitoring capacity, as was noted in the W&S case. Therefore, it should not be assumed that the service is delivered adequately and as stipulated by the by-law. Overy's (2013) findings suggest that there are major problems with refuse collection and area cleaning in informal settlments.

Interestingly, policy champions used sustainability as the "discursive framework" (Swilling & Annecke, 2012: 274), which had emerged in the CCT, largely through an increased awareness of climate change and carbon mitigation, as related in Chapter 6. The sustainability discourse is far more appealing to the executive council and politicians than the technical issues of SWM. The by-law was therefore supported by department officials, outside of the Planning Branch, who saw the value of the IWM as a way to garner political support needed to address the long-term challenge of diminishing airspace in Cape Town.

7.5.3 Processes that underpin momentum for change

The resolution to adopt the IWM By-Law (*IWM By-Law* C/15/03/09, 2009) was influenced by the series of learning processes, initiated in the Integrated Strategy and Policy Division.

This is an important aspect of change processes for the CCT, because the CCT "tends not to make radical change and reconfigure how it spends its [budget], it tends to … change things at the margin … budget managers tend to be more incremental so as to not destabilise the fiscus" (Cartwright, 2014). The case of the W&S Department in Chapter 6 demonstrated how a commitment from the CCT to allocate budget took a significant amount of time and the right set of circumstances for external actors to demonstrate the political importance of the need for a Janitorial Service and gain traction for the initiative. On the other hand, the ERM Department relies on national funding, via DoRA for the EEDSM programme. Accessing sufficient funding remains a central challenge for the implementation of alternative infrastructure configurations, due to financial resource constraints and the risk associated with financial mismanagement. This will be elaborated on in section 7.5.6 and Chapter 8.

By tracking the process backwards it is possible to identify significant, catalytic events that provided the evidence base to demonstrate the benefit of minimisation initiatives and thereby mobilise support for alternatives. The final step prior to the adoption of the by-law was in response to the Finance Portfolio Committee's "request that the potential cost of the provisions of the by-law be determined for further decision-making purposes" (CCT, 2009d: 257). An external consultant, De Wit Sustainable Options (Pty) Ltd, in collaboration with the Sustainability Institute at the University of Stellenbosch, was appointed to conduct the research. In essence, a model was developed that costed the IWM By-Law in terms of the net additional cost or benefit of alternative service delivery mechanisms, which takes into account minimisation obligations in order to determine if these costs will be considered favourable in comparison to the baseline of landfilling options (see De Wit 2009; De Wit and Nahman, 2009; CCT 2009d). The outcome of the study showed that landfill costs, both operating and capital expenditure, will rise from R54 per tonne in 2004/2005 to approximately R250 per tonne by 2019 (De Wit & Nahman, 2009). Findings further demonstrated that in addition to the existing system, recycling practices for the most affluent households would yield the best results for waste diversion for landfilling while incurring the minimum costs (De Wit & Nahman, 2009).

The Danish Government Development Agency (DANIDA) funded this research on the back of an extensive research project funded by the United Nation Development Programme (UNDP), also managed and coordinated by the Sustainability Institute in 2007. The UNDP research project consisted of an integrated baseline analysis that provided a comprehensive description of the water, sanitation, energy and solid waste flows and the way in which these interact in the local economy in the Cape Town Metropolitan. These reports made a major contribution to how Cape Town's sustainability is understood, and stimulated dialogue around the future of Cape Town as a sustainable city (Pieterse, 2010b). Following this, the CCT and the Sustainability Institute commissioned a series of academic papers to reflect on the sustainability challenges in Cape Town, published in an edited volume[92] (Swilling, 2010). As part of the methodology of the edited volume, CCT officials, members of CCT management, sustainability consultants and academic elite of Cape Town attended a series of workshops hosted and facilitated by the Sustainability Institute. The goal was to understand the resource flows and associated socio-economic challenges, and potential alternatives for Cape Town. The informal and formal exchanges during these workshops were not only instrumental in encouraging interaction between social groups, but also in the transferal of knowledge between participants (Coetzee, personal interview, 2013, July 19). In many ways, the nature of these interactions, and interactions going forward, facilitated learning processes between actors, who established a common language and experience that influenced how challenges were perceived and addressed. Furthermore, it gave the CCT officials access to networks of professionals and academics who eventually conducted the by-law costing, and sparked the foresight of recognising:

> that a systems approach would be needed to achieve [ISWM] as intended in legislation and in practice. Part of this already existed, but there was no real understanding as to the combined benefits other than just saving landfill airspace (Coetzee, 2014 pc).

Subsequent to the completion of the baseline study, DANIDA made funds available via the ERM Department for projects related to urban environmental management (Coetzee, 2014) and, through an internal request, the SWM Department was granted funding (Coetzee, personal interview, 2013, July 19). The DANIDA-funded model was used for the waste-costing model, which informed the IWM By-Law. Also, “the direct contribution is that the costing (affordability) of the by-law could be determined … the result [being that] compliance and smarter IWM would follow when the money would [eventually] be invested and the major changes would take place” (Coetzee, personal interview, 2014, June 4). This

[92] Themes included: water and sanitation; energy; solid waste; transport; natural space and city growth; urban form; economic and industrial development; sustainable architecture and building materials; social justice; sustainable housing; sustainable agriculture and food security; and city financial flows.

indicates a deep recognition of the value of *preparation* before major shifts in investment strategies take place.

Two processes unfolded in parallel, while the reports, policy and by-law were being developed. The first was the implementation of minimisation interventions, and the second was the roll-out of satellite stations, and the planning and construction of the regional landfill site. It is baffling that these processes use the same rationale, considering the divergence from the underpinning aspiration: to resolve a crisis of limited airspace in the context of changing legislation.

7.5.4 Conflicting process of change: where momentum and inertia meet

The issue of waste minimisation made its way onto the council agenda at the Trading Service and Infrastructure Portfolio Committee (now Utility Portfolio Committee) meeting in June 2006 (CCT, 2006d). The IWM Policy was introduced to council two months before, piquing the interest of the council members who were beginning to grapple with the ideas of urban sustainability. Most concerning was the dramatic increase in waste generation and diminishing airspace and the (pending) obligations of NEMWA. The minimisation chapter of the IWMP Status Quo Report (Mega-Tech, 2004) was offered as a progress report in the portfolio committee meeting. In response, councillors:

> …expressed their concern for the lack of recycling … and requested that at the next meeting [the] Portfolio Committee be given some positive ideas on what the [SWM] Department propose for the way forward on waste minimisation, the budget provision and action plan (CCT 2006d: 07).

The Minimisation Division, located within the Planning Branch was established soon thereafter. The IWM Policy, and later the IWM By-law, was used as a guide[93] to support a number of proactive interventions for waste minimisation taken by the SWM Department. Interventions include public awareness, communication and education campaigns, partnerships for job creation and infrastructure. At an operational level, the Minimisation

[93] The absence of a complete MSA Section 78 Assessment makes this necessary. The MSA Section 78 stipulates that the department must conduct an assessment to determine whether the SWM Department is able perform this additional service and provide infrastructure not previously mandated by the constitution, or whether alternatives should be considered. The MSA Section 78(3) Assessment is a mandatory process that municipalities must undergo when obliged to deliver new services. This will be discussed later in the chapter.

Division works alongside the Collections Branch and several other private sector service providers in six pilot areas of Cape Town as part of the Think Twice recycling initiative. In 2006, the dual Wet and Dry Waste Collection Service, referred to as the *split bag* project, was piloted to collect separated waste (Davison, 2011). While the Think Twice project has been *implemented* successfully, it can be viewed as an early attempt to appease political pressure to implement recycling projects, as it is unsustainable in its current form, recovering only 1.5 percent (in terms of tonnage) of the total recycled waste in Cape Town (Kasner, personal interview, 2013, November 8) at a great additional cost currently born by the CCT, which will eventually be transferred to customers through the tarriff (OEKO, 2011). Significantly, those residential areas that receive the split bag recycling service range from middle to high income, and the CCT absorbs the additional cost of providing that service.

Minimisation activities have been bundled with the construction of additional waste management facilities (WMF) across Cape Town. These include expensive material recovery facilities (MRF) in addition to existing refuse transfer stations (RTS), and the expansion and improvement of drop-off sites which house recycling initiatives, composting, and facilities for chipping garden greens and crushing builders rubble (Akhile Consortium, 2011). "The drop-off facilities [divert] the highest tonnage of waste [from landfill while] garden waste chipping projects at drop-offs contribute to the highest diversion [in terms of volume]" (Nkala, 2012: 80). Therefore, evidence shows that the reconfiguration of existing operations currently contributes most to diversion. However, in 2006 records showed that approximately 12-15 percent of waste generated was diverted from landfill (CCT, 2006d). Diversion percentage rates in 2012, over half a decade later, are on par with those seen in 2006. The question is why more minimisation has not been achieved, considering there is an incentive to expand these activities.

7.5.4.1 The material recovery conundrum

RTSs and MRFs are central to Cape Town's SWM story. These are namely the Swartklip RTS, Athlone RTS and dirty MRF, which receives mixed waste, and Kraaifontein RTS and clean MRF, which receives separated waste. Recommendations of the Wright-Pierce Report (1999) suggested the construction of RTSs and MRFs as satellite transfer stations to divert waste from landfill and minimise costs associated with transporting waste to the regional site.

The Kraaifontein IWM Facility, operational since 2011, is designed as a one-stop[94] WMF. This R230 million facility is described as "ultra-modern and award-winning … [with the distinction of being] the first of its kind in South Africa" (CCT, 2014g: 1). It acts as a drop-off site for recyclables, an MRF (100 tonnes/day) and an RTS (capacity 1000 tonnes/day), as well as a facility for green waste chipping and builder's rubble crushing. The yield of recyclables extracted for beneficiation is an average of 11 percent, versus the 2 percent of recyclables extracted at the dirty Athlone MRF (Kasner, personal interview, 2013, November 8).

The Kraaifontein IWM Facility is an exemplary example of a facility that would fulfil national legislation requirements and the conditions of the IWM Policy, and feed the regional landfill site; it is considered an ideal model for satellite stations in Cape Town. But this facility is operating at capacity, because of the presence of the split-bag programme in that catchment and the fact that the private operator, WastePlan, also has the collection tender to collect waste from service points within that catchment area (Hall, personal interview, 2014, June 3). This was not by design of the Disposal Department, and for other facilities to operate successfully, "the Collections Branch will have to roll out the [split bag] programme in other areas" (Hall, personal interview, 2014, June 3). There is little deliberate interaction between branches within the department to ensure that capital investment and operations are aligned. The outcomes of this are stifling momentum in this arena. While "the intention was to align all the satellite stations with the principles of minimisation and IWM" (Hall, personal interview, 2014, June 3), these good intentions have fallen by the wayside. The new Bellville WMF, the most recently constructed, was conceptualised as a "fully integrated facility at the planned site" (CCT, 2011e: 288), but as a senior official in the Disposal Branch explains, there was a urgent need for "a transfer station because landfills were filling up and closing, so it went ahead as a [conventional] RTS" (Hall, personal interview, 2014, June 3). He elaborates, stating that the department:

> would liked to have had recovery capacity but there were so many big ideas being bandied about ... which derailed [material recovery]. Also, until the Collections Branch roll out programmes for separation at source in the Bellville WMF catchment area, material recovery is impossible (Hall, personal interview, 2014, June 3).

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[94] This facility does not accept hazardous or medical waste, sewage sludge or large loads of builder's rubble (OEKO, 2011).

Despite diversion from landfill being in the urgent interest of the Disposal Branch, "the policy for rolling out separate collections and reducing recyclable waste to landfill, is in the hands of the Collections Branch" (Hall, personal interview, 2014, June 3). In other words, the Disposal branch is *hands-off*. Without extending the programme to the rest of Cape Town, or at least catchment areas with MRFs, no facilities will be financially viable, due to the volume of waste required that will bring a facility to an economy of scale. However, constructing RTFs instead of MRFs in the short term will result in technological lock-in in the long term. Considering the importance of a secure "direct revenue stream … when motivating a capital investment" (Court, 2014), there is a major challenge to convince the Finance Department of the value of these facilities when the supporting activities have not been implemented.

At the same time, the Disposal Branch has been taking action to secure the land needed to construct its regional landfill site prescribed by the Wright-Pierce Report (1999). The process of identifying a location and constructing a regional site has been on the agenda since 2000, and was originally expected to become operational by 2012. However, this is still unresolved, and now it is estimated that this site might only be operational by 2019 (Novella, personal interview, 2014, October 22). Even though it is described as "the sad saga of the regional landfill site" (Hall, personal interview, 2014, June 3), decision-makers are still taking steps to identify sites for the construction of a single, centralised landfill site. Two potential sites, (i) South of Atlantis and (ii) Kabalskraal were identified after a lengthy feasibility study, followed by a detailed Environmental Impact Assessment (EIA) on each site in 2004 as authorised by the Department of Environmental Affairs and Development Planning (DEADP) (CCT, 2008d). Finally, in 2007 a report was submitted to DEADP based on which a Record of Decision was made, authorising the development of the South of Atlantis site. "Due to appeals from community members, led by a property developer ... who spent a lot of time drumming up support from the community in Atlantis," (Hall, personal interview, 2014, June 3) this Record of Decision was set aside. Subsequently, the MEC for DEADP confirmed the Record of Decision for the new replacement landfill site to be established at the Kalbaskraal site (CCT, 2012i). "This was a political decision [at the Provincial Level], ten days before the election in an attempt to get the Atlantis community vote" (Hall, personal interview, 2014, June 3). Kalbaskraal community members and the farming community subsequently lodged appeals, and in May 2011 the High Court set aside the latter Record of Decision, citing procedural issues. The property developer however interrupted the reversion back to the Atlantis site. Some of these events were beyond the control of the CCT, but the process to secure a site for a regional landfill has all but had to start from scratch. Supplementary EIA processes as well as extensive public participation process (Western Cape Government, n.d) for both sites were concluded in 2013; however, this remains unresolved, as the selected regional site in the Kalbaskraal area has been challenged in the High Court again (Lindgren, 2015).

Moreover, the experience described above is percieved by officials as proof of the difficulty of implementing long-term projects, let alone alternative approaches. This was expressed as follows by one official:

> "EIA challenge has proved how difficult the identification and establishing of a landfill site [can be] and it makes the challenge of introducing [alternative technologies that support longer term sustainability objectives like] incineration and flaring even more daunting: ... landfilling… [remains] the only viable option" (Hall, personal interview, 2014, June 3).

Moreover, a common theme that emerged during the interviews suggested that officials are unwilling to embark upon processes to implement alternatives, as they assume delays and inevitable failure. Here, a lack of effective leadership and activated agency that can recognise the need for a new way of doing things, a new way of thinking and implement alternatives, is evident. The delay in the approval process for identifying a regional landfill site has placed significant pressure on the Cape Town's solid waste infrastructure system. Now, the trajectory of waste generation in Cape Town in comparison to available airspace is not promising, especially since the saving grace was to be the regional landfill site. Without the additional landfill space, or any commitment to invest in alternative waste management practices, the SWM Department will find itself in a particuarly precarious situation. The techno-fix solution of extending the lifespan of existing landfill sites will only delay the inevitable crisis in the sector. This worst case scenario does not seem to concern officials within the department while the landfill remains an absolute imperative as a central component of the IWM sector plan in terms of the Fixed Asset Strategy (CCT, 2013f; CCT 2012i) and budget allocation (CCT, 2014h).

7.5.4.2 Overriding dominant service delivery model

It is evident that waste disposal at landfill remains the dominant technology in Cape Town, and the dominant approach embedded in the institutional memory of the department while alternatives are perceived to be inadequate or too risky. The regional landfill site saga speaks to the dominance of the incumbent approach. Not only has this process been ongoing for over a decade but the "money has poured out of the CCT for legal fees and for relative consultants … to get permission to proceed" (Hall, personal interview, 2014, June 3). It would be inconceivable to abandon it now. This is despite the legislative obligations and policy changes within the CCT. It seems that many officials cannot imagine that a different approach is possible.

The dominance of the landfill technology is not only evident in the budget allocation to date but the *intention* for future budget allocation expressed in the Fixed Asset Strategy for a regional landfill site, RTSs and pubic drop-offs, where the only real minimisation practices are taking place, which will lock Cape Town into to a pattern of waste disposal for a minimum of 30 years. What perhaps should be explicitly articulated is that if (although this is a matter of when) the regional landfill is constructed; the investment will have to be recouped. Consequential pressure on the tariff will limit the CCT's options for deviating from this SWM approach, which will all but destroy any momentum of emerging recycling initiatives.

Drawing conclusions from the capital budget allocations between 2003 and 2013, the most consistent investment over the past decade has been in the development of landfills (CCT, 2014h). Capital has been allocated for the closure of existing landfills sites and the construction of new landfill cells and associated infrastructure, amounting to approximately 75 percent of the total budget. The Technical Services branch receives approximately 23 percent, leaving a marginal amount for collections and area cleaning (CCT, 2014h). It is worthwhile to remember that the Collections Branch is resposible for implementing the split-bag programme and the Cleansing Branch for servicing informal settlements. The major increase in capital budget in 2006/2007 (see Figure 7.5) was allocated for the closure and rehabilitation of landfills[95] (CCT, 2014h). Moreover, there was the need to extend the lifespan of Bellville South[96] and Coastal Park landfill sites, entailing the construction of new lined disposal cells in lieu of any alternatives ready for implementation. Expenditure trends match

[95] The closure of landfill sites entails site capping and the implementation of gas, stormwater and leachate management systems (Engledow, 2007).

[96] Although, when the Mega-Tech Report (2004) was being compiled, the Bellville South site was going to be prematurely closed due to "close proximity to residential areas and the risk of contamination to the underlying Cape Flats aquifer" because approximately 30 hectares of the site is unlined (Mega-Tech, 2004: 7-12).

historical investments; capital has been allocated to infrastructure at the end of its lifecycle, but also to new infrastructure of the same configuration. In other words, the SWM Department is repeating established expenditure cycles.

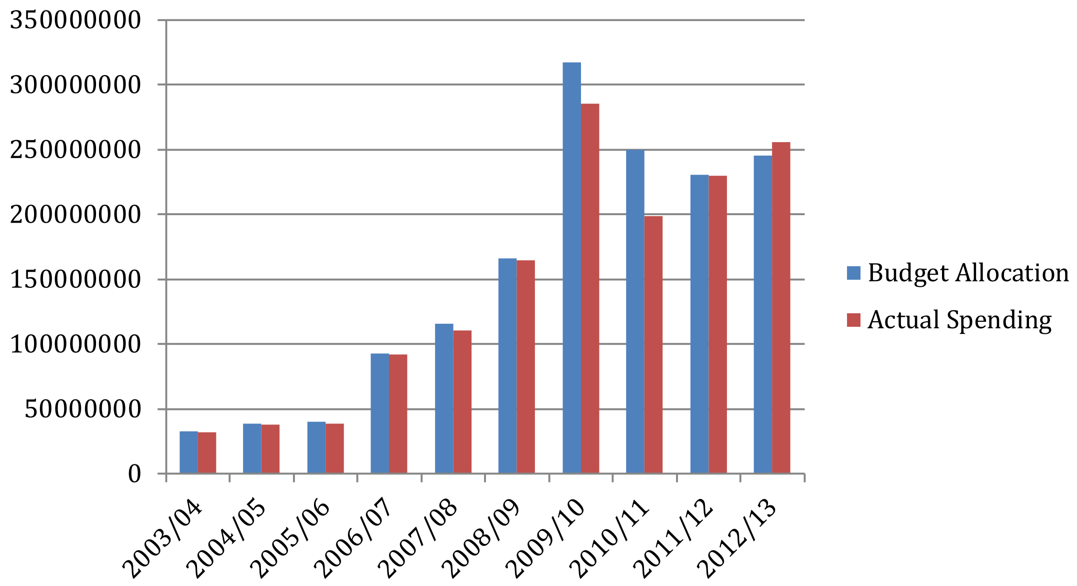


Figure 7.5: Trends in capital expenditure 2003-2013
Source: Adapted from information gathered in CCT (2014h)

While rehabilitating decommissioned sites is critical, it does bring into sharp focus the real cost of landfill infrastructure over time. The rehabilitation of closed landfill sites is an alarmingly high expense, which highlights the long-term implications of the decision about developing and expanding landfill sites, and the construction of the regional site. Investment priorities of the department, based on the information provided by the budget and the IWM Plan [97] for future investment, blatantly exclude any substantial allocation for IWM, minimisation activities or service improvement in informal settlements.

The capital budget allocation breakdown is in sharp contrast to the allocation of operating budget. The structure of the operating budget makes analysing the department expenditure priorities a challenge (see Figure 7.6), although approximate allocations to branches can be

[97] Include the maintenance and upgrading of fleet vehicles, construction of transfer stations, the authorisation of the regional landfill site, the provision of equal services across the city and material recovery facilities and drop offs in order to minimise waste to landfill, (CCT 2009e; CCT 20011g; CCT 2012i; CCT 2013f; CCT 2014h).

considered as follows: Collections receives approximately 40 percent, Area Cleaning approximately 30 percent and Disposal approximately 20 percent, leaving the remainder for support functions (Akhile Consortium, 2011). However, the allocation also says something about where the costs of delivering services are the highest in terms of operations. Vehicle-intenstive Collections (responsible for formal residences and drop-offs) and labour-intensive Area Cleaning (responsible for urban cleansing and informal settlements) account for the highest portion of the operations budget while the important task of managing MRFs is the responsibility of the Disposal Branch. However, it was mentioned earlier in the chapter that service delivery in informal settlements is inadequate. Therefore, these allocations illustrate the departmental priorities; providing a high level of service to middle and high-income residents and keeping Cape Town clean and litter free to meet standards that match world-class cities while material recovery and basic service delivery is a marginal priority. Investments are generally aligned with (urgent) priorities of the department as they emerge within the broader priorities of the CCT. While it is not as simplistic as this, pressing challenges and issues are accommodated, leaving those less critical projects for a later stage.

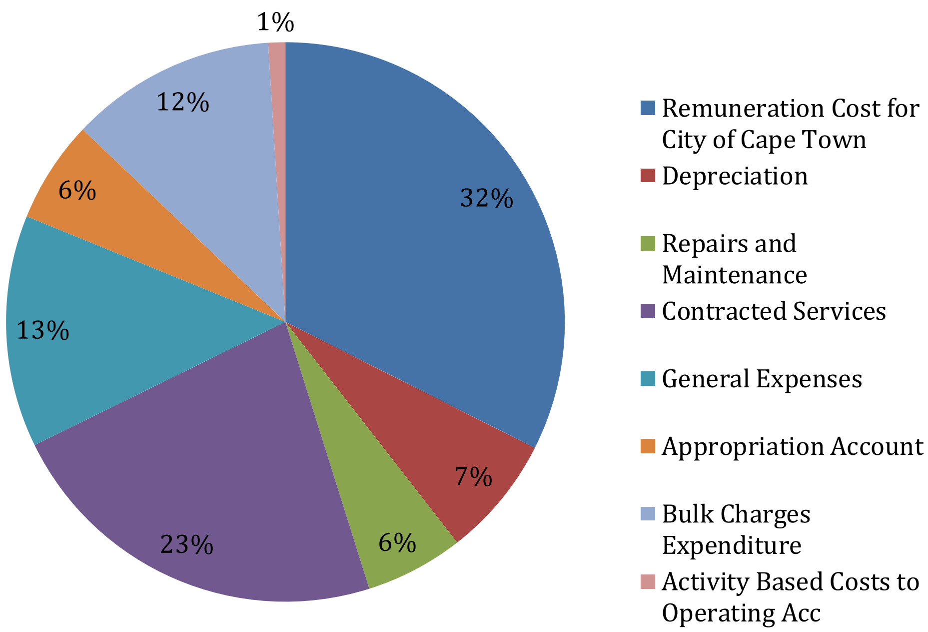


Figure 7.6: Operating budget cost drivers
Source: CCT (2014i)

The budget application process is therefore an important component of planning and implementation. Projects are prioritised in the form of the budget, which is then presented to and approved by the Finance Committee and awarded to a specific ward. Projects are aligned with SFAs and KPIs of the IDP, and given effect by the SDBIPs where the budget allocation is recorded. However, those driving innovation within the organisation need the support of senior management and the finance cabal to push an agenda forward. Political support for a new agenda is not offered lighlty. Although it is challenging to quantify, it is true that the long-serving department stalwarts, who maintain the incumbent systems, have a good relationship with the Finance Department and are therefore able to have budget applications approved with little difficulty, as long as it is within the institutionalised bounds of delivery.

Underlying the expenditure patterns and investment priorities is the implicit yet obvious absence of appropriate interventions for ISWM as a policy objective, while waste minimisation interventions at present fall squarely within the parameters of the operating budget. Of course, the operational branches are the implementers of the minimisation strategy and supported by the Minimisation Division, however, because the department's priorities are maintaining existing landfill infrastructure and collection vehicles, very little investment can be allocated to minimisation. The SWM Department now finds itself in a difficult situation. The aspiration of minimisation has become conflated with the goal of a single regional landfill site, yet managed in a very separate way. The Minimisation Division and the Disposal Branch are responding to the same challenge of diminishing airspace without any real collaborative engagement on the topic. The Minimisation Division oversees minimisation programmes, yet the operational branches are responsible for managing the facilities and implementation. Infrastructure that forms the base of minimisation interventions existed in 2006, while the newer MRFs are the responsibility of the Disposal Branch, and have been constructed to feed the regional landfill site. Other than that, the configuration of the socio-technical system has largely remained the same, while the rules and culture have remained intact. Part of the inertia has been attributed to the delay of the Section 78 Assessment, a condition of the MSA.

7.5.4.3 Implications of the Municipal Systems Act Section 78 Assessment

Section 78 of the MSA provides the process and detailed procedure through which municipalities determine whether an internal or external service delivery mechanism is most appropriate. This requires that all associated direct and indirect costs and benefits of an external mechanism be assessed (Mega-Tech, 2004).

The Section 78(1) assessment was conducted to test internal capability for the delivery of minimisation initiatives, as a pending municipal obligation. The MSA Section 78(1) Assessment (Roman, 2007; CCT, 2008c) report was finalised in 2008, finding that there are sufficient grounds, due to limited capacity, for the CCT to explore the alternative mechanisms, advising "that a proper decision can only be taken if the complete choice set is available" (Roman, 2007: 28). This sentiment is equivalent to telling the SWM Department to do nothing until all information is available. Subsequently, the recommendation was made to council and the Utility Services Portfolio Committee to proceed with the MSA Section 78(3) (Roman, 2007). After major delays, due to the onerous internal procurement process (Diedericks, personal interview, 2014, September 4; Coetzee, personal interview, 2013 July 19), Akhile Consortium was finally appointed in 2010, to conduct the Section 78(3) assessment, and presented recommendations for alternative service delivery mechanisms to the SWM Department in 2011 (Akhile Consortium, 2011). Important findings show that the department will require private sector involvement to give effect to the NEMWA, due to a lack of skills and capacity, and insufficient budget. Moreover, it showed that regardless of any large scale interventions, the regional landfill site will be imperative for waste management and that existing waste minimisation initiatives are unsustainable, because waste cannot be economically recovered for the purpose of re-use, recycling and energy recovery under the status quo (CCT, 2011e).

The overall financial sustainability of minimisation interventions have been brought into sharp focus since the completion of the Section 78(3) assessment in 2011. This poses a significant challenge for implementing alternative delivery options, considering that “it remains financially more feasible to landfill waste rather than to collect, process and divert waste[98] … if funded by the CCT alone” (Akhile Consortium, 2011:xxxvi). Moreover, officials, such as the Head of the Collections Branch, are fully aware that “waste minimisation is not financially viable and sustainable in its present form” (Carroll, personal interview, 2013, November 25). Hereby the willingness of other branches to participate in innovative projects is compromised, and until a (financially) *sustainable* option is presented, it is unlikely that momentum for systemic change will be generated.

In the case of infrastructure projects, it is common for the “sustainability aspect to be linked to the affordability of a service over time for customers [and therefore the financial viability]

[98] This excludes builder’s rubble (Akhile, 2011).

as the utility departments are very concerned with recovering costs to ensure the ongoing maintenance of services" (Dhlamini, personal interview, 2013, August 2). The question regarding the *financial viability* of infrastructure is how the notion of sustainable infrastructure is understood and incorporated into the planning process by many CCT officials in the Utilities Directorate. The Funding and Revenue Strategy (CCT, 2012i) of the SWM Department is articulated as the procurement "of non-government funds, … the improvement of cost recovery and revenue completeness, the remodelling of tariffs to improve the sustainability of services, … and [the ring fencing] of revenue generated though the council's waste management activities to improve SWM *sustainability* and minimise future tariff increases" (CCT, 2009e: 8; CCT, 2011f: 10; CCT 2012i: 11, author's emphasis).

Sustainable service delivery, in this sense, refers to the responsibility of local government to ensure that the cost of capital, maintenance, and rehabilitation over time is sustainable into the future (*MSA 32 of 2000*, 2000). This understanding is deeply entrenched in officials as the overarching principle of sustainable service delivery. In fact, the only reference the IWM Plan makes to sustainability is in regard to funding and revenue strategies. It was explained by Hadingham, the Manager of Economic Information and Research in the Economic Development Department that:

> local government … [has a] particular language. Changing [what is understood by the notion of sustainable urban infrastructure] requires a process of raising awareness of what this means [in the institution]. There needs to be a learning process so people can start thinking in a new way. Environmental sustainability is still seen as a luxury good and nice-to-have rather than a necessity (Hadingham, 2014).

The SWM Department "has [minimisation] pilots. But the reality is that [the department] should not be doing it because it is unsustainable. But because we need to tick a box and so we are doing it" (Carroll, personal interview, 2013, November 25). In this instance, the Head of the Collection branch is commenting on the financial inefficiency of the incumbent practice of waste minimisation but it speaks to an underlying culture within the CCT. The statement that the SWM Department is required to deliver minimisation interventions because it is necessary to "tick the box" (Carroll, personal interview, 2013, November 25) is underpinned by "certain public administration norms, which by their very nature make the organisation bureaucratic. [Officials] work within those norms, but often they are constraints … [which] limits the ability to take risk" (Oliver, personal interview, 2013, November 25).

Being able to work inbetween the administrative norms and the margin is a central aspect of implementing alternative practices. Therefore,“acting in a progressive way… [within] the shackles of the bureaucracy … is actually quite remarkable (Oliver, personal interview, 2013, November 25). When considering these boundaries, employees reflect on the CCT and characterise it as “a good employer but also extremely demoralising” (Naude, personal interview, 2013, November 28) and say it is necessary “to motivate yourself” (Ladouce, personal interview, 2013, November 28), while “a positive attitude and passion are important values when working in the CCT” (Oliver, personal interview, 2013, December 2). These strong statements are illustrative of how challenging it can be to align innovative projects or experiments, outside of the bureaucratised routines and established silos, with institutional standardised expenditure cycles and regulatory constraints.

Working within the boundaries of the bureaucracy is one thing, but the CCT is a highly political environment that tends to lean toward short-termism, which influences the ability to take action, be it an actor or branch:

> There are always competing interests … where politicians have influence over technical aspects of the business … for all the wrong reasons…. Political imperatives that drive decision-making are not [within] the field of the officials, who are technocrats, and there are often disagreements when political issues take precedent over technical issues (Oliver, personal interview, 2013, December 2).

But a problem emerges “when officials choose to be political stooges, who assist politicians [to] guide a process in their favour…. Competing powers within the department [exist] because of ignorance and an attempt to survive” (Carroll, personal interview, 2013, November 25). The presence of competing power is not surprising. Politicians are considered as a board of directors who use their power to dictate the direction and activities of a department, and some councillors make the assumption that they know better than officials, who actually have expertise in their field (Smit, personal interview, 2013, December 2).
At the departmental level, when looking at the SWM Department human resource records, there is evidence that there are groups of individuals who have been in the employ of the CCT since before the 1994 transition (CCT, 2014e). They have a particular understanding of how the system should operate and a vested interested in retaining the system as they *know* it. “City officials are self-serving, the culture of the organisation in the end [forces] officials to be self serving, to survive” (Trollip, personal interview, 2013, November 7). In fact:

> change needs to take place … but staff resistance comes into play when officials feel like they have been doing a job for a number of years and are comfortable doing what they know ... systems that have been institutionalised over many years and to make a change within that is not easy (Coetzee, personal interview, 2014, June 4).

7.5.6 Institutional dynamics that account for departmental practices

When looking deeper, the practises of the SWM Department are merely an illustration of how the utility departments operate. That which is within the area of mandated responsibility of a particular branch is exactly that, and there is little indication that there is any cross-pollination of ideas, knowledge or experience. From the perspective of a division head in the Collections Branch:

> there tends to be a reluctance to open up the [branches]. I could have a positive influence on [another] branch ... but there is no mechanism in place. There is nothing stopping me from trying to influence operations, but there is no formal existing way of achieving this (Oliver, personal interview, 2013, December 2).

There are identifiable issues that may account for this; the first is the fact that the CCT does not have a culture of open engagement and the second is the siloed nature of departmental actions, which may well be the underlying cause of the first. Firstly:

> there is a huge amount of intellectual capacity present within the CCT yet at the same time pressure to let go of that intellectual capacity and get on with the task at hand. Pressure to churn out the next deliverable, report, memo, SDBIP ... at the expense of reflecting on lessons learnt in job experiences … to make a more creative solutions (Cartwright, 2014).

Despite the inherent connection between branches and across departments, because branches are so inward looking it has become difficult to see where collaboration can take place within and across the departments, despite the overarching core business being one and the same. "Branches of the SWM Department act in insolation [and responsibilities] are very territorial" (Ladouce, personal interview, 2013, November 28). Clearly defined roles and responsibilities for each branch keep employees' actions bounded, limiting the desire to take initiative and step out beyond defined protocol. To some extent branches work independently of each other for various reasons; employees assume "some branches are antagonistic toward one another"

(Naude, personal interview, 2013, November 28) and there is a distinct resistance to overlapping functions, limiting internal communication and coordination. This antagonism has carried over into an “unwillingness to openly share information and intellectual property” (Ladouce, personal interview, 2013, November 28) between branches and individuals. Overall, employees reflect the attitude that there is a degree of mistrust between branches:

> One of the biggest problems … [is that the utility departments] don’t work as a directorate. [They operate] as islands, even within the departments. In the SWM Department if there is a very difficult issue, they are hesitant to put it toward one another, they would rather use a third party to engage them (Hendricks, personal interview, 2013, August 5).

Aligned with this phenomenon, is a sense of internal trust within the isolated branches. The SWM Department Director has a high degree of confidence in “extremely competent branch heads” (Hendricks, personal interview, 2013, August 5) to carry out a respective responsibility, based on a proven track record of efficiency, technical expertise and knowledge of the existing socio-technical system. Branch heads therefore have a high degree of control over how the branch functions. The trust within the branches does not extend beyond that specific operational responsibility and the consequences of this culture are apparent. What this translates into is a barrier to innovative practises that requires dynamic processes of interaction, as described in Chapter 3.

The notion of organisational silos is often articulated as a challenge of local government, and the CCT is no stranger to this phenomenon (Salga, 2011). While the organisational structure is designed to ensure efficient service delivery, it is, in fact, counter-intuitive to integrated service delivery. This is deeply problematic, especially since the goal is integrated service delivery, but delivery is carried out is a systematic way by (alienated) branches with specific sets of responsibilities. The institutional implications of being tightly rule-bound within organisational silos are significant, considering the continuous learning processes required for systemic transitions that give rise to more sustainable approaches to infrastructure investment and management. The SWM Department branches tend to have tunnel vision with a focus on the efficient delivery of services. Despite the fact that the managers of branches are extremely competent with a lot of experience, by continually acting in the same way, the system is reinforced and routines are further entrenched, limiting the openness to participate in and adopt new approaches.

The CCT Mayor has made explicit the need to focus on capacity building, which is dependent on accruing sufficient revenue to "employ the right people in the right positions" (CCT, 2009g: 6). Service delivery failure is often attributed to limited human resource capacity (Salga, 2011). However, to clarify: while a lack of capacity is a major issue, it is evident that many of the individuals employed at intermediate levels, management and senior management are highly skilled and have extensive experience and knowledge of the system (CCT, 2014e). In fact, a sound base of technical and engineering expertise allows the SWM Department, and the other Utilities, to implement large scale, generic infrastructure projects with relative ease in comparison to innovative projects with fewer quantifiable results. An outlying example illustrates that in the presence of some kind of external facilitation, this expertise can be harnessed for alternative projects, such as the Kraaifontein IWMF.

Two issues are neglected in the discussion on the capacity crisis of management. The first is that existing expertise is no longer sufficiently appropriate to meet the demands of alternative delivery approaches and technologies. The arena in which these expert actors are participating is changing and the landscape for utility management is no longer the same. It requires an additional set of skills that can negotiate the changes to the external environment, i.e. environmental changes, diminishing resources, or financial constraints. Skills required may include project conceptualisation, the ability to develop financing models and overall project management in instances where outcomes cannot be certain. The second issue is that while there is vast expertise, it is isolated. Branches do not interact in an integrated manner to realise the benefits of integrated service delivery. In fact, branches are consciously kept separate from one another as a result of internal politics that emerge due to divergent views on network expansion priorities and boundaries of responsibility.

Suggesting that the capacity crisis is the biggest challenge to the integrated service delivery is a somewhat simplistic statement. Moreover, a precondition for branches cross-pollinating and collaborating is effective leadership aligned with the commitment to institutionalise such imperatives. However, the capability of leadership within the organisation is questionable. In the case of the SWM Department:

> the director is not leading [the branches] as a group … there are a lot of strong individuals and each of them plan how they see fit, but [the branches] are not harnessed together by the director who [should be] giving the direction of future planning (Hendricks, personal interview, 2013, August 5).

At a higher level, it was also evident throughout the interviews that there is the perception that the Executive Director (ED) of the Utility Directorate does not deem intervening directly in the various departmental operational activities as appropriate (Hendricks, personal interview, 2013, August 5; Ward, personal interview, 2013, December 10). It was remarked that the Utility Directorate ED:

> will not step in and tell a [department] director what to do because she is terrified of those directors then pushing back … there are other things that the ED needs to get directors to do, and so is very wary of making decisions which the directors don't fully support (Ward, personal interview, 2013, December 10).

The ED, who has allocated power through the hierarchical structure (Schweigert, 2007), rather acts as a mediator with a reporting function, leaving the directors, who have *de facto* power, to determine the department or branch vision rather than follow the cohesive and coherent vision of the Utility Directorate. Here, this power circumscribes agency of those in the Technical and Strategic Support Unit. There is an absence of effective leadership and clear communication within and across the three departments. The Utility Departments "are not thrusted in the same direction and they are not functioning as a coherent unit or directorate" (Hendricks, personal interview, 2013, August 5). Rather than communication, reporting up the hierarchy is well institutionalised while instructions are channelled down.

Instructions are delivered via muncipal performance management agreements. The Municipal Performance Management Regulations oblige municipalities to implement Municipal Performance Management Systems in which senior managers enter into performance agreements. As a result:

> [The] SWM Department is caught up in a risk-averse culture that makes it difficult to do anything new. But the senior management of the directorate prefers to get clean audits rather than risk mismanagement of public finances. This is really important considering that the department cannot afford to maintain existing minimisation projects … but they are so strict on compliance that they lose sight of the service that has to be delivered and even when there is have a really good idea, they are so risk averse that they do not make a move (Hendricks, personal interview, 2013, August 5).

At the same time, it should be noted that "at the top level of management there is tremendous political pressure" (Oliver, personal interview, 2013, November 25). The focus on achieving specific quantifiable outputs inevitably leads to the prioritisation of projects that are easily quantifiable even if they are not viable in the longer term. The outcomes-based nature of performance enters into all facets of service delivery, especially when it comes to the planning process and budget allocations, therefore officials abide by the cultural norm and only commit to what they know for certain is achievable. The risk-averse nature of the organisation, particularly the financial departments, results in conservative budget allocations for projects without an immediate, measureable impact. Moreover, the risky nature of projects creates a general fear of failure, as senior managers are held personally accountable for mismanagement of finances in the instance of project failure, disincentivising and demotivating the implementation of innovative projects.

7.5.7 Consequences for ISWM in Cape Town

The role of minimisation in its current form in Cape Town is brought into sharp focus considering these complexities and how seriously the CCT and SWM Department have taken the environmental imperative of ISWM to date. Institutionally, Minimisation Division is a small unit within the Planning Branch, but is responsible for the management of all waste minimisation activities. But the division does not have the capacity or power to influence decisions, while the majority of the department has not adopted minimisation as a core function. The delivery and maintenance of the existing services is the main focus.

Moreover, the legislative changes have not yet been substantially reflected in the departmental targets set in the SDBIP. It is assumed that the conclusion of the Section 78 Assessment is a crucial part of the process before the CCT can make drastic, or even minor, changes. That being said:

> the SWM Department is very thorough but in the same way they are very risk averse … forgetting to actually make decisions and move forward. The Section 78 assessment is a very detailed study [but] it took three years ... [and the department] cannot afford the delays … they are trying to find [a] 'silver bullet', but there is not a single solution. The problem in choosing an alternative is that mistakes are possible [and] the money invested makes it difficult to walk away (Hendricks, personal interview, 2013, August 5).

Delays seem inevitable, and "although systemic interventions are needed to resolve major challenges … interventions that reproduce the least amount of risk, are very expensive and are not necessarily appropriate for systemic problem solving" (Cartwright, 2014). Uncertainty about how to proceed with interventions creates a constant state of inertia, perpetuating the incumbent system, maintained through established targets, which is how the CCT measures outcomes and success of interventions.

Consider the 2007/2012 five-year IDP. The CCT IDP is the product of a series of planning processes that take place throughout the institution and it acts as the overarching guiding document, articulated through the SFA. The IDP informs and is informed by departmental business and sector plans which lay out specific strategies aligned with focus areas. The Finance Department allocates budget for these focus areas, such as the *Sustainable Urban Infrastructure and Services* SFA and the *Energy Efficiency for a Sustainable Future* SFA introduced in Chapters 5 and 6. The same office sets measureable annual targets, which are key performance indicators, described in the SDBIP and directly linked to the SFAs of the IDP. Figure 7.7 illustrates these links.

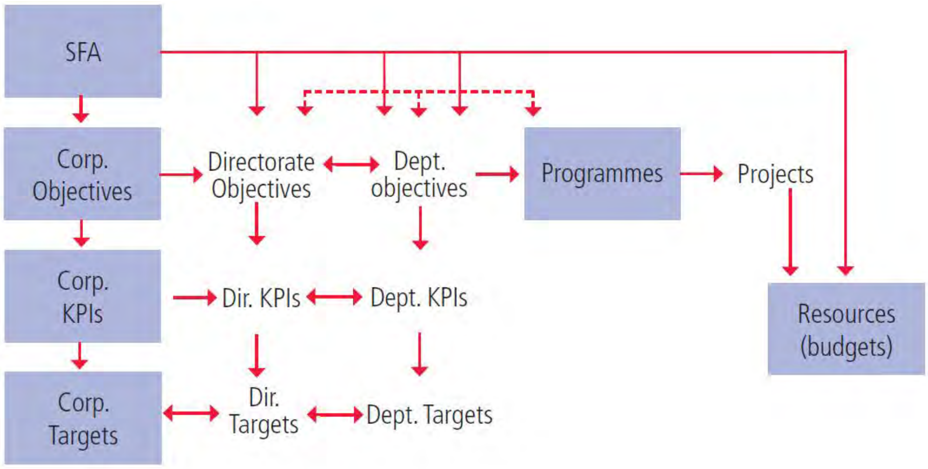


Figure 7.7: The link between the IDP and CCT Budget
Source: CCT (2007a)

The specific annual targets and strategies have largely remained standard across this five year IDP cycle despite the changes to policy and legislation. Looking further back at the first CCT IDP linked to a multi-year budget cycle in 2003/2004 through to the more recent 2007/2012 IDP, there is most certainly a shift in how SWM is articulated, although this does not transcend into major shifts in key performance indicators and targets as reflected in the IDP. Nor has it signalled a shift in the budget allocation, explored in section 7.5.4.2. Table 7.3

summarises waste-specific aspects of the IDP, demonstrating changes to how the challenge of waste management is perceived and articulated.

Table 7.3: Shifts in Solid Waste Management specific targets in the IDP (2003 -2012)

Year	Strategic Focus Area (within IDP)	Objective	Indicator	Interpretation of approach to infrastructure system and service delivery
2002/03	Trading Service			Basic, affordable service delivery
2003/04	Trading Service			Increase urban cleanliness
2004/05	Sector Plans for Utilities: develop IWM Plan	Waste production down 30% per capita	Volume of waste landfilled	Save Landfill airspace although this is articulated as part of the 'Sustainable City' 2020 Goals for Cape Town
2005/06	Clean City Program	Waste production down 30% per capita	Volume of waste landfilled	Increase urban cleanliness while the existing landfill capacity was expanded (Visserhoek North) and the Regional landfill site EIA underway
2006/07	Integrated Service Delivery: That addresses improved basic municipal services and customer satisfaction	Equitable delivery	% reduction of airspace saved in relation to volume of waste disposal[99] (% age reduction of collected solid waste versus what is finally land-filled)	Urgency to save airspace
2007/08	Sustainable Urban Infrastructure and Services	Conservation of natural resources	% reduction of airspace saved in relation to volume of waste disposal (% age reduction of collected solid waste versus what is finally land-filled)	Urgency to save airspace
2008/09	Sustainable Urban Infrastructure and Services	Conservation of natural resources	% of airspace saved in relation to the volume of waste generated	Urgency to save airspace

[99] This indicator reflects the % of airspace saved by diverting recyclables from the waste stream in relation to the volume of waste disposed of. Implementation of waste-reduction strategy (greens chipping, rubble crushing, composting, streaming and MRF, industrial waste.
% reduction in airspace used = total waste stream diverted (cub.m – m_3) / total waste disposed (cub.m – m_3)

Year	Strategic Focus Area (within IDP)	Objective	Indicator	Interpretation of approach to infrastructure system and service delivery
2009/10	Sustainable Urban Infrastructure and Services	Conservation of natural resources	% of airspace saved in relations to volume of waste generated	Urgency to save airspace
2010/11	Sustainable Urban Infrastructure and Services	**Minimise waste** (within the ambit of conservation of natural resources)	% of waste diverted from landfill	Minimisation through diversion to save airspace
2011/12	Sustainable Urban Infrastructure and Services	**Minimise waste** (within the ambit of 'conservation of natural resources)	% of waste diverted from Council WMF	Minimisation through diversion to save airspace

Source: CCT (2002), CCT (2003d), CCT (2004), CCT (2005), CCT (2006e), CCT (2007a), CCT (2008e), CCT (2009f), CCT (2010h), CCT (2011b).

The shifts in policy and strategy pertaining to SWM, demonstrates a shift in how SWM is perceived and articulated in both the department and the CCT. There are however significant barriers to realising a systemic shift toward ISWM in practise. Achievements thus far are the outcome of processes taking place at the margin, whereby a small division within the department took on the task of building an evidence base to gather political support needed to purposively intervene in a way that would shift the system onto a more sustainable pathway. Establishing broad-based buy-in, at a departmental level, for a new vision is evidently not a simple process, especially considering the "rule bound" (Ward, personal interview, 2013, December 10) nature of actors. Parallel to the policy shifts, the operational branches have continued to express the importance of the regional landfill site, described in the Wright-Pierce Report (1999), as central to SWM. There has been no deviation in capital spending for investment in alternatives. Nor is there an indication from the IWM Plan yet, in terms of the departmental strategy or substantive strategies for waste minimisation.

That some officials have taken on the task of drafting a policy and by-law in order to prepare the CCT for the obligations of minimisation as per the legislation, and a future of inadequate airspace, while also initiating the Section 78 process in an effort to be prepared for the national promuglation of NEMWA, demonstrates their willingness to work patiently within institutional constraints and devote resources to the lengthy process. This is done in spite of internal apathy in the department. A major challenge is therefore ensuring sufficient capacity to maintain these initaitives. Originally, the project champion operated out of the Policy and Stategy Unit in the Planning Branch, but now operates within a Technical and Strategic Support Unit, which up until 2012 had only one employee (now there are two posts) responsible for strategic support to the entire Utility Directorate. The Technical and Strategic Support Unit "is the sole group involved in long-term strategy, and this is a major [limitation] in the CCT. Departments such as utilities need a forward planning capacity in the form of a team, and people who are innovators" (Ward, personal interview, 2013, December 10).

7.6 Conclusion

It is evident that, from a technical perspective, the "system is designed to ensure boundary-to-boundary service delivery" (Stevens, personal interview, 2013, November 18). Moreover, the entire "service delivery system is structured to fit hand-in-glove ... new approaches [to delivery] depends on other departments; like the Finance Department playing along but there is little wriggle room because the budgets always need to balance" (Coetzee, personal interview, 2014, June 4). Therefore, interventions that do not fit within the existing system are not easily incorporated into daily operations. Adjustments to daily operations require inter-branch and cross-branch cooperation and communication. However, even minor changes, which do not necessarily require an adjustment of budget allocation, are difficult to embed in the institution. On the other hand, the reallocation of capital can be near impossible within the incumbent structure, as "motivating a capital investment that does not have a direct revenue steam attached, that can be captured by the CCT, is difficult" (Court, 2014). As such ,the status quo remains largely the same. The idea that the entire system – from procurement to delivery – is configured to work together hand in glove is not only entrenched in the officials, but is also a source of comfort as "many people within in the CCT fear change" (Coetzee, personal interview, 2013 July 19). Exploring the structure and dynamics gives insights into critical elements of the socio-technical system, including the overall institutional priorities, culture, capacity and capability for innovation and change.

Interestingly, throughout the period under analysis there are events that suggest the opportunity for socio-technical transitions is still viable. The momentum generated around the extensive research and numerous publications pertaining to the waste sector and, more generally, resource flows in Cape Town have provided an evidence base that supports the intention to shift to a service delivery model, underpinned by ISWM. Commitment across the branches has however been limited, and changes to policy have not been implemented in a way that is closely aligned to the principles of ISWM. That being said, the political receptivity to the issue is evident. This is so despite the fact that there have been no major investments that fundamentally reconfigure the networked infrastructure system, and interventions that seek to deliver more sustainable infrastructure services are somewhat divergent. The IWM Policy and the IWM By-Law following NEMWA are based on the principle of minimisation. However, these processes have become conflated with the strategy that addresses the rising cost and diminishing returns of conventional disposal technology and the diminishing airspace in the absence of sufficient fiscal resources.

Chapter 8, which follows, offers further insight and generalisable findings by drawing on Chapter 6 and using the conceptual frames developed in Chapters 2 and 3 to explain the prospects and relevance of sustainable urban infrastructure in Cape Town. This analysis and the conclusions are followed by Chapter 9, which concludes this thesis by explaining the importance of this research going forward.

8. The prospects and relevance of sustainable urban infrastructure in Cape Town

The purpose of this chapter is to look across the primary case study of the SWM Department and the secondary cases of the ES Department and W&S Department, and seek out the generalisable insights about the prospects and relevance of sustainable urban infrastructure in Cape Town. The three departments together address the topic, because they shed light on the dynamics of managing the reconfiguration of networked infrastructure as a socio-technical system. Using the case study method to identify "recurrent processes [that generate] a specific kind of outcome" (Mayntz, 2004: 237), it has been possible to identify which variables contribute to systemic change processes and what factors might inhibit such processes. The conceptual frames developed in the Chapters 2 and 3, have been used as the lens for extracting the most pertinent findings to respond adequately to the research questions, the main concern being what conditions enable "socio-technical systems [to] evolve toward greater sustainability" (Stamm et al., 2009: 25) from the perspective of middle-income cities in the global south. The intention of the analysis is to enhance existing literature that speaks to these conditions, as well as offer novel insights, gained though empirical study.

The research questions set out in Chapter 1 have guided the empirical study. Without directly answering them each in turn, this chapter will address and respond to those questions in an integrated, non-sequential way and draw conclusions. The questions that guided the research can be grouped into two categories. The first are those questions that relate specifically to Cape Town. The questions were designed to determine whether sustainable urban infrastructure, as a conceptual frame, is useful and relevant in Cape Town by tracing how the elements of the academic theory have manifested in the policy discourse within the CCT, and the extent to which this discourse has been absorbed into routine decision-making and management within the primary utility departments. The questions in the second category were designed to encourage broader reflection on the use and relevance of existing knowledge and theory on sustainable infrastructure and urban transitions in middle-income cities of the global South. It summarises gaps in the theory that emerged through an analysis of the case studies and seeks to expand the existing literature.

The literature review presents mid-level theory, and depicts the status of the literature and emerging policy discourse that prescribe sustainable urban infrastructure as one of the means to address the urgent challenges of unsustainable urban development, ecological deterioration and resource scarcity. The first part of this chapter highlights the findings of Chapter 2 in an effort to summarise the broad conclusions about how socio-technical systems might be reconfigured to shift urban infrastructure onto a more sustainable development pathway, with reference to the Cape Town context. It then uses existing literature to explore the prospects of sustainable urban infrastructure literature for Cape Town and the purchase of interventions to effect change, considering the CCT's responses to urban crises. The second part of the chapter considers the variables that support the institutional uptake of alternatives that are considered in light of the discursive domains of the sustainable infrastructure discourse identified in Chapter 2. These are efficiency, eco-efficiency, ecological restoration and regeneration, and social justice aligned with ecological restoration through the principle of sufficiency. Attention was paid to how sustainable urban infrastructure as policy agenda is adopted, and in that way the chapter seeks to understand how these discursive domains are institutionally mediated in the CCT. Therefore, the institutional mediation conceptual frame, developed in Chapter 3, is deployed to understand the institutional mediation of the identified variables to further our understanding of the conditions necessary for socio-technical transitions, with a specific focus on distilling the key challenges that may face local governments and cities.

8.1 Sustainable urban infrastructure: a lever for urban transitions

Cities have taken centre stage within the global development agenda. As the hub of social and economic activity and the home to the majority of the global population, cities have become a fascinating research locality, offering both a spatial and temporal setting. Manifestations of global environmental change are however becoming apparent in cities, and they are therefore at the centre of the sustainability agenda. Urban transitions theory suggests that the city scale is primed to be an intervention point to address these challenges because of the presence of an agglomeration of economic activities, knowledge and innovation. Furthermore, it explores and reveals the dynamics of change and development processes at the urban scale in an endeavour to resolve the unanswered question of how to develop more sustainable cities. The theory indicates that urban sustainability is best achieved through the acceptance that a healthy and thriving urban economy is largely dependent on socio-ecological sustainability realised through greater levels of social justice and ecological restoration (Agyeman, 2013; Swilling & Annecke, 2012). Decision-makers are expected to intervene to shift urban development toward an alternative pathway to avoid the negative environmental consequences of the incumbent development paradigm.

Chapter 2 introduced sustainable infrastructure and highlighted the arguments made for purposive interventions that meet the long-term objective of realising more sustainable urban development. Contemporary urban transitions theory problematises the role of networked infrastructure as socio-technical systems, moving far beyond the focus on mere technological interventions. The supposition of the literature is that by adopting the notion of networked infrastructure as a socio-technical system, it becomes possible to see how, through processes of innovation, change can occur. Socio-technical systems and transition literature reveal that networked infrastructure is not merely technologically deterministic, and reconfiguring urban infrastructure does not equate to the replacement of technological artefacts. Rather, the reconfiguration of infrastructure is the process in which a number of components that constitute a socio-technical system adjust and transform – these can include markets, technology, infrastructure or regulatory frameworks – as different institutions and actors, working at different levels, organise and reorganise systems (Loorbach et al., 2010; Geels & Kemp, 2007; Geels & Schot, 2007; Lawhon & Murphy, 2012). In an effort to understand what triggers and occasions sustainable urban transitions, much of the research agenda is located within the larger theme of transitions theory*,* which explores how to activate and accelerate transitions to sustainability (Van den Bergh et al., 2011; Loorbach et al., 2010; Geels & Kemp, 2007; Geels & Schot, 2007; Lawhon & Murphy, 2012). In Chapter 3, transitions are described as complex, long-term and co-evolutionary processes, during which one socio-technical system shifts to another through a reconfiguration process and results in significant changes that influence society on a macro scale. Technical and non-technical components are therefore co-dependent, and the transformation processes are directly influenced by the context in which these components are embedded.

Tracing how socio-technical systems adjust over time explicates how they can be purposively unlocked. Innovation, defined as the outcome of learning processes between the various actors within a system brought together to resolve a crisis, is a key driver in the process of system transition (Lundvall, 2007). To summarise, the literature suggests that learning must necessarily be a central theme when intervening for purposive transitions. Moreover, learning is the outcome of active engagement between people and networks with a range of experiences and perspectives (Johnson & Wilson, 2009). Diversity assists the attainment of real co-production of knowledge between participants, during which a shared vision for the future is established (Hodson & Marvin, 2011). Importantly, knowledge generated must be incorporated into institutional rules and culture for systemic change to take place. However, there are certainly identifiable gaps in the knowledge of these processes, not least a coherent and standardised definition of sustainable urban infrastructure.

Central to this thesis has been the goal of moving toward a working definition of sustainable urban infrastructure, a notion adopted by many and used as a normative guide for reconfiguring networked infrastructure packages. The sustainable urban infrastructure discourse prescribes a range of normative outcomes, to be achieved by a series of purposive interventions, each with possible economic, ecological and social implications. In this thesis, the sustainable urban infrastructure knowledge has been reinterpreted though an analytical device that artificially organises it into discursive domains, in a conceptual framework, for descriptive and analytical purposes. This is achieved by differentiating distinct but overlapping discursive domains in order to organise the material in the endeavour to analyse the data and interpret findings.

Across each of the discursive domains, there is a baseline commitment to an idea of sustainability, yet there are inherent trade-offs in each. At the centre of this thesis is the acknowledgement that more sustainably configured infrastructure is linked to a reduction of resource-intensive production and consumption, and the negative environmental impacts of such practises. Moreover, social justice requires that the configuration ensures affordable access to services in a way that fulfils ecological and socio-economic rights, and creates the opportunity to enhance livelihood strategies through the provision and modalities of service delivery to offer an economic pathway out of systemic poverty. Critically, it holds to the idea that sustainable urban transitions will depend on the ability to grapple with the questions of institutional challenges and social justice of developing world contexts. This is a prerequisite for future development imperatives.

Considering the question of institutional challenges, the review reveals that how to activate successful purposive interventions that enable paradigmatic shifts is not adequately dealt with in the sustainable urban infrastructure literature. What triggers, occasions and sustains transition processes that enable the institutional uptake of alternatives remains uncertain, especially outside of developed country contexts, where most of the literature originates from. A major limitation going forward is the lack of a comprehensive understanding of i) what conditions are necessary to account for the reorganisation of systems that lead to paradigmatic shifts and ii) how institutional rules and culture might militate against change. While there are a number of social intermediation processes, this research focused on the institutional dynamics. The sustainable urban infrastructure literature pays attention to the institutional dynamics that emerge during socio-technical processes, but the role of dynamic interactions between actors, social groups and networks in determining the outcome of purposive interventions, remains under-specified and under-explored. This key theme is explored in this chapter.

Considering the second prerequisite, much of the theory on the subject does not engage with the question of *sufficiency* (Swilling & Annecke, 2012) in the endeavour to realise higher levels of social justice and how this fits within the debate, while the questions of economic growth through the securitisation of natural resource flows and, to a lesser extent, environmental sustainability dominate the debate. Importantly, the principle of sufficiency implies a **reduction** and **redistribution** of socio-economic metabolic flows to ensure more sustainable and, importantly, a socially just urban system. However, there are no detailed studies that quantify the quantum of resource and carbon savings accrued, and socio-economic gains through the menu of interventions offered as sustainable urban infrastructure. Decision-makers are expected to take for granted that interventions will contribute, in some way, to intended sustainability goals.

The typology of reconfigured networked infrastructure bundles, illustrated by Figure 2.4 and distinguished by Hodson and Marvin (2010a), is useful when planning and structuring intervention processes, because it makes it possible to discern how to configure and reconfigure infrastructure systems to suit various contexts. Importantly, it encourages a shift away from the one-size-fits-all approach to one that encourages the modular establishment of compatible systems, depending on context. The typology of rebundled infrastructure configurations, juxtaposed to the various urbanisms (Graham & Marvin, 2001; Swilling and Annecke, 2012) emerging from urban transitions theory, provides a window for understanding urban form, the principles that underpin the incumbent infrastructure systems and a way in which this can be challenged and reimagined – veritable preconditions for advancing sustainable infrastructure.

The sustainable infrastructure theory is useful in its categorisation of interventions, which bundle a selection of services, of different levels and standards, into suitable packages. Recognising and understanding that different interpretations of sustainable urban infrastructure, and the bundle of infrastructure services selected, will have different outcomes is relevant for future development processes in Cape Town. In summary, Cape Town faces significant natural resource constraints juxtaposed to a myriad of socio-economic challenges. The networked infrastructure system is in a state of disrepair, requiring urgent maintenance, and the entire network requires expansion. At the same time, across Cape Town, different settlements receive standardised services, but at different levels; the major dichotomy being world-class infrastructure juxtaposed to inadequate, basic services. The case context demonstrates the overwhelming socio-political challenge of delivering infrastructure services in urban areas where competing urbanisms co-exist. For urban sustainability to become a reality, in the short to medium term, it will be necessary for the high and middle-income classes and rate-payers to reduce their expectations of the quality of a specific service and potentially pay more per unit of service, depending on the configuration of a new service delivery model, en route to ensuring full access on a suitable basis. Here the ideal of the sustainable urban infrastructure theory, represented by the principle of sufficiency, is connected to the political and fiscal realities of implementation in the South African context, which represents a highly unequal society. This is the reality for sustainable urban infrastructure in middle-income contexts of the global south.

The underpinning principles of each discursive domain have different implications for the outcomes of purposive interventions that seek to contribute to sustainability transitions. The potential interventions provided by the literature, amassed through case studies and results from experimentation, demonstrate the usefulness of reimagining how natural resources can be directed and configured for a more sustainable socio-economic metabolism. Table 8.1 offers some examples of more sustainable infrastructure systems that are applicable to Cape Town. The management of a shift from one type of system to another is however not a simple process, and in Cape Town there is evidence of resistance to change within the utility departments, despite the policy discourse that has emerged in the CCT. Foregrounding the centrality of institutional dynamics is a central contribution of this study to the literature.

Table 8.1: Sustainable urban infrastructure systems applicable to Cape Town.

Alternative system technology and alternative design principles are offered to officials and decision-makers in Cape Town:	
Electricity Systems	1. Wind farms across high wind zones for electricity generation, specifically along the west coast. 2. Centralised large-scale concentrated solar power and photovoltaic (at a regional scale), and geothermal power stations. 3. Investment in solar panel and solar hot water heaters industry to install at the neighbourhood or household scale. 4. Retrofit building adopting the principles of efficiency, eco-efficiency and sustainability (at the precinct and neighbourhood scale). 5. Make use of municipal solid waste and sewerage for gas-to-electricity interventions.
Water and Sanitation Alternatives	1. Increase the sustainable exploitation of the underground water sources through a sustainable aquifer management system. 2. Identify local water resources and harness to promote cascading resource flows. Rainwater harvesting is a critical element to this intervention. 3. Semi-centralised and circular water supply and water treatment systems for both water and sewerage. 4. Increase efficiency and eco-efficiency interventions to reduce consumption and losses. 5. Zero waste principles for sewerage through grey water reuse and recycling.
Solid Waste Management Alternatives	1. Aggressive recycling and reusing with the expansion of IWM facilities as well as drop-off facilities. 2. Full-scale separation at source. 3. Composting of green waste and sewerage sludge. 4. Zero waste principles.

The following section attempts to reveal some of the variables that account for the uptake of alternatives, and reflect on why, in Cape Town, the prospects for sustainable urban infrastructure seem poor in the short term. Best practice prescriptions of sustainable urban infrastructure remain on a normative and aspirational plain while the important question of social justice has not been included in the CCTs sustainability debate or its articulation of sustainable urban infrastructure and services. Therefore, the appetite and staying power for such change will not emerge from within the CCT under the existing conditions. The status quo will remain as long as *sustainability* interventions are not supported by a strong policy agenda and alignment across the institution, which can be linked to embedding interventions in society. The natural resource and carbon saving targets prescribed in the IMEP, the CCTs environmental *guide* (CCT, 2009a), are minimal and obtainable, but restrict the agenda to the efficiency and eco-efficiency discursive domains elaborated in Chapter 2. Moreover, service delivery targets are underpinned by the assumption that by freeing up both system capacity and financial resources through efficiency and eco-efficiency measures, it is possible to meet targets through the expansion of networked infrastructure services, using the incumbent service delivery model. But, while there is not significant institutional appetite, ability or preparedness within the organisation to adopt a new service delivery model, there are interesting lessons to be learnt.

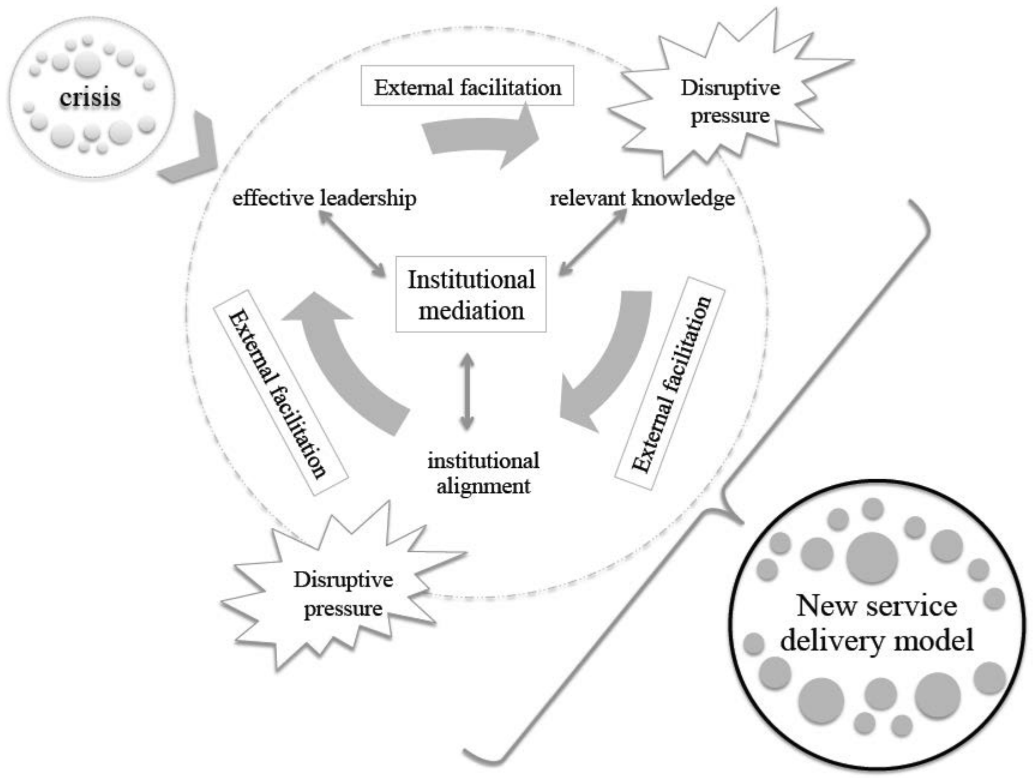
8.2 Variables relevant to the institutional uptake of alternatives

The discursive domain conceptual frame constructed in the literature review was developed to explore the driving questions of this research, which fundamentally seek to explore the prospects and relevance of sustainable urban infrastructure in middle-income cities of the global south. This section offers a high-level analysis of the three utility departments and focuses on innovative purposive interventions.

Across the cases, themes emerge that assist the endeavour to understand variables that determine the institutional uptake of alternative infrastructure configurations. Each of which are the reflection of a series of engagements that have undergone a process of institutional mediation. It is possible to identify where, in each of the three cases described in the empirical chapters, these variables are absent and what the implications are for successful purposive interventions going forward. These variables are non-sequential, and do present themselves in different formats at different times during transitions processes. Moreover, reflexivity and learning are implicitly present, as interventions undergo institutional mediation. But for the purposes of this chapter, as revealed in Chapters 6 and 7, they will be described in the following order: (i) a moment of crisis[100], (ii) the pre-existing presence of effective leadership, (iii) institutional alignment, (iv) access to knowledge, and (v) external

[100] Following Pieterse (2006), the notion of crisis should not stir up negative connotations of uncertainty, but rather reference a critical moment in time when important decisions about the future are made.

facilitation to mitigate against institutional inertias that militate against the implementation of a new, well-informed model of service delivery. Importantly, this new model of service must not just reflect changes to the technical or financial aspect of delivery, but the fundamental institutional logic that perpetuates systems. These variables, and how they interact within a particular boundary that determines the scope of action, are visually represented in Figure 8.1.



8.1: Stylised representation of variables that support system change
Source: Author

8.2.1 Moments of crisis

Moments of *crisis*, which have occurred within each of the utility departments, have precipitated the urgent need for new ways of thinking and new ways of doing, and therefore acted as a catalyst for change or development. Each of the utility departments has responded to a particular crisis in a way that could be considered as an intention of committing to a more sustainable socio-technical configuration. The academic inquiry reflects on whether the crisis was deep enough to stimulate sufficient change processes to shift the development trajectory of the municipality (and, by extension, the city) to a more sustainable pathway. The empirical inquiry reflects on the nature of an intervention in two ways; the first being how it is represented by a particular discursive domain, familiar to a department or CCT official acting as project champion, and second being whether an intervention point is at the operational level or through renewal and expansion activities.

The management of networked urban infrastructure can be divided into two broad categories, under which fall a number of activities and processes to ensure the ongoing functioning and reproduction of the system. The first is that of renewal and expansion activities, which implies capital investment for the expansion, replacement and rehabilitation or refurbishment of the networked infrastructure, generally requiring a significant amount of capital investment. The second is that of operational activities, both operations and maintenance, which implies operational expenditure for daily operation and necessary maintenance of the infrastructure network. By tracking the processes that unfold in the CCT Utility Directorate as departments seek to influence operational and capital-based activities, the variables that shape institutional change become clearer.

Responses to moments of crisis unfolding in the SWM Department are noted in the process to transform the service delivery model from one that relies on disposal to one that is embedded in the principles of ISWM. Similarly, the ERM Department is undertaking to introduce and institutionalise energy efficiency and electricity savings measures. The W&S Department's introduction of WC/WDM initiatives and the Janitorial Service are additional examples of these responses. These interventions would however be dispersed across the discursive domain conceptual framework, depending on the type of the technical intervention and the underpinning rationale. The underpinning rationale determines the efficacy of interventions in ensuring successful purposive interventions for sustainable urban transitions. Evidently, the financial and technical assumptions, reproduced through institutional habit (held onto by officials), have to be recognised as being false or inadequate for emergent contextual conditions, in order to implement a new business model that translates into a fundamentally different service delivery model.

Efficiency gains are noted in electricity consumption attributed to demand-side management (DSM) interventions. This is specifically attributed to efficiency retrofits to council-owned properties, although there are market-related factors that affect electricity consumption trends. Electricity sourced from the DWF, on the other hand, would be more closely aligned to the eco-efficiency domain. Similarly, in the W&S Department, overall water consumption decreased due to WDM interventions as part of the WC/WDM Plan (CCT, 2007f). The most significant gains are attributed to leak repairs, pressure management and the reuse of treated effluent. WC interventions transverse the efficiency domain, and the restorative and regenerative domain, but WDM interventions transverse the efficiency domain and eco-efficiency domains. Moreover, the process that resulted in the inclusion of a Janitorial Service for informal settlements may be construed as an intervention that promotes a higher level of social justice, because it reflects an intention to ensure access in an effort to fulfil socio-economic rights. However, the impact on the ecological sustainability remains undetermined and in general, there is a lack of recognition of social justice, as well as ecological restoration as central components for the successful delivery of sustainable urban infrastructure and services. The absence of these elements within the institutional discourse is an indication of the systemic impossibility to absorb the full implications of sustainable urban infrastructure theory and, by association, adaptively pursue its logical conclusion in this context, which is the transformation of the service delivery model to ensure full access to socio-economic rights.

In the SWM Department, relatively minor changes to the operation and management of drop-off facilities accounted for a significant reduction in both the volume and tonnes of garden waste and builder's rubble disposed of at landfill. The improvements noted here each took place during a time when services were continually being extended across the city of Cape Town. Interventions such as these at the operational level do not require substantial capital investment, but have had a positive impact on efficiency gains in the case of the electricity sector, and represent efficiency and eco-efficiency gains in the case of the water and sanitation sector. The literature does propose that the larger the capital allocation for investment, the more scope there is for the rapid dissemination of innovation for socio-technical transitions. There have not been any permanent adjustments to the major capital allocations, but the construction of the Kraaifontein IWMF is an example of a major change to conventional operating procedure, requiring a relatively substantial capital contribution. The combination of minimisation and beneficiation activities diverts waste from landfill and inserts recyclables back into the socio-economic metabolism, offsetting emissions. This represents the eco-efficiency discursive domain. These interventions have been dispersed within the conceptual frame, illustrated in Figure 8.2.

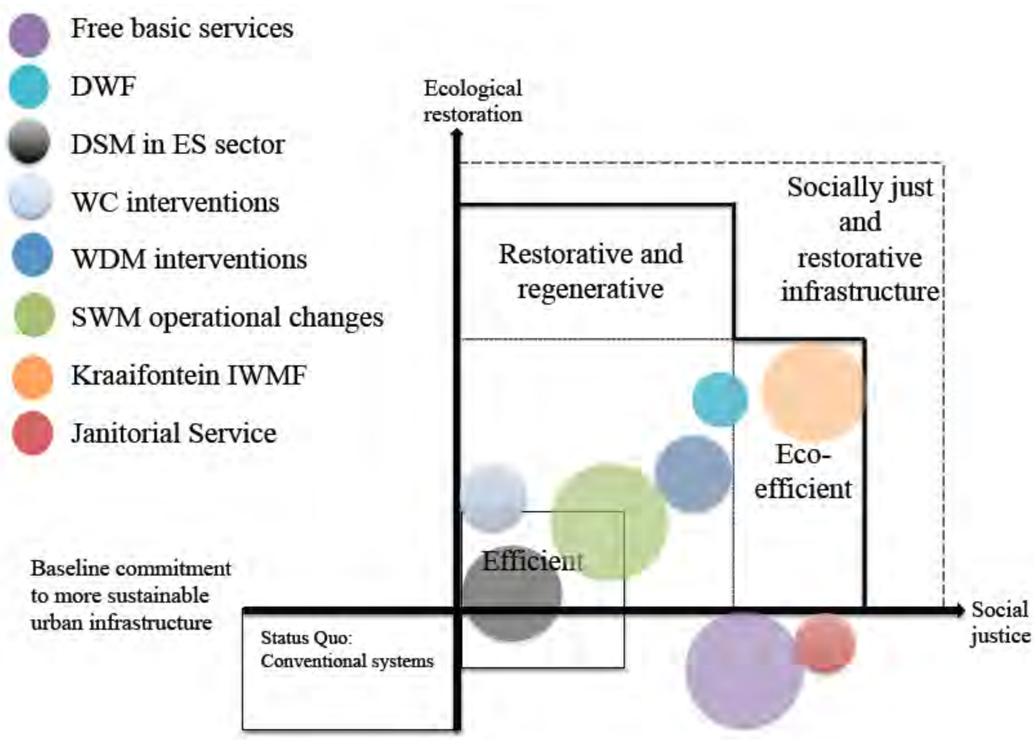


Figure 8.2: Representation of interventions as dispersed in the sustainable urban infrastructure discursive domain

Source: Author

Projects of the departments have been neatly nestled within the conceptual frame to illustrate how the discursive domains have been used as a legitimating discourse. It is less clear how the activities that account for these *alternatively* configured socio-technical systems relate to conventional institutional activities represented in the bottom left-hand corner of the framework. Moreover, how will these activities cohere in a way that drives systemic change through the introduction of a new service delivery model, where activities are grouped in the top right-hand corner of the conceptual framework? Figure 8.2 reveals the extent to which the discourse has been absorbed into routine decision-making and practise of the utility departments, as well as which elements of the discourse is absent. The broader socio-economic and inclusive aspects of sustainable urban infrastructure theory remain well beyond decision-makers' conceptual framing of infrastructure challenges in Cape Town. Moreover, evidence collected during interviews suggests that most officials consider these interventions to be adequate, having resolved an immediate problem emerging out of a moment of crisis or instability. They are however short-term solutions to a systemic issue and consequently place the CCT in the precarious position of perpetually managing crises.

Extending the life span of existing infrastructure will not solve the problem. Largely, the status quo remains, reinforced by repeating established expenditure cycles. That free basic services are delivered is considered adequate, even though these services are of an inferior quality and do not secure marginalised citizens access to the socio-economic metabolic flows provided by the urban system. This major shortfall was alluded to in Chapters 5, 6 and 7. The institutional rules that structure activities, the bounded nature of delivery practices and the institutional culture that predominates, which will be elaborated on in section 8.3, account for this. However, these elements of the academic theory have to be part of the conversation if urban territories intend to shift toward a more sustainable development paradigm. Speaking plainly, from this it is possible to conclude that the service delivery model and the interpretation of crisis are driven by the technical assumptions of officials, the financial model that ensures the production of the technical system, and the existing institutional habits, which reinforce the service delivery model.

8.2.2 Presence of leadership

The success of an intervention for systemic shifts is however evidently dependent on *pre-existing effective leadership* that can transform an identified crisis, usually solved via short-term reactive measures, into an opportunity for system change with long-term intention. If one considers the definition of leadership to be the "development of vision and strategies, the alignment of relevant people behind those strategies, and the empowerment of individuals to make the vision happen, despite obstacles" (Kotter, 1999: 10) it is important that leadership must be equipped with a relatively well-formed and coherent discourse to promote a legitimate alternative discursive domain, supported by evidence. Considering the understanding of leadership as explained in Chapter 2, it is necessary for an actor or network to be able to aggregate the right collection and combination of people, evidence and power for the activation of purposive transitions. This is confirmed by the data represented in the Chapters 6 and 7.

The SWM Department presents the most convincing example of such leadership. Actors in the Policy and Strategy Unit in the Planning Branch, now the Technical and Strategic Support Unit that provides support for the entire Utility Directorate, have provided the leadership necessary to initate transformation processes in this sector. The long-term plan to adopt an alternative approach was underpinned by the consistent acknowledgement of the need for ISWM as the legitimating discourse, supported by pending national legislation and contextal evidence. Purposive interventions in this sector have gone ahead despite the incumbent regime's tight grip on the dominant conventional technology of landfilling, which is likely to be included in the combination of technologies for ISWM. Recognising the need and being able to work within the bounds of the bureaucratic structure while persuing activities that do not neatly fit into conventional siloed institutional structures, at the margin of the organisation, is a demonstration of *phronesis* (Grint, 2007), which, when coupled with knowledgeability and capability, is an example of effective leadership.

Similarly, the Energy and Climate Change Unit has taken on the task of addressing the electricity and energy crisis as a real and urgent challenge in Cape Town. However, in this instance, the discourse emerged before actors were consolidated into an institutional unit. Now the issue is firmly emdedded within the institutional practice through the inclusion of *Energy for a Sustainable City* as a SFA of the IDP and actors are actively pursuing initatives to make inroads to resolving, specifically, energy-related challenges. At the other end of the spectrum is the W&S Department, where responses are reactive in the absence of pre-existing leadership equipped to transform a crisis into an opportunity. Here, the crisis in the water sector is dealt with in an ad hoc, disjointed way with the overarching intention being to extend the lifespan of the network through demand-side interventions and augment supply through conventional means. Even though efficiency (and some eco-efficiency) measures are included in the WC/WDM Strategy, they are limited by the inward-looking approach to water and sanitation services. This is a signficant shortfall, because it limits occasions for alignment across the department, directorate and the CCT. The case of the Janitorial Service is somewhat different, but it can be interpreted in the same manner. The SJC, along with their actors, used the opportunity of the sanitation crisis, and more specificially the Toilet Wars, to generate momentum and raise awareness for the issue of social injustices in Cape Town. This is a unique but valuable expression of practical wisdom (Schweigert, 2007) as an expression of leadership in the context of crisis. However, we see how these promising activities have become reduced to petty, fruitless engagements between the CCT and the SJC in the absence of adequate institutional reflexivity and learning within a particular, bounded collaborative structure.

8.2.3 Institutional alignment

The expression of effective leadership – to recognise opportunity in a crisis and act with wisdom, knowledgeability and capability – must be matched by a degree of *alignment*: a key variable for the success of purposive interventions. This refers to the institutional alignment of political and institutional support whereby an intervention or experiment has political support, backed up by financial resources, and enough senior management and officials who buy into the notion and support a particular intervention. At the same time, demonstrating the need to change the status quo, even if it is at the margin of organisational activities, will be surfaced by effective leadership that is able to draw attention to the contradiction between policy and practice or the inadequacy of the status quo. Evidence suggests that once actors have aligned these elements, it is possible to fashion a pilot or special programme. The intended and unintended impacts of interventions are fed back through continuous learning processes, which stimulates the institutional appetite for transitions and/or encourages further learning processes. This is however not a pre-existing or permanent mechanism; rather, it is the outcome of purposive activities of an interlocutor who is able to surface the tensions within the institution.

The departure point to explore this variable is the acknowledgement of the impacts of poor alignment. It is evident within the utility departments, where there is a lack of political and departmental support for the delivery of the *Sustainable Urban Infrastructure and Services* SFA. As demonstrated in Chapters 6 and 7, the *Sustainable Urban Infrastructure and Services* SFA is the responsibility of the utility departments alone, and lacks political oversight and administrative support. This is unlike the support for the *Energy for a Sustainable City* SFA, institutionalised in the form of an Energy and Climate Change political committee, which comprises Councillors that represent several sectors, as well as high-level officials. Arrangements such as these keep topical issues on the agenda, offering opportunities to gain institutional and financial support as well as overarching institutional alignment to drive reform.

Staying with the example of the ERM Department – its relationship with the ES Department comes into question, and it is possible to identify how *alignment* is a variable for successful interventions. The ERM Department has managed to realise a substantial alignment from a political standpoint, enabling institutional coordination and legitimising the activities of those driving reform. That there is an established SFA for *Energy for a Sustainable City* as well as the Energy Committee, which provides coordinating capacity and oversight, and reports directly to Executive Mangement, is an indication of this. However, while the EEDSM programme has been successful, the unit is now coming up against limits because of poor alignment with management of the ES Department. Despite the commitment in the ES Sector Plan to promote alternatives in the electricity sector, there is limited effort to include those commitments in day-to-day routine and departmental habits. The literature suggests that through cooperation between the ERM and ES Departments, there is potential for learning to align departmental visions for ES in Cape Town and encourage innovative activities to support that vision (Flood, 1999; Johnson & Wilson, 2009; Hodson & Marvin, 2010b). But, currently, there is little room for this type of engagement between departments for a number of reasons, which will be elaborated on in section 8.3. How this significant political alignment was achieved warrants attention.

The political need to be seen as a cutting-edge municipality at the forefront of urban reform is a very powerful driver in Cape Town. The CCT considers itself a leading municipality and has positioned itself as a globally-orientated, world class African city. Ensuring that what is internationally recognised as best practice and as cutting-edge ideas are included in policy statements evidently influences the priorities of the CCT. As such, the presence of a climate change and sustainability agenda must necessarily be present, because of the nature of global policy circuits and the adjoining discourse. However, it does not mean that the CCT's executive management, councillors and officials have a deep understanding of the implications of these discourses, as discussed in section 8.1. Yet, the mere fact that these issues are on the agenda is noteworthy for understanding the emergence of a particular discourse within an institution, and how that is used for development processes. There is a professional imperative for senior managers to be seen to be on the cutting edge of their professions and disciplines. They therefore need to translate global policy discourses about what constitutes good, forward-looking, modern policy agendas into the local arena. It is these mobile, mutating policy discourses (Peck & Theodore, 2010), combined with local political and disruptive pressures that compel vested interests to engage with alternatives. The implication here is that as a precondition there must be, in principle, a commitment to the sustainability agenda that gives leadership within the institution, the opportunity to draw attention to inconsistencies and to establish alignment by utilising the right discourse at the right time to frame and reframe moments of crisis.

Returing to the question of alignment, the events that transpired over time in the SWM Department can be attributed to the institutional support for and alignment with its endeavour to realise ISWM. Using the Status Quo Report (Mega-Tech, 2004) as a starting point, actors resolved to draft the IWM Policy and IWM By-law using the the pending legislation and airspace crisis as a rationale. Political support was won due to the importance of a sustainability agenda, and despite the absence of a coherent vision across the branches and department, senior officials were aware of the need to get approval for IWM facilities that would provide relief until the regional landfill issue was resolved. The Kraaifontein IWM Facility represents a product of alignment; it secured the financial resources and institutional support necessary to complete such a project. The outcome is a novel, successful intervention that supports the intention to embed ISWM practices into the institutional service delivery model. In parallel to this, were the ongoing processes of the IWM By-law and the Section 78 Assessment, stipulated by legislative parameters set out in the MSA and MFMA, which provided the legitmating policy and rationale for this kind of investment. By building a case for ISWM over time, through the alignment of activities, has demonstrated how alternatives become embedded within the institution. Before moving on to the next variable of *useful knowledge*, which has been both pertinent and invaluable to the SWM Department's relative success, the case of the W&S Department represents an interesting example of alignment presented in an altogether different scenario.

The roll-out of the Janitorial Service in informal settlements represents a facinating divergence from the centralised service delivery approach driven by the municipality. Alignment between the W&S Department and the Executive Council for the delivery of this service was only achieved after a significant amount of lobbying and pressure from civil society. This is an interesting scenario wherein an external body exerted disruptive pressure on the political arm of local government, forcing the executive committee to engage with the utility department to resolve an issue. What is fascinating, is its demonstration of the importance of external pressures, exerted by actors who used a moment of crisis to alert the CCT to challenges facing marginalised communities, which forced CCT to reconsider the viability of its conventional approach to routine service delivery in this context. By acknowledging the inadequacy of incumbent practice, the CCT is shown to have recognised a particular *crisis,* a crucial variable of change processes, as it has been argued. However, because solutions were driven by reactive crisis management and the intervention was premised on internal technocratic approaches, disconnected from external pressure, the result was an unfeasbible intervention. The literature suggested that including those whose lives are affected by interventions, using a participatory approach to decisiom-making, is critical for social justice (Uvin, 2007). Here, the CCT failed to recognise the opportunity to engage collaboratively with civil society in this matter. It remains to be seen how external, disruptive pressure can advance social justice in this instance. Through the additional pressure from this external body we might see systemic change to the business model as the principles of planning, monitoring and maintenance, juxtaposed to adequate budget allocations, become more embedded within the institutional makeup. Importantly, pressure from civil society thereby may well be a way to achieve greater levels of transparency from local government, especially around the issue of social justice, especially since the CCT does not have the mechanisms to recognise inadequacy and tensions in incumbent practice.

8.2.4 Access to knowledge

Useful knowledge is an important variable that supports the institutional uptake of alternatives. The institutional mediation conceptual framework highlights how continuous learning processes between actors and networks, both internal and external, are at the centre of change processes that result in the adjustments to institutional rules and culture (Bernard & Armstrong, 1998; Flood, 1999; Geels, 2004; Johnson & Wilson, 2009; Avelino & Rotmans, 2009). Access to relevant and useful knowledge, achieved by engaging with intermediaries, academics, researchers and other specialists as well as communities that are expected to benefit from a service or intervention, has proved to support deeper and more effective purposive interventions.

There is the strong indication that the failure of the Janitorial Services can be attributed to the absence of relevant *knowledge* in the CCT resulting in poor planning and implementation. The Janitorial Service is considered a significant accomplishment, as it represents a shift in the CCT's understanding of the challenge, which demonstrates the value of slow advocacy. However, the service was rolled out without adequate planning and management. The project in its current form has therefore, in many ways, failed and also aggravated the conflict between the municipality and key social movements such as the SJC.

We learn from the SWM case that the production of useful and accessible knowledge is a central component of transition processes. Throughout the period of analysis, there had been a constant presence of learning processes that encouraged the production of useful knowledge that provided leadership with evidence to support their intention. The success of both the IWM By-Law and the Section 78 Assessment rests on the learning processes and the generation of useful knowledge within the institution over time as an outcome of engagements between a multiplicity of actors and networks. Interestingly, the impetus of learning processes and knowledge generation, within the SWM Department and CCT, was often external or facilitated beyond the CCT structures through academic institutions. Stemming from a set of research processes that relied on international funding flows and a complex set of institutional arrangements between international aid organisations and academic institutions, evidence was generated to support intervention processes, which, at the same time, were partly triggered by the research outcomes. Herein lies the importance of intermediaries and action networks where there is strong emphasis on knowledge creation. However, as will be elaborated on below in section 8.3, the CCT's ability to engage in an collaborative way is extremely limited.

It is common for external actors or social groups to be included in decision-making processes, and consultants are looked to for analysis, recommendations and technical support. There are several instances of this in the SWM Department, where major capital expenditure was influenced by an external group. The Kraaifontein IWM Facility is the outcome of engagement and collaboration between a number of social groups, which included CCT officials, engineering consultants and environmental consultants (as well as input from a range of other specialists), and surrounding communities, facilitated by a community liaison. As a point of reference, compared to the process that determined the configuration of the Bellville WFM, which meets only the standard requirements of an RTS, rather than an IWMF, the success is evident. Similarly, a consultant was commissioned to conduct a feasibility study of waste management practices in Cape Town (Wright-Pierce, 1999). The process of selecting landfill disposal technology as the dominant technology for SWM and identifying the landfill site location was a direct result of the consultant's recommendation. Interestingly, these processes demonstrate an example of the outcome of selecting a single intermediary as a knowledge generator versus identifying social groups to participate in an action-centred network with a common interest. Consultants in this case, as intermediaries, are from the same intellectual school and world-view, with similar professional training as the cohort of senior managers that rely on them. Therefore the product of consultative processes reinforces existing practice. On the other hand, action-centred networks are more capable of representing a comprehensive solution that reflects the views of all those that participate within the network. This is not to suggest that decision-making processes within these networks are not complex, yet the inclusion of multiple actors, including intermediaries, creates the space for learning and arriving at a more durable response, if not solution. Here learning is achieved through the deconstruction or devolution of power from one social group, making room for agency within the network for actors from other social groups participating within the domain.

8.2.5 The role of external facilitation and disruptive pressure

Across the departments, themes emerge that offer a possible answer to the question posed above: what variables shape institutional uptake of desired alternatives? Combined, incremental changes at the margin do suggest there is potential for greater shifts toward more sustainable infrastructure configurations; activities that, combined, will possibly cohere for systemic socio-technical change. However, interventions in operational and capital-based activities are not spontaneous. Opportunities are revealed by actors or social groups with effective leadership, either within the institution or external actors, such as social movements, who recognise the opportunity of crisis and apply disruptive pressure to bring attention to the inadequacy of the status quo. Recognising the opportunities for interventions requires reflexive learning processes, during which decision-makers are exposed to novel development approaches. Moreover, translating those lessons learned during pilot interventions and project-based activities into substantive evidence that supports the case for the institutional uptake of alternatives is mandatory for the reforming of institutional rules and culture, and thereby the implementation of a new service delivery model. The description of the utility departments in Chapters 6 and 7 indicates that reflexive learning processes are not common within the institution. A major issue is that the institution does not have the mechanism or interlocutors to surface inherent contradictions between policy and practice, the status quo and those vested interests associated with it, and thereby a way to determine what needs to be done to overcome these institutional blind spots and inertia. This raises questions around how to encourage greater reflexivity towards systemic change.

The SWM Department has made substantial inroads to achieving the adoption of a new service delivery model that encompasses the principles of ISWM. However, there is a degree of inertia encompassing the process. Institutionally, poorly understood and defined challenges, a lack of engagement with alternative discourses and risk aversion, encumber the implementation of purposive interventions. In the meantime, the incumbent service delivery model remains deeply entrenched, due to the superstructure of programmes, policies, strategies and plans aligned with political and financial commitments (Carley & Christie, 1993) that maintain the existing regime. This can equally be said for the ES Department and the W&S Department. Evidence from the findings suggests that there is a need for facilitation to mitigate institutional inertia that militates against the implementation of a new, more transformative model of service delivery, or external, disruptive pressure from social movements that draws attention to malfunctioning practise. There is evidently more to the idea of ensuring access to useful knowledge through learning processes: relevant and useful knowledge must be delivered in such a way as to transform the service delivery model, not merely the business model of delivery. Not only must the technical assumptions and financial commitments of a business model be challenged, but so too the institutional habitats of an organisation. Therein lies the opportunity to reconfigure the service delivery model whereby the nature of the service, infrastructure and, importantly, the outcomes are transformed. Through the presence of useful knowledge it is possible to build the business case for an alternative, which the institution adopts through learning processes. Leadership, however, may not be enough to facilitate practices to overcome the inertia commonly found around these processes.

Strategic intermediaries as critical facilitators of change processes are not necessarily present and therefore relevant in developing contexts. Yet, transitions theory relies heavily on the role of intermediaries and intermediation to overcome the deeply complex institutional challenges that influence decision-makers and, therefore, strategies for changes processes. Therefore, when considering existing knowledge on sustainable urban transitions juxtaposed to sustainable urban infrastructure, the case study reveals the prospective value of external disruptive pressure to draw attention to moments of crisis whereby even the most complacent institutions are forced to reconsider the viability of the status quo. Social movements, in addition to intermediaries, that represent civil society on a non-governmental, multi-stakeholder platform may initiate or insert themselves into transition processes as a means to overcome inertia associated with change processes.

Precedence demonstrates that in circumstances where a project is novel, exogenous to the traditional silos and possibly supported by external funding flows, there is opportunity to generate integrated solutions across two or three departments or branches, achieved through an (initially) ad hoc project team or action-group that provides a supporting structure. The momentum generated for changes can become lethargic as barriers begin to arise where insufficient attention is paid to the importance to institutional learning between the various overlapping departments required to participate beyond routine institutional practice. Therefore, there is certainly the need for skills and knowledge as well as agency, and the commitment of a dedicated project champion with effective leadership capacity. With the support of external facilitation, and through processes of institutional mediation, the institutional uptake of alternatives may become a reality.

8.2.6 Prospects for purposive interventions in Cape Town

Overall, the empirical chapters demonstrate that the provision of sustainable urban infrastructure remains a secondary priority and the aspiration of only a few actors within the CCT. A clear message about what sustainable urban development means for the CCT and the city has not been clearly defined in policy. There is a distinct disconnect between the overarching strategy and plans that guide the CCT and those activities of the utility departments. Infrastructure-led growth is a key component of the overarching development plan for the city, while Sustainable Urban Infrastructure and Services SFA is the defining strategy to ensure the development of a sustainable city (CCT, 2012c). However, this SFA is interpreted with a lens that magnifies financial sustainability, and there is a very limited conceptual understanding of the role that infrastructure plays in facilitating natural resource flows through urban territories, which enable socio-economic activities to ensure that the city continues to function. Moreover, there is little grasp of the fact that the commitment to providing sustainable urban infrastructure and services can contribute to sustainable socio-economic development. Rather, the status quo of service delivery remains strongly institutionalised, and investment is concentrated in projects that continually shift capital toward established expenditure patterns. This occurs despite noticeable moments of crisis or periods of instability in the incumbent system, and opportunities for purposive interventions within the utility sector. The following section reveals the institutional conditions that reproduce the incumbent service delivery model by distilling the key challenges that encumber purposive interventions. In other words, its reveals how institutional rules and culture heavily influences the institutional uptake of alternatives.

8.3 Distilling the key challenges

The institutional mediation conceptual framework makes two implicit assumptions that rely on feedback loops. The first is that the quality of the human and non-human resources within the collective and the strength of the interactive continuous learning processes will greatly influence the prospects of transition processes. Resources include the human actors and capacity present as well as capabilities that actors, together, possess, and the non-human artefacts, including but not limited to assets, materials or capital, monetary, artefacts and natural resources (Avelino & Rotmans, 2009). The second implicit assumption pertains to the quality of retrospective reflexive learning. It assumes that the intended or unintended consequences of purposive interventions are considered and reflected on, and fed back into ongoing learning processes. By exploring the themes of the insitutional mediation conceptual framework with reference to the Cape Town study, it is possible to distill some of the challenges experienced by governments in the endeavour to institutionalise alternatives. Themes that are explored with reference to the evidence provided include: (i) learning and innovation, (ii) divergent views and consensus, (iii) culture and norms, and (iv) issues of capacity and capability.

8.3.1 Innovation and learning

It was shown in the literature review that innovation is particularly important for socio-technical transitions because of the technological momentum, path dependency and lock-in that characterise large technical systems (Hughes, 1983; Summerton, 1994; Unruh, 2000; Geels, 2004). Moreover, that learning and on-going learning processes, achieved through interactions and collective learning experiences during which knowledge is created and incorporated into institutional arrangements (Lundvall, 2007; Johnson & Wilson, 2009), are fundamental to innovation that supports sustainable urban development, and subsequent successful transitions. However, quite unlike the call from the literature for radical sustainability-orientated innovations (Stamm et al., 2009), innovation that encourages systemic change is likely to be incremental, as purposive interventions gain traction over time to become embedded in institutional rules and culture. Therefore, innovation that supports institutional and relational change as well as technological change (Swilling & Annecke, 2012) is central to socio-technical transitions wherein rules that govern decision-making are re-written (Flood, 1999; Geels, 2004).

Evidence from the case of the Utility Directorate suggests that learning processes cannot be assumed nor artificially inserted in purposive transitionary processes. In fact, in the absence of learning processes, the prospects for introducing purposive interventions with a developmental agenda for sustainability transitions are poor. Interviews with a number of institutional actors revealed that cross-branch and cross-departmental collaboration is limited, and the possibility for this type of interaction is stifled by a range of factors, some of which will be discussed in what follows.

The willingness of actors to collaborate is limited by a number of factors, not least being the divergent views and expectations regarding the nature of organisational responsibilities of each branch or department. Yet, what is further evident is that the skills and capabilities needed to implement innovative projects are not located solely within a single branch or department; rather, multi-departmental capacity is required for building capabilities for purposive interventions. In the CCT, evidence indicates that officials work in isolated silos where responsibility is determined by the service delivery function, prescribed by a constitutional mandate. Specifically, because of divergent priorities and expertise collaboration is unusual between environmental experts and professionals, and technical experts and engineers, and designated project management teams that have the capacity for a long-term project conceptualisation and implementation.

More importantly, it has also been shown that the nature of interventions, in response to an anticipated crisis, is dependent on the context of the crisis, and how that crisis is perceived and understood by actors and social groups. The primary case study of the SWM Department and two supporting cases of the ES Department and W&S Department, demonstrate how within the CCT, different departments or branches respond to crisis within a sector. An example is how the various branches within the SWM Department, in the absence of deliberative learning spaces, have understood and responded to the crisis of diminishing landfill airspace. Similarly, the ES Department and the Energy Efficiency and Climate Change Unit's divergent responses to electricity savings exemplify how the priorities of these two departments differ. This is so regardless of their mutual mandate to save electricity. Clashes between branches and departments, due to antagonism and a lack of trust, affect the ability of project champions to implement innovative projects while opportunities for open and positive engagement are reduced. Prospects of overcoming the barriers to collaboration are particularly bleak where actors have a vested interest in maintaining the status quo.

The culture, orientated to cultivating *self-serving* officials, as described in Chapter 7, disrupts knowledge transfer between officials and branches, particularly where information is considered confidential or the intellectual property of a particular department or actor. This phenomenon further affects information and knowledge sharing between branches and departments, even if they are concerned with the same specific departmental responsibility. Information is not openly or readily shared amongst colleagues; this is counter-productive to reflexive learning. As such, one of the major issues of organisational silos in this context is the negative impact that it has on collaborative and effective decision-making that ensures continuous learning, adaptation and the pursuit of new modalities of service delivery. South African municipalities however require that basic services are delivered in a predictable and consistent fashion, based on hierarchical authority and accountability structures. Therefore, the disjuncture between technocrats, financial administrators and environmental professionals is problematic, especially where some departments inherently have more power than others. Interestingly, power is allocated based on a set of premises held within the institution, based on institutional habit. For example, actors within the ES Department use its role as a major income generator to lobby the Finance Department to agree to reduce its financial commitment to the ERM Department. The relationship between these two departments is strong because of positively reinforcing and mutually beneficial engagements.

In order for transformative processes to take place, a learning culture must become embedded in the institutional culture or, at the very least, the institutional culture must be open to alternative mechanisms of engagement. Committed personnel as well as adequate resources are required to cross the boundary between divergent perspectives and intellectual positioning (Bernard & Armstrong, 1998). This is not to deny the importance of **both** effective cross-cutting networks and silos. Knowledge of sustainable urban infrastructure emphasises the role of integration, which emerges as key theme within the literature discussed, and dominates much of policy discourse (Suzuki et al., 2009; Moffatt et al., 2011; Schramm, 2011; World Bank, 2009; 2010 UN-Habitat, 2012). However, it is, in fact, argued here that in middle-income contexts, where infrastructure services are only partially delivered but institutional routines are fairly well established, the desired goal of integration through institutional consensus and adoption of a single vision for service delivery is unlikely. It has become evident that one of the specificities of the context under analysis is precisely that the larger portion of innovation is sectorally specific. Within that, there is the need for a higher level of inter-silo cooperation and collaboration. In this way, those activities that take place at the margin of departmental routine can collate and cohere, and through a process of sectoral reconfiguration there is opportunity for a transition to manifest. Cross-cutting action networks can overcome some of the challenges associated with silos juxtaposed to limited reflexivity by encouraging reflexivity while supporting sectoral innovation, wherein engagement is both vertical and horizontal. This pertains to the CCT, the utility directorate as a whole, and the individual departments. Herein lies the link to the importance of both *leadership* and *alignment*.

8.3.2 Divergent views: when difference overwhelms consensus

Johnson and Wilson argue that “the relative power of collectives or collective action [is greater] opposed to individual action” (2009: 128). Moreover, Hodson and Marvin (2009) indicate that contestation and negotiation are important aspects of transformative learning and conflict does characterise change. However, empirical evidence suggests that establishing a collective with a common goal is elusive. The primary case and two supporting cases illustrate that overwhelming differences can evidently militate against change. The utility departments, which have divergent normative orientations coupled with a set of strong, and sometimes contradictory, rules, are illustrative of this. The result is a breakdown of communication, further entrenchment of silos and a culture that rejects synergies emanating from cross-cutting networks on a fundamental level. In simple terms, negotiation does not always work, and establishing a shared vision is elusive. Bernard and Armstrong (1998) eloquently explain that "integration will succeed only to the extent its proponents recognise that, although it is true that individuals and organisations may need better ways of knowing, adapting and reflecting their actions, the learning required to achieve these goals is inherently risky, difficult and fairly chaotic" (Bernard & Armstrong, 1998: 46).

Establishing an integrated, shared vision for infrastructure management has been elusive in the CCT. The alignment of shared visions becomes improbable when interactive and learning spaces are not conducive to transformative learning. Officials tend to avoid chaos, difficulty and discomfort, preferring to only participate in processes with which they are familiar. Specifically, the mechanism for constructing a common vision for the Utility Directorate is inadequate and there is no unifying goal for future planning. The overarching vision for Cape Town is articulated in the IDP – the highest strategic decision-making tool (CCT, 2007a). Policy discourse of the CCT expressly includes the delivery of sustainable urban infrastructure and services as an SFA of the IDP, which speaks to infrastructure and is the responsibility of the Utility Directorate. However, it does not receive the support required to make substantial inroads to change capital and operating budget allocation. Rather, the activities of the departments are articulated in the SDBIP, which is the product of departmental sector and business plans underpinned by a set of established technical assumptions, developed during disconnected and divergent processes. Reaching a mutual normative orientation and understanding of issues so that departments follow an integrated approach will be impossible without at least recognising the need for a new way of engaging. How, then, do we understand change processes in the absence of consensus?

The literature suggests that strategic intermediaries are key to resolve differences, establish consensus, and ensure outcomes that would not have been possible with out them (Hodson & Marvin, 2009), but the presence of intermediaries cannot be assumed. S*trategic* *intermediaries* have largely been absent in the empirical cases due to the contextual specificity. Rather, evidence indicates that intermediaries, as knowledge facilitators, have been present when additional technical expertise was required. It is common practice for the CCT to procure the services of a consultant to conduct an investigation in instances where the CCT lacks adequate capacity to carry out such a study. In instances where an intermediary is included as a facilitator of new knowledge, the information and knowledge generated, whether a text or technology, becomes a regime artefact and therefore part of the collective (Long, 2001). Evidence from the case study suggests that even if the intermediary is no longer in commission, the legacy of the knowledge created can be substantial and astounding. The significance of this lies in the fact that an intermediary has a relatively high degree of control of what knowledge is transferred, which is based on a particular set of experiences and the interests of that intermediary. This can pertain to who is included or excluded in knowledge creation processes associated with intermediation and what that intermediary might consider as important knowledge. The two reports compiled for the SWM Department, the Wright-Peirce (1999) and Integrated Solid Waste Management Plan Status Quo Report (2004), are examples of this. The theoretical underpinnings and the conceptual frame used to compile these two reports were based on a set of assumptions that are not necessarily consistent with sustainability intentions, but still guide the SWM Department's decision-making. This is despite the presence of new, well-informed policy.

Recognising that knowledge is a regime resource and becomes power-laden (Avelino & Rotmans, 2009) to varying degrees at different times, depending on the actors present, can be of great value to actors considering purposive interventions. In the same breath, it is for this same reason that resources can also be used for deviant purposes. This raises concerns for what type of intermediaries should be invited into change processes for both strategic purposes and more simple knowledge-transfer processes. In this context, action-centred networks, held together by a linking pin would perhaps offer greater value. Considering the absence of learning spaces, establishing action-centred networks that have a common interest in reaching a specific outcome may be a way to overcome overwhelming differences. This was elaborated on above in the discussion of the Kraaifontien IWM Facility and provides the link to the value of *external facilitation*.

8.3.3 Rules that govern the institutional culture and norms

Politicians and decision-makers in senior management positions have the power to both pursue and stifle sustainability-orientated interventions. Institutional norms and culture play a significant role in transition processes and this cannot be underestimated. Activities are structured and coordinated around these regime rules (Geels, 2004), which impact how meaningful purposive interventions are. Rules that actors and social groupings adhere to are deeply entrenched in the institutional culture and processes and constantly reinforce one another. The literature demonstrates that despite the relative inappropriateness of certain activities and established orthodoxy that frame actions, there is a reluctance to let go of them and embrace new means and methods (Flood, 1999; Geels, 2004). This has been noted across the Utility Directorate where established means and methods are dominant and the introduction to novel concepts, ideas and innovations are not always readily welcomed. Therefore, introducing alternatives does not mean that they will become pervasive. Rather, it is dependent on the receptivity of political and institutional climate, and the appetite for change and potential risk. Transition processes are inevitably socio-political in nature. This will be explored further in the formal, normative and cognitive rules that govern behaviour.

8.3.3.1 Formal rules

Formal or regulatory rules are usually legally binding agreements or well-established systems that govern behaviour (Geels, 2004). The suite of legislation that governs the activities of local governments is specifically designed to ensure the long-term fiscal viability of municipalities (National Treasury, 2013). Evidence suggests that the prescribed legislation that regulates procedures strictly controls how officials are allowed to and endeavour to deliver services. Stringent regulation, designed to ensure the delivery of services in a consistent fashion based on hierarchical authority and accountability structures, is perceived as onerous and a barrier to change processes, which has, evidently, limited the willingness to participate in change processes. This is explicitly expressed by officials in the SWM Department.

Performance management: aspirations for a clean audit

An example of prescribed rules to which officials are obliged to adhere are the performance management agreements, aligned with the municipal Performance Management System (PMS), which are entered into with senior management and municipal leadership on an individual basis. These agreements outline a set of "targets and indicators for efficiency and effectiveness" (CCT, 2011g: 74), which dictate and drive the behaviour of senior management and senior officials, especially since it is also attached to a financial bonus system. While the PMS ensures transparency and accountability, targets are structured to ensure the rapid delivery of services, and the maintenance and rehabilitation of networked infrastructure aligned with the sector plans of the SDBIP and departments. This diminishes the willingness of senior management to allocate resources to uncertain, novel projects that may not have the requisite impact on targets set out in the PMS. These contracts perpetuate the self-serving culture where officials have two options: *deliver or die*. Officials are bound by a structure that defines functions and actions. This is especially dominant in the Utility Directorate, which is service delivery-orientated and responsible for spending the bulk of the City of Cape Town budget. Silos, in conjunction with delivery targets and performance management targets, mean that officials have tunnel vision, limiting the scope of synergies that might appear in the periphery.

Criminalisation of financial mismanagement

In addition to the Municipal PMS, the Municipal Finance Management Act (MFMA), which prescribes financial management practices for municipalities, places a number of conditions and restrictions on municipal officials. The MFMA criminalises any manifestation of financial mismanagement and stipulates that the municipality can place the liability for deliberate or negligent actions when performing a function of office on officials and thereby recover any losses or damages from them (De Visser, 2012). The implication is that any perceived wasteful expenditure could be penalised, which limits the incentive to pursue innovative interventions and enforces a risk-averse culture. The "prospect of personal liability for the incorrect interpretation of law [forces CCT officials] … to strive for strict compliance rather than for purposive interventions" (De Visser, 2012: 144). The pressure to be legally compliant encourages risk avoidance over experimentation. The tight control and regulatory stipulations are also representative of rule-following under all circumstances rather than contextual decision-making in some circumstances.

8.3.3.2 Normative rules

The normative rules that govern the behaviour of utility managers in Cape Town have been institutionalised over time as the organisation has matured and dictate how things *should* be done. Rules that guide the normative orientation of an organisation are generally shared and considered the organisations priorities. However, the normative rules that govern the actions of individual members of a branch or a department may differ, which creates an interesting context for change processes.

In principle, achieving universal service delivery is not only the core mandate of the CCT but the fundamental underpinning value that utility managers adhere to. However, during analysis of the empirical evidence, it became clear that ensuring that the lights are on, the water is running and waste is removed as efficiently as possible for rate-paying members of the population is the institutional priority. This might be a subtle difference to some, but not to those who lack access to essential, basic services. Moreover, the way in which this is carried out does not necessarily match what is envisioned in the Constitution. Long-serving senior management and officials have interpreted local government's obligation to deliver services in an "equitable and sustainable manner" (Constitution of RSA, 1996, Section 155) in the narrowest sense, and applied a conventional technocist understanding of service delivery mandates. The normative standard of this value equates to ensuring service delivery in the most financially affordable manner so as to relieve short-term pressures and maintenance requirements.

Environmental sustainability is considered a *nice to have,* and the broader socio-economic challenges of social justice remains an under-conceptualised and therefore a secondary priority rather than part of the core function of the utility departments. Even with the presence of policy that promotes integrated waste and water resource management, and electricity efficiency and savings, the attempt to contribute to attaining goals laid out in these policies remains ad hoc.

It is furthermore considered that realising efficient universal service delivery is contingent on accruing revenue using a consumption driven model. Using a different discourse, a deeply entrenched development value considers the financial sustainability of the CCT dependent on the ability to generate income through the sale of services, facilitated by networked infrastructure underpinned by natural resources. Therefore, maintaining world-class infrastructure in wealthy suburbs and business districts, at all costs, to ensure the CCT's ability to deliver cheap, basic, essential services to poor and indigent households through the tariff model is a priority. Service delivery has become corporatised in a number of other metropolitans in South Africa, whereas the City of Cape Town has been deliberate in its effort to maintain control of service delivery, because of its importance for revenue generation. Fiscal resources continue to flow to the utility departments as long as the allocated budget is spent in a particular way prescribed by the MFMA (*MFMA 56 of 2003,* 2003), which then ensures the ability to generate income in the future. This means that there is a disjuncture between policy and how budget is allocated, limiting the opportunity for novelty and innovation.

Service delivery, coupled with financial sustainability, therefore remains the normative institutional rule. Overcoming this requires practical examples and empirical evidence that convinces decision-makers that service delivery is not only possible with a combination of demand-side management interventions and the implementation of sustainable urban infrastructure, but service delivery will become impossible without it.

Within this nexus of normative standards, the overarching tendency of the CCT is to be risk averse; a culture that is enforced by the Finance Department. Mandatory compliance with legislation requirements of National Treasury, audited by the Auditor General, creates the ideal environment for well-known practises that are low risk and safe. Therefore, the utility departments continually fall back on tried and tested technologies, where outcomes can be quantified based on a cognitive understanding of the life cycle of revenue generation capacity and the maintenance investment required. Moreover, in instances where attempts to reconfigure infrastructure bundles are made, the novel nature of sustainability-orientated innovations forces project champions to follow the letter of the law. Significantly, stricter compliance and onerous procurement processes delay project progress, which limits the willingness of additional actors to participate in such processes and generate adequate momentum for pervasive change. This is linked to the perceived onerous requirements of legislation when considering long-term investments, and the establishing of private–public partnerships, which are inevitably required for the reconfiguration of infrastructure bundles on an appropriate scale.

8.3.3.3 Cognitive rules and accepted truths

Cognitive rules that govern behaviour have been developed over extended periods and are sense-making tools for actors within the field. The competencies, skills and knowledge accumulated are considered the cognitive capital of actors within a field (Geels, 2004). Actors and social groups responsible for the management and operations of network infrastructure are only able to understand what knowledge they have accumulated through experience; in this instance, conventional infrastructure systems.

The CCT, in its current form, has been in existence since 2000. The numerous institutional changes to the government roles and mandates since the previous dispensation, enabled through the MSA (*MSA 32 of 2000*), have taken place over a relatively short period. Conversely, many of those in middle and senior management have a set of core competencies that are deeply entrenched and determine how they understand the priorities, means and methods of service delivery. These competencies have not altered in parallel to legislative and policy changes. Engineers responsible for the operation and management of these networked systems have accumulated knowledge pertaining to that system, refining how the system is understood and the role it plays within the socio-technical system.

What is important to take note of is the fact that each actor has their own cognitive rules and built up competencies. The introduction of an alternative discourse or technology may be incomprehensible to some, who have worked in a particular manner for the bulk of their employment. Others might welcome such activities if they are exposed to these practices. Well-established cognitive rules cannot be used to understand the new problems that have arisen in Cape Town. The standardisation of networked infrastructure in Cape Town has further limited exposure to alternative systems. There are only a few instances where those with technical expertise and skill in the departments are able to grasp the need for an alternative development agenda that takes into account resource scarcity and environmental insecurity, as well as the associated socio-economic challenges and to need to introduce higher levels of social justice.

8.3.4 Capacity and Capability

The importance of capacity and capability for transitions was raised in Chapter 3. Considering that the role of a strategic intermediary is the building of capacity and capabilities, it is unclear how these two qualities develop over time for transition practices. There is well-established literature that explores capability and capacity in organisations (Lichtenthaler & Lichtenthaler, 2009), but it is inadequately cross-referenced by transitions literature. Moreover, it is assumed that strategic intermediaries are present to cultivate capacity and capability.

The case study is illustrative of the inadequate level of capacity and capability within the CCT to successfully engage in purposive transitions processes. This simply means that the CCT does not possess the requisite capabilities, required to mobilise capacities that enable transformative processes. Moreover, capacity constraints, for example of skills, knowledge and know-how, and resources, further limit possibilities for purposive interventions. Capabilities can be enhanced through collaborative processes, and thus can also be improved upon, but this is restricted by the nature of institutional interaction.

In the case of the Utility Departments, technical and engineering professionals who manage networked infrastructure have been educated and trained in a particular paradigm that defines their competencies. The principles that guide network configuration ensure the construction of a sophisticated, convenient, reliable and financially efficient system. The professional field of engineering and institutional rules that govern behaviour reinforce this, and thereby reinforce their personal aspiration of meeting expected engineering-based standards. Across the utility departments, and the political spheres that allocate power, technocrats are considered experts and are allocated a great deal of responsibility with regard to service delivery. The lens of delivery is therefore highly technical, but lacks an integrative lens, not dissimilar from how mono-disciplinary fields of study are taught, academically.

At a broader professional level, a single set of norms has been continually reinforced since officials completed and received their qualifications. Therefore, despite the fact that these individuals are experts in their field, with a great deal of experience, the knowledge – both skills and information – required to adopt alternative delivery systems, remains intangible to them, unless it becomes a professional imperative. Furthermore, long-serving officials are unconsciously confronted with a self-reinforcing vested interest in maintaining the status quo, because of the professional identity, sense of personal achievement and accomplishment associated with conventional engineering practices. At the institutional level, as has been shown before, the performance and assessment system reinforces the existing logic.

The phenomenon of long-serving officials in middle and senior management in the Utility Directorate who have not undergone reskilling or competency-enhancing processes limits capacity at the institutional level, and compounds this challenge. There is no evidence of systematic processes within the CCT to expose officials to alternative approaches or opportunities for reskilling. Although there are examples of some officials, along with political counterparts, attending international conferences, and municipal and academic institutions under the guise of *study tours* to gain exposure with the intention to transfer knowledge on return (Cartwright, personal interview, 2015 March 2), the effectiveness of this must be called into question, given the CCT’s extremely limited culture of engagement and collaboration.

It is not the intention to dismiss those individuals who do possess adequate leadership skills, knowledge and expertise to recognise the need for the reconfiguration of networked infrastructure. There are examples where, over time, opportunities, generally arising from crisis and inconsistencies in incumbent orthodoxy, have opened up to those with foresight and agency to take action. Actors who activate their inherent agency with effective leadership skills have an important role in initiating and sustaining successful purposive transitions. While the literature suggests that a degree of political and institutional power is needed to take action, evidence suggests that an actor's agency can be activated before accruing power. In this way, it is possible to take action in an effort to obtain power or for resources to become sufficiently power-laden, using Avelino and Rotman's (2009) terminology, through alignment processes. While Smith et al. argue that "the loss of the ability to make a difference is the loss of power" (Smith et al., 2005: 1503), perhaps power is rather distributed, or other social groups are empowered which indicates its fluid and dynamic nature.

Power both hinders agency, and makes way for agency, and as power is reconfigured and distributed across social groups that are empowered to embrace new ways of participating in and configuring socio-technical systems, actors are able to activate inherent agency to engage in those organising practices necessary for change processes. This dynamic construction and reconstruction of power is evident in the SWM Department. Gathering data around the long-term challenge of airspace availability through a series of learning processes brought attention to the urgent need for both legislative and policy changes, and operational adjustments, sanctioned by both the Executive Council and Finance Department. However, this is still met with obstacles in the form of the Disposal Branches effort to maintain the status quo by what Grin et al. (2010) call privileging a certain type of expertise or practice already present within the institution, i.e. landfill technology. Despite this inertia, the presence of continuous learning processes is encouraging, even where actors seeking change are embedded in departments with insufficient power to take action. The growing appreciation for the need of new ways of delivering services across the CCT implies a form of empowerment across the institution and, as such, the possibility of systemic change.

8.4 Conclusion

The purpose of this chapter was to reveal i) what conditions are necessary for the reorganisation of institutional systems that lead to paradigmatic shifts in the configuration of urban infrastructure and ii) how institutional rules and culture militate against change. This chapter used evidence gathered about the Utility Directorate of the City of Cape Town, as the institutional body responsible for the management of urban infrastructure. In this way, its revealed variables that shape institutional uptake of desired alternatives. Variables include moments of crisis, effective leadership, institutional alignment, relevant and useful knowledge, and external facilitation to enable actors within the institution to see beyond their entrenched frames of reference to consider alternatives. These variables are discernable within the cases, although they certainly did not present themselves in such a neat and orderly fashion. Rather, these variables emerged during different periods of on-going change processes, often in parallel and in different guises.

Evidence suggests that a response, resulting from a crisis, is the outcome of the recognition of the necessity for change that emerges from engagement processes. Acknowledging the inadequacy of an incumbent system occasions the need for purposive interventions. Sustaining transition processes is critical for a sustainable urban future, yet this clearly remains an under-studied area. The findings suggest that there is varied scope for successful purposive interventions. Within the operational category it becomes possible to see how the CCT can expand efforts to initiate change on a broader level. Low-tech and low-capital interventions, especially with a demand-side management focus, seem to have some purchase in decreasing socio-economic metabolic flows. However, decisions to intervene at particular moments have been associated with the urgency to resolve supply crises and are therefore reactive rather than proactive. Going forward, it would seem the capacity of the institution to anticipate the long-term changes necessary to reconfigure the network infrastructure bundles to shift Cape Town toward a more sustainable development trajectory is poor. Where major capital contributions are required, it is possible to begin to discern how institutional culture and routine practice militate against purposive interventions. In Carley and Christie's words, the "superstructure of programs, political and funding commitments and careers … built around [the] definition" (1993: 166) of what utility managers and officials assume to be within their area of competence, stifles innovation. It demonstrates just how challenging it is to implement new ideas and processes within the institution. Tightly regulated mandates and boundaries of responsibility, linked to a well-defined set of rules that structures activities, maintain the status quo.

The literature placed learning at the centre of innovation and change processes (Lundvall, 2007; Grin et al., 2010). Learning for development depends on a number of factors, which can be loosely summarised as high quality resources and reflexivity. But these factors cannot be assumed, and the CCT is testament to that. Simply stated, there is very little space for learning within and across departments. It was explicitly referenced that the discipline of removing oneself from daily routine to be exposed to *the other* is extremely uncommon. What then will innovation look like in these types of contexts?

On reflection, it is evident that without relatively pervasive changes within the rules and culture that structure activities of the incumbent regime, achieved through interventions as the outcome of learning processes between multiple actors and social groups that foster innovation, it is unlikely that alternatives that support a transition toward a more sustainable development trajectory will become embedded. The current institutional culture tends towards maintaining the status quo, militating against interventions in preference of conventional practice. There is evidently a lack of recognition and understanding of sustainable urban infrastructure as the facilitator of more sustainable resource flows, which, when considered in conjunction with the principle of sufficiency, can contribute to increased levels of social justice and sustainable socio-economic metabolic flows through urban territories.

Juxtaposed to these findings, are two valuable contextual specificities that enhance our understanding of urban transitions in these contexts. The value of sectoral rather than integrated innovations, supported by cross-cutting networks, that do not necessarily rely on fully integrated institutions has been introduced. At least for the immediate future, until alternatives become more acceptable, there is value in nurturing activities that take place at the margin within silos, while an evidence base is developed to a point at which there is institutional coherence around these issues. There is a need to introduce deliberative learning spaces that encourage interaction and dialogue between officials from different branches and departments. The quality of resources within the system means very little when the structure of the organisation creates well-run silos, but that limits room for cross-cutting networks and engagement. In addition, the role of external facilitation and disruptive pressure from social movements, as both an initiator of changes processes and a sustaining energy, is an interesting specificity of middle-income contexts where poverty and inequality predominate. While, this requires a greater level of interrogation, there is certainly a role for disruptive pressures exerted by actors who can use moments of crisis to sustain challenges that force even recalcitrant and complacent institutions to reconsider the viability of the status quo.

9. Conclusion

> "When our analytical focus centres on how the wires, ducts, tunnels, conduits, streets, highways and technical networks that interlace and infuse cities are constructed and used, modern urbanism emerges as an extraordinarily complex and dynamic sociotechnical process. Contemporary urban life is revealed as a ceaseless and mobile interplay between many different scales, from the body to the globe" (Graham & Marvin, 2001: Xx).

When I first read these few opening sentences of Graham and Marvin's (2001), seminal *Splintering Urbanism*, I did not imagine that it would shape, and define, the burning questions of my research. But, the banality that I associated with infrastructure was overwritten by the astonishing realisation of my role, as not merely a passive user but as a component of the system that continually reproduces the technical network on which urban dwellers are so reliant. This fundamental shift has shaped my understanding of cities, in the context of global environmental change, diminishing finite natural resources, poverty and inequality. Cities, and the modern urbanisms which define them, are not an **outcome** of a set of actions, but a **constant** socio-technical process that is incessantly reproduced and can be reconfigured. Committing to a sustainable reconfiguration, and navigating messy and unknown sustainable pathways for urban development, is a defining challenge for the 21st century. From the global mega-trends described in the introduction of this thesis, to the evidence amassed in the empirical chapters, it is clear that a sustainable socio-ecological transition is the only viable option to achieve integrated and just future development trajectories. Sustainable urban infrastructure has been identified as a potential solution for the multiple urban challenges. This is startingly evident in the framing of global and local development imperatives captured in the seventeen draft Sustainable Development Goals (SDGs) that were debated and ratified at the United Nations Summit in September 2015 by world leaders.

The SDGs mark the end of the Millennium Development Goals and the beginning of a new era of development goals that will set the agenda and policy priorities for how best to move away from an extractive, environmentally harmful and exclusionary development model to one that is resilient, reduces inequality and establishes a low-carbon economic development model. Following one of the largest consultative processes undertaken by the UN, the seventeen SDGs along with sub-goals and targets were drafted over the past three years. Of major significance and interest, from the perspective of the findings of this research, is goal nine: "Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation" (United Nations, 2015: 17); and goal eleven: "Make cities and human settlements inclusive, safe, resilient and sustainable" (United Nations, 2015: 18); and goal twelve: "Ensure sustainable consumption and production patterns" (United Nations, 2015: 19).

These three high order goals, as well as a range of sub-goals, speak directly to the arguments made in this thesis pertaining to increased resource efficiency, sustainable infrastructure and sustainable urban development transitions. Sub-goals intend to configure and construct sustainable, resilient, and inclusive infrastructure, emphasising affordable and equitable access (United Nations, 2015). Furthermore, there is specific reference to the retrofitting and implementation of efficient infrastructure and industries that reduce demands on natural resources and waste sinks by promoting sustainable industrialisation processes to promote the "endeavour to decouple economic growth from environmental degradation" (United Nations, 2015: 16). The SDGs underscore why the sustainable urban infrastructure literature is so vital at this particular moment in time. Arguably, no more so than in the global south where development challenges are most complex and most acute, which has been explicated by this research. It is with this in mind that the significance of this research will be clarified and discussed using three thematic points of reference.

The first thematic reference point is that this thesis has generated substantive findings, as discussed in Chapter 8, in the context of Cape Town. The empirical contribution of the study is the in-depth analysis of the institutional aspects of socio-technical dynamics of the CCTs utility sectors and Utility Directorate. The institutional aspects of the management and operation of networked infrastructure have received little attention to date, but offer a great deal of insight into the prospects for shifting Cape Town's development trajectory towards more sustainable pathways. The findings of this research feed into a growing demand for novel cases of underexplored contexts. In so doing, this study offers a theoretical contribution to the sustainable infrastructure knowledge and theory through emergent experiences in Cape Town.

The Cape Town metropolitan government adopted the discourse of sustainable infrastructure as early as 2007, but what this meant proved slippery across organisation, departments and branches within various infrastructure departments. Central to this thesis has been the goal to bring greater conceptual and definitional clarity to the malleable policy discourse of sustainable infrastructure in order to move beyond normative intent and foreground practice. The thesis demonstrates that in the absence of such clarity it is impossible to effect what exactly needs to be done, by whom, with what resources and towards what anticipated outcome and impact. These crucial institutional questions are further always underpinned by politics and power. Put differently, as long as there are multiple interpretations it becomes easy to blur the lines between successful purposive interventions and interventions implemented under the guise of sustainability, but which, in fact, perpetuate the status quo or produce a new model of (unsustainable) extractive capitalism (Hodson & Marvin, 2010a). This conclusion offers the ideal segway to the second significant contribution of this thesis.

The thesis has brought together much of the literature and discourses pertaining to sustainable urban infrastructure, which have up until now been disconnected, limiting our understanding and therefore capacity to research issues arising during transition processes, and purposively intervene. By constructing a conceptual model, illustrated in Figure 2.6, that illuminates the distinctions and overlaps between competing conceptions of sustainable infrastructure, expressed as discursive domains, it has been possible to distinguish between the various interpretations of sustainable urban infrastructure that emerge from the literature and discourses of reduction, redistribution and sufficiency, which invariably filters into policy and practice. Critically, it establishes that sustainable urban transitions will depend on the ability to grapple with the questions of institutional challenges and social justice of developing world contexts. The Cape Town case study, on which this thesis rests, is timely because it specifically uncovers the importance of having a sharper distinction between different conceptions of sustainable urban infrastructure, by drawing links between the literature, and the implications of those conceptions. Originally constructed as a heuristic device for the sole purpose of distinguishing between discursive domains and organising empirical data, the device in fact has been useful in the identification of various purposive interventions discussed in the empirical chapters. Therefore it is a valuable tool to analyse policy uptake and deployment, which enhances our understanding of the implications of interventions, so as to ensure the substantive transformation, as envisioned in the SDGs, in this and other contexts. Viewing interventions, through the lens of the conceptual frame translates high-level policy prescriptions for contextual specificities, allowing decision–makers to draw the necessary conclusions required for successful transformative processes. This is critical because policy uptake does not necessarily mean contextually relevant implementation.

Another valuable contribution gained from the study is that it foregrounds the institutional factors that will inevitably influence the uptake and deployment of policy intentions, using the framework devised in chapter 3. The adoption of the SDGs at an institutional level is not straightforward. Much of the theory that speaks to urban transitions, socio-technical transitions and sustainable urban infrastructure is unclear about what exactly triggers, occasions and sustains transitions that enable the institutional uptake of alternatives. Uncertainty broadens the debate to include a variety of possible factors that influence change processes in different ways, depending on the context, scale and geography. Using the case described, it is possible to discern that because of the uncertain, dynamic and complex nature of purposive interventions, successfully designing and managing change processes is unlikely without the presence of appropriate levels of organisational learning and reflexivity. Underpinning this conclusion is the understanding that change processes initiated by purposive interventions will only be recognised and internalised if appropriate levels of institutional reflexivity and leadership are present. The ability to purposively respond with appropriate interventions in moments of crisis that manifest from an inadequate and inconsistent incumbent development paradigm, is dependent on the capability and capacity of institutional actors and social groups present within the system. Activating agency in these moments is contingent on a set of factors that already exist within the institutional culture, not least the reconfiguration of the incumbent power structure and its redistribution across social groups that have a stake in decision-making processes.

Surfacing inconsistencies within the incumbent development paradigm will be a challenge for institutions who do not have the mechanisms or interlocutors that permanently seek to interpret the impact of routine practice as well as purposive interventions. In the absence of deliberate reflexivity and learning, institutions must necessarily be open to engagements with multi-stakeholder groups that represent a rich and multivalent institutional ecology. Intermediaries and strategic intermediaries will likely be inadequate to draw attention to the delinquent tendencies reproduced by the service delivery model. Both external disruptive pressure, and facilitation therefore have important role to play this transition processes. The multitude of barriers, held up by vested interests, will be overcome through a combination of intermediaries, the external facilitation that secures access to new forms of knowledge and external, disruptive pressure that represents the demands of social movements and civil society. This fuels the important continuous learning processes that occur within cross-cutting, internal and external networks, during which new knowledge is generated. Therefore, considering the governance relations between the various social groups that participate in transition processes, and the relation to governing institutions, will be a key theme when endeavouring to engage in such policy deployment.

Lastly, by exploring the themes of the institutional mediation conceptual framework with reference to the Cape Town study, this thesis reveals and distills some of the challenges experienced by governments in the endeavour to institutionalise alternatives and extract important lessons. The context-specific narrative of the CCT has resonance in, and therefore lessons for other cities of the global south, which is the third significant contribution of this thesis. Here the ideal of the sustainable urban infrastructure theory, represented by the principle of sufficiency, is connected to the political and fiscal realities of implementation in the South African context, which represents a highly unequal society. This is the reality for sustainable urban infrastructure in middle-income contexts of the global south. It is worth reiterating the two valuable contextual specificities that enhance our understanding of urban transitions in these contexts. The first is the value of sectoral rather than integrated innovations, supported by cross-cutting networks, that do not necessarily rely on fully integrated institutions who lack adequate institutional coherence. The second is the role of external facilitation and disruptive pressure from social movements, as both an initiator of changes processes and a sustaining energy for transition processes. While, this requires a greater level of interrogation, there is certainly a role for disruptive pressures exerted by actors who can use moments of crisis to sustain challenges that force even recalcitrant and complacent institutions to reconsider the viability of the status quo.

As the groundswell of sustainability related sentiments gain momentum, in the effort to address the challenges discussed in this thesis, the criticality of engaging with the sustainable urban infrastructure theory, as it relates to urban transitions, is growing in urgency. The programmatic goals and targets of the SDGs are poised to embed the sustainable urban infrastructure agenda into the planning and policy process of nations and cities. However, without foregrounding the power relations and institutional mediation of these policy choices, the reconfiguration of socio-technical processes in the endeavour to achieve sustainable urban development maybe stifled.

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Annexure I: Interview list

Name	Position	Date of interview
Basholo, Z.	Manager: Water Demand Management and Strategy, Water and Sanitation Department	2013, October 31
Carroll, T.	Manager: Collections & Drop-Off Facilities, Solid Waste Management Department	2013, November 25
Coetzee, B.	Manager: Technical Strategic Support. Utility Services	2012 October 4
Coetzee, B.	Manager: Technical Strategic Support, Utility Services	2013 July 19
Coetzee, B.	Manager: Technical Strategic Support, Utility Services	2014, June 4
Diedericks, B.	Senior Technician: Cleansing, Solid Waste Management Department	2014, September 4
Dhlamini, L.	Managing Director: Johannesburg Water	2013, August 2.
Hall, C.	Head: Contract Management Services, Disposal Branch, Solid Waste Management Department	2014, June 3
Hendricks, N.	Director: Development Services-Office of Deputy CCT Manager	2013, August 5
Jones, B.	Head: Green Energy Electricity Services Department	2012, October 10
Kariem, A.	Manager: Finance, Technical Support S	2013, December 4
Kasner, S.	Executive Associate, Engineering and Environmental Consultant, Jeffares and Green (Pty) Ltd.	2013, November 8
Leeuwendaal, D.	Manager: Finance and Commercial, Electricity Services Department	2013, October 14
Ladouce, M,	Head: Research and Development, Solid Waste Management Department	2013, November 28
Mackay, W.	Water Demand Management and Strategy Branch, Water and Sanitation Department	2014 September 17

Mahomed, S.	Energy and Climate Change Unit, Environmental Resource Management Department	2014, June 4
Naude, A.	Head: Disposal Specialist, Disposal Branch, Solid Waste Management Department	2013, November 28
Novella, P.	Manager: Disposal, Disposal Branch, Solid Waste Department	2014, October 22
Oliver, I.	Area Head: Disposal Branch, Solid Waste Management Department	2013, November 25
Oliver, I.	Area Head: Disposal Branch, Solid Waste Management Department	2013, December 2
Rhode, P.	Head, Bulk Water, Water and Sanitation Department	2013 November 4
Roux, S.	Mistra Urban Futures Researcher	2014, November 29
Rodkin, J.	District Head, Reticulation Branch, Water and Sanitation Department	2013, October 13
Trollip, H.	Faculty Member, Energy Research Centre, University of Cape Town	2013, November 7
Siyengo, L.	Water Demand Management and Strategy Branch, Water and Sanitation Department	2014 September 17
Smit, E.	Senior Professional Officer: Research and Development Collections Branch, Solid Waste Management Department	2013, December 2
Smit, E.	Senior Professional Officer: Research and Development Collections Branch, Solid Waste Management Department	2013, November 25
Stevens, D.	Area Head: Tierberg Cleansing Branch, Solid Waste Management Department	2013, November 18
Ward, S.	Head: Energy & Climate Change, Environmental Resource Management Department	2013, December 10
Van Vuuren, A.	Manager: Planning Branch, Solid Waste Management	2013, July 15