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A measure of sustainability in the context of urban water management in South Africa

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DOCTOR OF PHILOSOPHY

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Declaration

I, Kirsty Jane Carden, know the meaning of plagiarism and declare that all the work in this document, save for that which is properly acknowledged, is my own.

Signed: _____

Date: _____

Acknowledgements

This thesis is dedicated to the memory of my godson, Mark Roux, who still had so many of his own dreams to follow

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Abstract

The aim of this research was to develop an understanding of and measure the potential for sustainability in a South African urban water context. This was achieved through the use of a systems approach to develop and evaluate a composite index – the Sustainability Index for Integrated Urban Water Management (SIUWM) – based on a vision of what sustainable urban water management means to decision makers at selected local authorities around the country. The vision was expanded into a sustainability framework to identify suitable key indicators for the index, as well as those which link with existing regulatory measurement initiatives in the South African water sector. The hypothesis was that if a city improves its scores on all of its indicators over a period of time, there is potential for long-term sustainability in the specific urban water system. The SIUWM was applied as a ‘snapshot’ analysis to nine case study cities (using 2010 / 2011 figures) and the results highlighted the inherent strengths and weaknesses in the management of urban water in each city, and consequently across each dimension of sustainability. Regularly-updated and publicly-available quantitative data as well as qualitative information from interviews with municipal officials were used as input to the index. Key performance indicator scores from the Department of Water Affairs’ regulatory performance measurement systems were also used in the computation of the index scores. In this way the SIUWM was able to provide a detailed analysis which could be used over time to track changes in performance, establish goals and inform strategic processes to leverage support for improved water services. Through its visioning process, the SIUWM is also able to identify vulnerabilities in the water system and provide information that is potentially useful for mitigating the root causes of these vulnerabilities. Sustainability assessment in the urban water sector, by way of initiatives such as the SIUWM, is not only about taking stock of progress – it is also about identifying shortcomings and challenges so as to contribute to initiatives and policy-making aimed at achieving sustainability. By clarifying what sustainability constitutes in the context of urban water management in South Africa through the use of a multi-dimensional approach to sustainability assessment (as is achieved by way of the SIUWM), the mindsets of decision-makers can hopefully be successfully shifted to embracing a more integrated approach towards sustainable urban development and water sensitive cities.

Acronyms

ACC	African Centre for Cities
AM	Adaptive Management
AWV	Africa Water Vision
CBO	Community-Based Organisation
CCT	City of Cape Town
CDI	City Development Index
CLTS	Community Led Total Sanitation
CUO	Cape Urban Observatory
DALY	Disability-Adjusted Life Years
DAMS	Data Acquisition Management System
DBSA	Development Bank of South Africa
DFID	Department for International Development, UK Government
DHS	Department of Human Settlements
DM	District Municipality
DMP	Disaster Management Plan
DOH	Department of Health
DPLG	Department of Provincial and Local Government
DPR	Drivers, Pressure and Response
DPSIR	Driving Force-Pressure-State-Impact-Response
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWQRS	Drinking Water Quality Regulatory System
EDC	Endocrine Disrupting Chemical
ELCA	Environmental Life Cycle Assessment
EF	Ecological Footprint
EPI	Environmental Performance Index
ERWAT	East Rand Water care company
ESI	Environmental Sustainability Index
EU	European Union
eWQMS	Electronic Water Quality Monitoring System
FBW	Free Basic Water
FBS	Free Basic Sanitation
FP6	European Union's 6 th Framework project
GCIF	Global City Indicators Facility
GDP	Gross Domestic Product
GEAR	Growth, Economic And Redistribution programme
GHG	Greenhouse gas
GIS	Geographic Information System
GWP	Global Water Partnership

HCES	Household Centred Environmental Sanitation
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HDI	Human Development Index
HDR	Human Development Report
HFA	Hyogo Framework for Action
HPI	Human Poverty Index
IBNET	International Benchmarking Network for water and sanitation utilities
IDP	Integrated Development Plan
IMESA	Institute of Municipal Engineering of Southern Africa
IQMS	Integrated Quality Management System
ISA	Integrated Sustainability Analysis
IUWM	Integrated Urban Water Management
IUWRM	Integrated Urban Water Resource Management
IWA	International Water Association
IWRM	Integrated Water Resource Management
KPI	Key Performance Indicator
kℓ/hh.m	Kilolitres per household per month
LCA	Life Cycle Assessment
ℓ/c.d	litres per capita per day
LM	Local Municipality
LOS	Level of Service
m³/c.a	cubic metres per capita per annum
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MBI	Municipal Benchmarking Initiative
MCDA	Multi Criteria Decision Analysis
MDG	Millennium Development Goal
MIS	Management Information System
MPI	Multidimensional Poverty Index
NBI	National Benchmarking Initiative
NEMA	National Environmental Management Act
NGO	Non-Governmental Organisation
NPC	National Planning Commission, The Presidency, SA Government
NRF	National Research Foundation of South Africa
NRW	Non-Revenue Water
NWA	National Water Act of South Africa
NWSRS	National Water Services Regulatory Strategy
OECD	Organisation for Economic Cooperation and Development
O&M	Operations and Maintenance
PI	Performance Indicator
POWER	Partnership for Water Education and Research (UNESCO-IHE)

PPP	Purchasing Power Parity
PSR	Pressure State Response
RDP	Reconstruction and Development Programme
RHP	River Health Programme
RPMS	Regulatory Performance Measurement System, DWA
RSA	Republic of South Africa
SACN	South African Cities Network
SADC	Southern African Development Community
SAICE	South African Institute of Civil Engineering
SALGA	South African Local Government Association
SASS5	The South African Scoring System Version 5: Rapid bio-assessment method for rivers
SCA	Strategic Choice Approach
SD	Sustainable Development
SDI	Sustainable Development Indicator
SFWS	Strategic Framework for Water Services
SI	Sustainability Indicator
SIUWM	Sustainability Index for Integrated Urban Water Management
SoER	State of the Environment Report
SSA	Systemic Sustainability Analysis
SuDS	Sustainable drainage systems / Sustainable urban drainage systems
SUWM	Sustainable Urban Water Management
SWITCH	Sustainable Water management Improves Tomorrow's Cities Health
TARWR	Total Actual Renewable Water Resources
TEV	Total Economic Value
UAW	Unaccounted for Water
UEMP	Urban Environment Management Programme
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO-IHE	United Nations Educational, Scientific and Cultural Organisation; Institute for Water Education
UN-HABITAT	United Nations Human Settlements Programme
UN-WDPAC	UN-Water Decade Programme on Advocacy and Communication
UO	Urban Observatory
UWM	Urban Water Management
VIP	Ventilated Pit latrine
WASH	Water, Sanitation and Hygiene
WATSAN	Water and Sanitation
WB	World Bank
WC	Water Conservation

WDM	Water Demand Management
WfGD	Water for Growth and Development
WHO	World Health Organisation
WIN-SA	Water Information Network of South Africa
WPI	Water Poverty Index
WPR	Water Provision Resilience
WQM	Water Quality Management
WRC	Water Research Commission
WRM	Water Resources Management
WSA	Water Services Authority
WSNIS	Water Services National Information System
WSP	Water Services Provider
WSDP	Water Services Development Plan
WSSD	World Summit on Sustainable Development
WSUD	Water Sensitive Urban Design
WWAP	World Water Assessment Programme

Glossary of terms

Apartheid: the system of racial segregation in South Africa, enforced through legislation by the National Party government, the ruling party from 1948 to 1994. Under Apartheid the rights of the majority black inhabitants of South Africa were curtailed and Afrikaner minority rule in South Africa was maintained.

Apparent losses: These are made up of the unauthorised consumption (theft or illegal use) plus all technical and administrative inaccuracies associated with customer metering (Seago & McKenzie, 2007).

Basic sanitation: The infrastructure necessary to provide a sanitation service which is safe, reliable, private, protected from the weather, ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation related diseases by facilitating the appropriate control of disease carrying flies and pests, and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner (DWAF, 2003).

Basic water supply: The infrastructure necessary to supply 25 litres of potable water per person per day supplied within 200 metres of a household and with a minimum flow of 10 litres per minute in the case of communal water points, or 6000 litres of potable water supplied per formal connection per month in the case of yard or house connections (DWAF, 2003).

Carbon footprint: A measure of the impact that human activities have on the environment in terms of the amount of greenhouse gases emitted over the full life cycle of a process or a product measured in units of carbon dioxide (CO₂). Contributions to the carbon footprint from the water cycle include: energy consumption (CO₂ from fossil fuels); direct emissions – methane (CH₄) and nitrous oxide (N₂O) process emissions; and indirect emissions (CO₂ from energy used for chemicals and the organisation) (Frijns, 2012).

Criteria: A standard by which something is measured. Criteria describe the different aspects of sustainability on a conceptual level, and specify the desired maximum or minimum values for indicators.

Drainage: may refer to the removal of excess ground-water or surface water by gravity or pumping; the area from which water bodies are removed; or the general flow of all liquids under the force of gravity.

Environmental Life Cycle Assessment (ELCA): A detailed analysis of individual materials or services that provides the necessary instrument to assess and quantify the environmental

burden of a specific material or service taking into account its entire cycle, from ‘cradle-to-grave’.

Free Basic Water (FBW) The provision of a basic quantity of water (a minimum of 6000 litres per household per month, based on the WHO standard of 25 ℓ/c.d for 8 persons per household) free to all citizens by way of targeted cross-subsidies and (stepped) tariff-setting (DWAF, 2001).

Gini coefficient: Provides a measure of the deviation between the actual income distribution of a given nation or community and a ‘fair’ distribution, where different income brackets earn a proportional share of national income. It provides details on institutional and structural failures as well as broader economic problems, such as imbalances in labour markets and a lack of pro-poor policies. The scores range from 0 (no inequality) to 1 (complete inequality). The more unequal the distribution of income in urban areas, the higher the risk that economic disparities will result in social and political unrest.

Greenhouse gas (GHG): Gases in the Earth’s atmosphere that absorb and emit radiation within the thermal infrared range. The primary greenhouse gases are water vapour, carbon dioxide, methane, nitrous oxide, and ozone.

Greywater: Greywater (also known as sullage) refers to wastewater generated from domestic activities (washing clothes and utensils, bathing, washing hands and cleaning the household) and excludes wastewater derived from toilets (i.e. it does not include excreta).

Household: Refers to the total number of people living in one residential unit and sharing the same source of water.

Indicator: An indicator describes an attribute of a (urban water) system or one or a group of its elements at one point in time or as a time series (Van der Steen, 2011).

Indigent: Indigent means ‘lacking the necessities of life’. The Constitution of the Republic of South Africa Act No.108 of 1996 provides a guide as to what the necessities of life are (RSA, 1996).

Informal settlement: Informal settlements are generally characterised by an informally and non-bureaucratically organised urban landscape, high household densities (in excess of 200 dwelling units per hectare (du/ha) in some instances) and very poor living conditions – with many areas lacking adequate basic infrastructural services, including water supply, sanitation, drainage (including greywater) and solid waste removal.

Learning Alliance: A group of individuals or organisations with a shared interest in innovation and the scaling-up of innovation, in a topic of mutual interest. The aim of these stakeholder platforms is “*to guide and support the implementation of research and demonstration activities in cities, taking into account local problems and needs, and leading to effective integration of activities at the city level and scaled-up implementation of findings within these cities*” (Howe *et al.*, 2010).

Non-Revenue Water (NRW): Replaces the term unaccounted-for-water (UAW / UFW), and incorporates unbilled authorised consumption, apparent losses and real losses (Seago & McKenzie, 2007).

Peri-urban: Refers to areas of human settlement within or close to cities, which are characterised by levels of service between those commonly associated with urban and rural areas. Frequently peri-urban settlements are informal with inadequate planning and no legal land tenure.

Principal Components Analysis: A statistical technique used in the construction of weights to determine the maximum variation possible by way of the least number of factors. For example, indicators which display a high correlation with one another are assigned lower weightings, because they are assumed to assess similar, or the same, issues (De Carvalho, 2007).

Real losses: Physical water losses from the pressurised system up to the point of measurement of customer use. They are generally calculated as the difference between total losses and estimated apparent losses (Seago & McKenzie, 2007).

Sanitation service: The collection, removal, disposal or treatment of human excreta and domestic wastewater, and the collection, treatment and disposal of industrial wastewater. This includes all the organisational arrangements necessary to ensure the provision of sanitation services including: appropriate health, hygiene and sanitation-related awareness, the measurement of the quantity and quality of discharges where appropriate, and the associated billing, collection of revenue and consumer care (DWAF, 2003).

Sewage: Liquid and solid waste matter which is conveyed in sewers.

Sewerage: The physical infrastructure or system of sewers used to remove sewage from its origin to the point of eventual treatment or disposal.

Social learning: The incorporation of social issues to address sustainability through a process of learning with the involvement of stakeholders.

Solid waste: Matter in a solid form originating from any residential, commercial or industrial area, which is superfluous to requirements and has no further intrinsic or commercial value (CSIR, 2001).

Stakeholders: Key people and organisations involved in the management of urban water at local authority level.

Systems theory: Defined as “*the transdisciplinary study of the abstract organisation of phenomena, independent of their substance, type or spatial or temporal scale of existence. It investigates both the principles common to all complex entities, and the models which can be used to describe them*” (Heylighen & Joslyn, 1992).

Total Actual Renewable Water Resources (TARWR): Indicates the reality of human pressure on renewable but finite resources; defined as the total annual resources that are provided per person by the average annual inflow and runoff that feeds each catchment area / hydrosystem (UN-Water, 2009).

Unbilled authorised consumption: Volume of authorised consumption that is not billed or paid for (Seago & McKenzie, 2007).

Urban areas: Formal cities and towns characterised by higher population densities, high levels of economic activities and high levels of infrastructure (StatsSA, 2007).

Water services: Water supply services and/or sanitation services, or any part thereof (includes all aspects of the service necessary for the provision of an adequate service, specifically the business processes such as billing and revenue collection) and the communication of what constitutes good hygiene and water and sanitation related consumer practices (DWAF, 2003).

Water services authority (WSA): Any municipality that has the executive authority to provide water services within its area of jurisdiction in terms of the Municipal Structures Act 118 of 1998 or the ministerial authorisations made in terms of this Act (DWAF, 2003).

Water supply: Includes the abstraction from a water resource, conveyance, treatment, storage and distribution of potable water, water intended to be converted to potable water and water for industrial or other use, by or on behalf of a water services authority, to consumers or other water services providers (DWAF, 2003).

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1. Introduction

“Without effective measurement, knowledge and understanding of water services management information, service delivery is impossible” (Moshidi & Tompkins, 2009).

1.1 Background

Urban water management issues, and the negative social and environmental impacts on water systems caused by rapid urban population growth, industrialisation and climate change, are gaining increasing attention worldwide. This is no more evident than in the chosen theme for World Water Day 2011, “Urban water management: key issues and priorities for action”, which was aimed at encouraging governments, organizations and communities around the world to actively engage in addressing the water and sanitation challenges facing many cities, especially in developing countries. The UN-Water Decade Programme on Advocacy and Communication states that the main challenges in this regard concern: poverty (the urban poor can pay up to 50 times as much for water than their richer neighbours); over-exploitation of water resources; pollution of ground and surface water; health (from inadequate sanitation facilities and contaminated drinking water supplies); and leakage / wastage of up to 50% in some urban water distribution systems (UN-WDPAC, 2010).

Sustainable growth and development, and the reduction of poverty and inequality are core elements of a virtuous cycle towards building an equitable and prosperous society. A key focus of the latest Human Development Report (UNDP, 2011) is the need to fully integrate equity concerns into policies at national and local government level. It has been recognised that traditional methods of assessing progress fall short as they often do not include these distributive issues. The UNDP (2011) proposes the coordination of implementation, monitoring, reporting and verification systems – with civil society included as part of a transparent deliberative process – as a way of bringing about long-term accountability to local populations as well as to government partners.

Urban water systems need to be managed in such a way as to satisfy the changing demands (human and environmental) placed on them, whilst maintaining their ecological and environmental integrity. It is thus likely that solutions for improving the sustainability of water management in cities will require cross-sectoral coordination and changes in governance that lead to more efficient and equitable use of urban water resources. Lundie *et al.* (2005) state that sustainability is “*not a state to be arrived at, but a broad evaluative framework for understanding and justifying social practice*”. As such, sustainable water management is not about achieving an end point, but rather it is the process of influencing what people believe and how they behave. This new paradigm of urban water planning and management requires increased levels of communication between different decision makers in urban areas, and institutional changes in water governance as a result. A holistic view of planning such as this

involves the development of tools and methods that attempt to assess the impacts of all aspects of urban water management, including the various non-technical aspects, such as social, cultural and environmental factors (Karamouz *et al.*, 2010).

The UN World Water Assessment Programme (WWAP, 2009) noted in its 3rd World Water Development Report that investment in safe drinking water and sanitation contributes to significant economic growth – for each US\$ invested, returns of \$3 to \$34 have been estimated, depending on the region and technology used. One of the key messages from the report is that urban water systems must be effectively managed (through *inter alia* increased investment in water infrastructure and capacity development) in order to achieve social and economic development objectives and to sustain development. Urban water management programmes aimed at generating approaches and tools which will allow cities to improve knowledge of their water systems, as well as analysing the urban water situation to draw up more effective management strategies, are therefore becoming commonplace. In this way, the development of a fact-based vision for the water sector is a critical first step in making the adoption of a new paradigm possible (Addams *et al.*, 2009).

In common with other developing countries, the water sector in South Africa (SA) faces numerous challenges with respect to both providing access to water services, as well as sustaining this service provision over the long term. Whilst significant progress has been made in respect of service delivery targets, it is estimated that out of a total population of about 50 million, there are still approximately 2 million people in South Africa without access to any formal water supply infrastructure and over 12 million people without access to the minimum prescribed levels of sanitation (DWA, 2009). There have also been concerns about the sustainability of the services that have been provided – a study conducted by the Department of Water Affairs and Forestry (DWAF, 2005b) to audit the sustainability of sanitation projects implemented between 1994 and 2003 found that almost 30% of these projects were failing for a variety of reasons. More worryingly, a spot-check of water and sanitation projects showed that only 50% of the bulk sanitation projects, and a mere 5% of household sanitation projects complied with DWAF policy, standards and norms in 2006/7 (Duncker *et al.*, 2007).

Freshwater resources in SA are both limited as well as being disproportionately available relative to demand. The average rainfall of about 450 mm/year is well below the global average of 860 mm and, with an annual freshwater availability estimated at just over 1000 m³/person, SA is categorised as water stressed (UNEP, 2010). The country currently uses around 31% of mean annual run-off, compared with a global figure of about 10% (UN, 2006). Scenario planning by the Department of Water Affairs (DWA) estimates that by 2025 water consumption / demand is likely to exceed availability / supply, but more conservative predictions state that SA is likely to already face a supply deficit of 6% by 2013 and 11% by 2019 (WASH, 2010). This situation is likely to be exacerbated by climate change impacts, as noted by Schulze (2007): “*Water poverty, already acute in many meso-scale catchments, could be intensified by global warming if other socio-economic upliftment actions were to remain unchanged in the future*”.

Of particular concern is the status of water security in the major metropolitan areas as these are hubs of economic growth and are therefore resource intensive. Related to this is the fact that the quality of SA's freshwater resources is deteriorating – major sources of water pollution include: uncontrolled sewage disposal, poorly managed wastewater treatment works, chemical discharges, petroleum leaks and spills, acid mine drainage, runoff from human settlements, and agricultural chemicals (IFR, 2009). Not only is there a need to invest in new infrastructure in areas lacking safe water and sanitation services (such as informal settlements), but also in the upgrading and maintenance of existing water and sanitation infrastructure. As in most developing countries, however, urban growth in South Africa has outstripped the capacity of authorities to manage development and respond to the need for infrastructure, public services and land (Magnusson & Van der Merwe, 2005) – over the last 25 years the number of people living in cities has increased from just over 16 million (49% of the national population in 1985) to an estimated 30.4 million, or about 61% of the population in 2010 (UN-DESA, 2010). This has resulted in the growth of many informal settlements in urban areas throughout South Africa – it is estimated that 13.4% of the total population (about 6.5 million people, equating to more than a fifth of all urban dwellers) lived in informal dwellings in 2008 (StatsSA, 2009). The development and implementation of sustainable urban water management is crucial in order to address the main issues being faced by cities; i.e. access to services, urban wastewater pollution, resource degradation, and water-related hazards.

It is assumed that shortcomings in the management and provision of water services can partly be ascribed to the fact that there is a lack of integration in the planning and management of the various components that make up the total urban water system – often as a result of factors such as insufficient numbers of technically-qualified personnel and institutional mismanagement. Many municipalities plan, manage and operate urban water as separate entities, such as by service, i.e. water supply, wastewater, and stormwater (frequently linked with roads). There are many linkages between the various components of the urban water system however, with the hydrologic cycle being the 'connector', and it should thus be managed in an integrated manner (Mays, 2009). Integrated Urban Water Management (IUWM) considers interactions between the biophysical and social / economic components as well as their impact on the urban water cycle, thus providing a framework within which development objectives may be aligned and integrated so as to foster more efficient and sustainable use of water resources. A holistic approach such as this has been described as a structured process that “...addresses the need to bring together those who use water and those who impact on it, to work together to solve their water challenges...” (Muller, 2006). More sustainable urban water systems are likely to result when there is an integrated analysis approach to their design and management (Van der Steen & Howe, 2009). IUWM is a well-established concept in many developed countries and is increasingly being considered in municipal water and sanitation policies throughout South Africa, but there remains considerable potential for improving urban water management through further consideration of the various aspects, particularly in respect of performance monitoring and sustainability assessment.

1.2 Research aims

The purpose of sustainability assessment is to try and determine whether the current path being trod will be the same path to be trod in the future; i.e. it determines the likelihood of being able to proceed in the same manner such that a similar or better quality of life is maintained. This assumes some form of future ‘management’, which concerns much more than just scenario planning, but is about developing methodologies that prioritise actions, engage with stakeholders and enable proactive action (Pennington, 2010). This foresight process needs to be well-informed so that implementation strategies have buy-in, are relevant and far-reaching (ibid). It is in this regard that the SA Government has recently created a National Planning Commission – charged with developing a vision for SA for 2025 (RSA, 2009). In a society with deep social and economic divisions, neither social nor economic transformation is possible without effective government. The National Planning Commission’s Diagnostic Report (RSA, 2011a) noted that in order to “...bring about a capable State that can give effect to the national plan, it is necessary to identify areas where government is failing to provide realistic strategies for overcoming limitations in state capacity”.

The main aims of this research were to examine the concept of sustainability in the context of urban water management (UWM) in South Africa, determine a way / ways in which to measure sustainability aspects, and develop empirical evidence to justify the use of these measures. This has been done through the development and evaluation of a sustainability index, a tool that can be used to measure the potential for long-term sustainability in urban water systems by assessing the performance of various indicators of sustainable systems over time. An attempt was then made to determine how robust these indicators are in their ability to measure sustainability in urban water management.

The sustainability index was thus devised as a way of collectively measuring key performance indicators in urban water systems. The hypothesis is that if a town or city improves its scores on all of its indicators over a period of time, there is potential for long-term sustainability in the specific urban water system. It is envisaged that the research contribution will be as follows:

- i) A comprehensive understanding of sustainability in the context of urban water management in a developing country context such as South Africa in order to determine what the ‘leverage points’ are in moving towards sustainability, as well as the obstacles to achieving it.
- ii) The development of an advocacy tool for local authorities to help establish objectives and goal setting towards sustainability, promote appropriate action, and enable them to influence politicians to invest wisely in water services.
- iii) An analysis of the usefulness of indicators in general in assessing sustainability and in informing the linkages (integration aspects) in urban water systems.

- iv) A better-informed choice of indicators for input to policy and planning at national and local level; i.e. Integrated Development Plans (IDPs), Water Services Development Plans (WSDPs) etc.

Seen from another perspective, an added benefit of this form of assessment is to provide data to back up information relating to progress towards MDGs, particularly in respect of service provision (i.e. what do the MDGs themselves say about sustainability?). Data at both national and local level can be used as a means of targeting and tracking programmes and holding governments to account – with a focus on more accountability and new mechanisms for bringing governments to book when they fail.

1.3 Need for research

Various forms of benchmarking and performance assessment in the water supply and sanitation sector have been promoted and developed in the past decade by international and South African development organisations, sector agencies, water operators, academics and experts, owing to the fact that benchmarking is seen as a low-cost and effective tool for improving the performance of a water utility (UNESCO-IHE, 2009). What these benchmarking initiatives fail to do however, based on the fact that they are focused almost entirely on efficiency and service provision to existing customers, is to take into account service provision to the poor as well as provide an indication of the overall sustainability of the urban water system in question. This is especially relevant in a developing country context such as South Africa. UN-Water conducted an exercise of mapping existing global water systems and initiatives in which they identified 44 initiatives, 19 of which were classified as water monitoring activities (Faures & d'Amore, 2006). Some interesting findings emerged which are of particular relevance to this research:

- i) Monitoring programmes are not kept properly updated, which affects reporting capacity.
- ii) Data quality remains a major issue in assessing the reliability of monitoring systems; key information is often missing.
- iii) There is tremendous scope for better structuring of information among different systems.
- iv) The need to reinforce country capacities in setting up performance monitoring systems was stressed, as well as the strengthening of national capacity to collect water data. This was further highlighted in the Johannesburg Plan of Implementation chapter IV, para. 27 (UN, 2002), which states: *“Support developing countries...in their efforts to monitor and assess the quantity and quality of water resources, including through the establishment and/or further development of national monitoring networks and water resources databases and the development of relevant national indicators.”*

There was also a recommendation for UN-Water to further investigate the definition of water-related indicators of sustainable development and the consolidated collection of data in this regard, with the possibility of creating a ‘Sustainable Water Development Index’ – a

recommendation that, by 2011, has not yet been followed through. As is evident from the recommendation to further investigate sustainability issues though, it is not sufficient to merely report on the monitoring of specific aspects such as levels of water availability, access to services etc.; performance measurement of separate indicators cannot provide sufficient information to show whether an urban water management system will be sustainable into the future. The challenge is to develop a way of defining and measuring the potential for sustainability in the water sector. This sort of analysis needs to be part of an integrated framework which takes into account the various interactions that take place across the entire urban water cycle. The decision was therefore taken as part of this research to take existing SA benchmarking / performance measurement initiatives a step further through the development of a Sustainability Index for Urban Water Management (SIUWM).

The research was partly funded by the South African National Research Foundation (NRF) and this thesis provides the final output from NRF project 61410, 'A sustainability index for urban water management'.

1.4 Thesis layout

This thesis consists of eight Chapters including this Introductory chapter, eight Appendices and a comprehensive list of references. Also included is a CD with the Microsoft Excel spreadsheets showing the SIUWM calculations for the nine case study cities.

Chapter 2 comprises a review of literature on various aspects pertaining to sustainable urban water management, the theory and methods of sustainability assessment, and a contextual description of urban water management in South Africa.

Chapter 3 provides some background to the research effort and describes the overall research method.

Chapter 4 provides specific detail on the development of the Sustainability Index for Urban Water Management (SIUWM), starting with a discussion on the theoretical framework that was adopted for the sustainability assessment process. It then goes on to describe how the indicators were selected and data identified for the computation of the index, as well as some detail on the aggregation and weighting methods that were employed.

Chapter 5 comprises a critique of the use of composite indices for sustainability assessment in urban water management and presents some of the constraints and limitations of the research, specifically with respect to data management.

The summarised results from the SACN city SIUWM assessments are provided in **Chapter 6** (specific details on the individual cities are supplied in Appendix G). The inherent strengths and weaknesses in the management of urban water in these cities are highlighted, drawing attention to specific challenges and areas of 'unsustainability' within these areas.

Chapter 7 presents a discussion of the overall findings of the research and conclusions regarding the use of the SIUWM in a South African urban water context. It provides a

discussion on the meaning of sustainability in the context of urban water management in a developing country, as well as an indication of the likely impact of the use of an index such as the SIUWM at local and national government level in South Africa.

Some general comments on sustainability assessment in the context of urban water management in South Africa are given in **Chapter 8**, which also provides recommendations with respect to future research in this field.

The various **Appendices** provide the supporting documentation for the main thesis including, *inter alia*, discussions with city officials, specific details on the indicators for the SIUWM, data for the index calculation, and the comprehensive results from the application of the SIUWM to the nine case study cities.

University of Cape Town

2. Literature review

2.1 Introduction

“Water is at the heart of all human development. The ability to harness the resource has determined the complexity of civilization and fuelled the definition of ‘power’ in social order”
(Wittfogel, 1957 in Swatuk, 2010)

The 2006 Human Development Report (UNDP, 2006) noted that the world may be approaching a “*global water crisis*”, not only in terms of water shortages, but also as a result of power struggles, inequality in distribution, and poverty; this is not considered to be a resource crisis however, but rather one of governance, which could be remedied largely through improved management systems. Critical water challenges related to the current unprecedented rates of urban expansion – from providing access to basic services, to ensuring environmental and human security – have also recently been highlighted in a joint briefing note by the World Water Assessment Programme and the UN Human Settlements Programme (WWAP & UN-HABITAT, 2010). With half the world's population already living in urban areas, the issue of sustainable cities is high on the international agenda; and water plays a critical role in ensuring their sustainability. In the developing world in particular, urbanisation is characterised by “*intense social and political struggles over water*” (Tovey, 2002); clean drinking water, improved sanitation services and protection against water-related disasters, by way of integrated water resources management strategies, are thus fundamental to environmental and human security and to sustainable urban development. This is reinforced by the findings of the WHO/UNICEF (2010) monitoring programme on water supply and sanitation which state that all of the Millennium Development Goals (MDGs) aimed at alleviating poverty are directly or indirectly linked to improvements in these services. This is further illustrated in Table 2.1 which shows the contribution of improved water and sanitation services to selected MDGs and highlights the impact that meeting these MDG targets has on poverty alleviation, health and environmental sustainability, specifically in the developing regions of the world. The MDGs thus serve as an example of social goal-setting linked to a delivery system that attempts to contribute an operationalisation of sustainable development (Jerneck *et al.*, 2011).

Studies in developing countries have demonstrated that impacts on public health from improving water and sanitation systems vary depending on local conditions in the country under review. Yet, the overall trend is that improved water supply results in reduced mortality, and the impacts are bigger when sanitation and health education are introduced (Ashley & Cashman, 2005). Investment in safe drinking water and sanitation has also been shown to contribute to significant economic growth; the UN World Water Assessment Programme noted in its 3rd World Water Development Report that for each US\$ invested, returns of \$3 to \$34 can be expected, depending on the region and technology (WWAP, 2009). The world is on track to meet the MDG target on drinking water (more than 90% of the world's population will

use improved drinking water sources by 2015), but does not look set to meet the target on sanitation (to halve the number of people without access). Based on current trends, the total population without improved sanitation in 2015 will have decreased only slightly, from 2.5 billion to 2.4 billion. The report states that demographics (the world's population is growing by about 80 million people a year, implying an increased freshwater demand of 64 billion m³/a at constant per capita consumption), and the increasing consumption that comes with rising per capita incomes, exert the most pressure on water. One of the key messages is that water systems must be effectively managed through *inter alia* increased investment in water infrastructure and capacity development, in order to sustain social and economic development objectives.

Table 2.1: Improving water and sanitation towards the fulfilment of MDGs
(WHO & UNICEF, 2004; De Carvalho, 2007)

MDGs	Contribution of improved drinking water and sanitation to MDGs
Goal 1: Eradicate extreme poverty	<ul style="list-style-type: none"> • Security of household livelihoods rests on the health of its members • Illnesses from unsafe water and inadequate sanitation generate high health costs relative to income for the poor. • Healthy people are better able to absorb nutrients in food. • Time lost due to long-distance water collection and poor health contributes to poverty and reduced food security. • % income to informal means of water supply and sanitation often much greater than that for access via formal means. • WATSAN programs open up economic opportunities. • The more productive people in the household the higher the household income.
Goal 2: Achieve universal primary education	<ul style="list-style-type: none"> • Improved health and reduced water-carrying improves school attendance. • Separate sanitation facilities for girls and boys in school increases girls attendance. • WATSAN programs have the added benefit of educating the public, particularly children, about sustainability in practice.
Goal 3: Promote gender equality / empower women	<ul style="list-style-type: none"> • Reduced time, health and care-giving burdens from improved water services give women more time for productive endeavours, adult education and leisure. • WATSAN facilities closer to home put women and girls at less risk of assault.
Goal 4: Reduce child mortality	<ul style="list-style-type: none"> • Improved sanitation and drinking water sources reduce infant and child morbidity and mortality.
Goal 5: Improve maternal health	<ul style="list-style-type: none"> • Accessible sources of water (reduced portage) reduce maternal mortality risks. • Safe drinking water and basic sanitation are needed in health-care facilities to ensure basic hygiene practices following delivery.
Goal 6: Combat HIV/AIDS, malaria etc.	<ul style="list-style-type: none"> • Safe drinking water and basic sanitation helps prevent water-related diseases. • Sufficient water and safe sanitation improve the ability to resist HIV/AIDS (less vulnerable immune systems).
Goal 7: Ensure environmental sustainability	<ul style="list-style-type: none"> • Adequate treatment and disposal of wastewater contributes to better ecosystem conservation and less pressure on scarce freshwater resources. • Careful use of water resources prevents contamination of groundwater and helps minimise the cost of water treatment.

2.2 Urban water management

Cities are not fixed physical spaces, but rather “*emergent outcomes of complex interactions between overlapping socio-political, cultural, institutional and technical networks that are, in turn, in a constant state of flux as vast socio-metabolic flows of material resources, bodies, energy, cultural practices and information work their way through urban systems*” (Swilling & Annecke, 2012). Urban infrastructure networks play a major role in the ‘metabolism’ of a city. Urban populations are demanding of resources and services supplied by these networks, including high quantities of energy and raw materials, water supplies, waste removal, transportation etc. In particular, urbanisation creates many challenges for the development and management of water supply systems and the management of excess water from storms, and causes changes in the rainfall-runoff components of the hydrological cycle. Palme (2007) uses the Swedish EPA systems definition for an urban water system as “*the technical system itself plus the organisation and technical functions needed to build, operate and maintain the system’s functions; i.e. producing and delivering drinking water, and conducting and treating wastewater and urban run-off. Within the system boundaries are included water reserves and receiving waters, the products used in the treatment processes (chemicals), the products extracted from these processes (energy and nutrients), and the various users and stakeholders.*” However, this assumes that there is a single urban water system that is an integrated whole. In reality, integration of the various components that make up this system is usually problematic or lacking, and is practically impossible to achieve (Mays, 2009).

The terms ‘South’ and ‘North’ are increasingly being used not only to distinguish between the economies of lesser developed /developing countries (largely in the ‘South’) and developed countries (largely in the ‘North’), but also to highlight their differences with respect to water management problems. There are some very significant differences when it comes to the status of, and response to urban water management issues such as: water shortages; access to infrastructure / services; urban wastewater pollution; resource degradation; and water-related hazards. These discrepancies in the way in which urban water is managed have the most impact on poor people in developing countries; as eloquently put by Mays (2009), “*Poor water management hurts the poor the most*”. The concept of urban water sustainability thus also has different meanings, depending on the level of development of a particular country. Table 2.2 (adapted from Tejada-Guibert & Zandaryaa, 2010) summarises some of the differences in the status of urban water problems in developed and developing cities, and gives an indication of an appropriate integrated approach response for each.

Major challenges to urban water management concern demographics, economics and urbanisation. Throughout the world, the main emphasis for urban water services provision has been placed on the development of new infrastructure, but this alone will not result in sustainability. Recent approaches to urban water management take into account the demands of rapid urbanisation and depleted / degraded resources by considering closed-loop systems rather than the conventional conveyance piped systems of the past, having recognised the adverse economic and environmental impacts of these traditional approaches (Ashley *et al.*, 2003;

Brown, 2009). System-level changes towards a more holistic and integrated understanding of water issues should result in the natural and built environment within urban watersheds being reconfigured to restore hydrological and ecological functions, provide for water needs, and maintain health, with less reliance on energy-intensive, ecologically-damaging imported supplies or exported wastes. If these are integrated with changes in behaviour, values, institutions, legal systems, professional disciplines and academic curricula, even greater improvements can be expected. Aspects such as the development of integrated urban planning and water demand management strategies; encouraging reuse and recycling of treated wastewater; promoting water conservation and giving high priority to capacity building should be incorporated into urban water planning strategies (Figueres, 2005, in Mays, 2009).

Table 2.2: Urban water management issues – developed vs. developing cities (adapted from Tejada-Guibert & Zandaryaa, 2010)

Urban water problem	Developed cities		Developing cities	
	Status	Possible response	Status	Possible response
Access to water supply and sanitation	Solved	n/a	Issues with access to water supply and sanitation; informal settlements	Collaborative, participatory and demand-led initiatives; Capacity building and skills development
Wastewater management	Mostly solved	Recycling of nutrients – ‘closed-loop systems’	Low levels of management	Source control technologies; Recycling and recovering nutrients from waste; Decentralised systems
Urban drainage and stormwater (quantity / quality)	Quantity – solved; Quality – problematic	Water sensitive urban design (WSUD) methods; Sustainable Urban Drainage Systems (SuDS)	Very low levels / non-existent	WSUD / SuDS methods where possible; On-site treatment and/or recycling of stormwater
Water pollution (aquatic ecosystems)	Mostly solved	Restoration / protection efforts required	Highly polluted	Improve wastewater collection and treatment systems, and quality of stormwater discharges
Global climate changes (floods, droughts, water scarcity)	Unresolved, dealing with uncertainty	Water demand management (WDM); Institutional reforms	Unresolved, dealing with uncertainty	Integrated land-use and service delivery planning

Driving fundamental change will require additional focus on how to guide urban development – far greater emphasis is needed on the encouragement of dialogue on water issues among the many stakeholders. The principles of this more integrated approach (described in Section 2.2.1 as Integrated Urban Water Management) can be summarised as follows (Mitchell, 2006):

- i) Consideration of all parts of the water cycle, and recognition as an integrated system.

- ii) Consideration of all requirements for water, both anthropogenic and ecological.
- iii) Consideration of the local context accounting for environmental, social, cultural and economic perspectives.
- iv) Inclusion of all stakeholders in the planning and decision-making processes.
- v) Striving for sustainability, aiming to balance environmental, social and economic needs.

2.2.1 Integration in water management

At the 2002 World Summit on Sustainable Development (WSSD) held in Johannesburg, delegates concluded that integrated water resources management (IWRM) and water efficiency planning should be an essential element in all national or regional development strategies by 2005 (Faures & d'Almore, 2006). This target was thus added to the list of Millennium Development Goals (MDGs) aimed at providing concrete targets for the provision of water and sanitation services and the appropriate management of water resources to ensure that development goals are aligned with sustainability concerns. Inherent in the concept of IWRM are the principles of water use efficiency, equity of access, a balance of competing uses, the application of appropriately sound technology, and participatory planning and implementation to include all sectors of the economy and society. In order for IWRM to be able to deal with the uncertainties around the changing nature of water supplies resulting from climate change, however, there is an increasing need to understand the complexities of water system processes. This has led to a growing demand for environmental information, as well as the consideration of social vulnerability (equity and fairness), and policy issues such as spatial planning (Timmerman *et al.*, 2008). In short, an IWRM approach provides the opportunity to translate verbalised goals to real and relevant action which can ensure that MDG targets are achieved and sustainability is continuously embedded in development paradigms.

There is no one unified definition of IWRM as it depends on the varying characteristics (geography, development levels, planning objectives etc.) of the catchment, but the Global Water Partnership conceptualises IWRM as “*a process that promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*” (GWP, 2010). As previously noted with respect to urban water management, there are some fundamental differences between IWRM in developed and developing countries. IWRM in developed countries, where environments are generally non life-threatening is focused more on quality of life and long-term issues such as preservation of the environment for future generations (Schulze, 2007; Walmsley *et al.*, 2004). As a consequence of poorer infrastructure and higher vulnerability to natural events, IWRM in lesser developed countries, like South Africa, frequently has to address more immediate issues, usually to do with managing water scarcity, i.e.: providing basic potable water supplies to households *vs.* providing water of the highest quality; managing the water supply *vs.* demand

management; poverty alleviation *vs.* quality of life enhancement; ‘harnessing’ the local environment *vs.* sustaining it; seeking short term needs *vs.* long term perspectives; or creating a basic infrastructure *vs.* maintaining, improving an existing one (Schulze, 2007).

IWRM is a principle endorsed by the National Water Act of South Africa (Act 36 of 1998), bringing together aspects of social equity, economic efficiency and environmental sustainability (DWAF, 2004). It is concerned with striking the right balance between a Local Authority’s developmental role and the need to maintain environmental integrity in fulfilling the Constitutional obligations of sustainable and socioeconomic development, and a safe and healthy environment (Burke, 2007). One of the keys to successful IWRM is the availability of good quality information. Integrated Water Resource Management Plans (IWRMPs) are aimed at assisting local authorities in developing all-encompassing water management plans which focus on service delivery and resource protection, as well as the collection of appropriate monitoring data. As will be discussed in more detail in Section 2.8 however, challenges of inadequate capacity in technical and administrative skills in local government to adequately fulfil water service delivery functions has meant that IWRM has been difficult to achieve in practice in South Africa (Haigh *et al.*, 2010).

Integrated Urban Water Resources Management (IUWRM) has been defined as “a structured planning process to evaluate concurrently the opportunities to improve the management of water, sewerage and drainage services within an urban area in ways which are consistent with broader catchment and river management objectives” (Andersen & Iyaduri, 2003). It provides a framework within which different development objectives may be aligned and integrated so as to foster a more efficient and sustainable use of water resources (Muller, 2006). IUWRM requires that the current approach of treating water supply and wastewater transport separately be abandoned and instead all urban water related issues (including water supply, water reticulation, sanitation, waste disposal, urban stormwater, urban runoff and receiving water-body ecological integrity) be dealt with in an integrated manner, so as to facilitate the achievement of a balance between economic, social, political and environmental objectives. As will be shown later in this chapter, IUWRM has not yet been successfully implemented in the South African context, mainly due to the fact that there is a lack of, or limited, integration between the various local authority departments responsible for the different components, such as stormwater management, water services, billing etc. This is exacerbated by the limited integration between water resource management (WRM) and water service provision at Provincial and National level also; WRM is conducted on a catchment basis while service provision takes place according to political boundaries (Burke, 2007).

Integrated Urban Water Management (IUWM) is a component of IUWRM and addresses the imposition of urban society on the natural water cycle as well as the exploration of avenues for improved service delivery through appropriate management and concerted action. It has been described by UNEP (2003) as “*the practice of managing freshwater, wastewater and stormwater as links within the resource management structure, using an urban area as the unit of management*”. IUWM reconciles social equity with economic efficiency as well as

environmental sustainability, and recognises that robust systems are needed to encourage structured decision-making in this regard. An IUWM approach to urban water services thus views water supply, drainage and sanitation as components of an integrated physical system (the urban water cycle), whilst recognising that the system resides within an organisational framework as well as in the larger natural landscape (Mitchell, 2006). In other words the social aspects drive what happens in cities rather than the natural inputs from the larger catchment, particularly in a developing nation context.

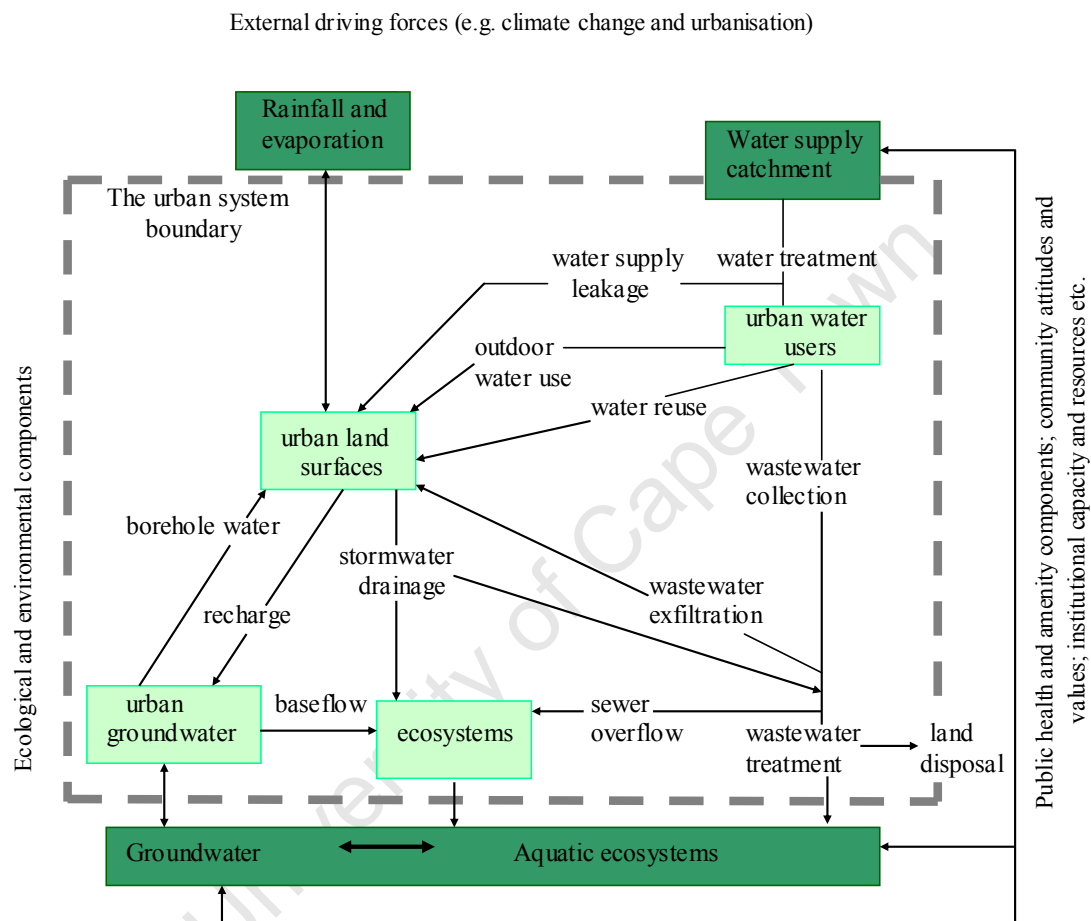


Figure 2.1: Integration of urban water cycle components (after Fletcher & Deletić, 2008)

The integration of urban water cycle components and the interactions that take place between them are illustrated in Figure 2.1, adapted from Fletcher & Deletić (2008). Figure 2.1 also indicates where the impacts of human activity are most likely to be felt. Effective management of urban water should be based on a scientific understanding of these impacts, as well as planning for the mitigation of these impacts (Marsalek *et al.*, 2008).

The lack of integration in the management of the urban water cycle may be illustrated in a number of ways. For example, stormwater is traditionally considered to be a nuisance and is conveyed away from areas as quickly as possible – potentially reducing groundwater resources

whilst eroding and degrading rivers and wetlands. Another example is the use of dry sanitation options in densely-populated low-income areas which can lead to greywater disposal problems. There are thus various aspects to consider in each of the different urban water services and sustainability will only be achievable if the planning of all the considered urban services (including aspects such as cleansing, electricity, telecommunications etc.) is done as a whole. A broad range of tools are employed within IUWM (Fletcher & Deletić, 2008), including:

- Water conservation / efficiency and demand management (appropriate levels of service, improved technology, leak detection etc.).
- Water sensitive planning and design, including urban layout and landscaping.
- Waste management (wastewater source control and pollution prevention, appropriate levels of service for different types of users, immediate reuse of greywater, waste minimisation etc.).
- Reduced runoff through local storage and infiltration, use of stormwater as a resource, improved quality of stormwater runoff, protection / remediation of urban rivers, etc.
- Bulk water and wastewater treatment (minimised costs, maximised effluent quality, promotion of reuse etc.).
- Utilisation of non-conventional water resources (groundwater, rainwater harvesting, evaporation control, etc.).
- Non-structural tools such as education, pricing incentives, regulations etc.

A fundamental prerequisite for IUWM is the availability of appropriate data in order to be able to examine individual components and understand the interactions between them. In this regard, data sharing networks like those offered by Urban Observatories (UOs) provide great opportunities for storing monitoring information on aspects such as urban meteorology, water supply, wastewater, stormwater, groundwater, and aquatic ecosystems. UOs are collaborative efforts between a range of public sector bodies which use large-scale data sets to inform evidence-based policy making and facilitate improved collaboration and learning by providing a platform for the collation, analysis and interpretation of timely and reliable data and information (ACC, 2009). Data collection should include consideration of: the variables themselves; scale; equipment; data validation; data handling and storage; and information sharing (Fletcher & Deletić, 2008). The IUWM monitoring programme must aim to develop an understanding of the whole of the urban water system rather than simply collecting separate sets of information on individual urban water components. Integration is the key concept, and the setting and monitoring of well-designed IUWM targets is very important.

IUWM should be pursued at two levels: 1) the integration of the technical system with the receiving environment, and 2) consideration of the interaction and influence of the socio-political system with the technology through processes such as stakeholder participation (Rauch *et al.*, 2005). There remains considerable potential for improving urban water

management through better integrated consideration of the various aspects and options; for example, the links to ecological systems have not yet received much attention, with issues such as evapo-transpiration management, surface and groundwater systems and management of environmental flows within regions having largely been ignored (Pearson *et al.*, 2010).

As has been discussed with respect to IWRM, however, it is clear that integrated monitoring programmes such as these are difficult enough to realise and effect in developed countries with their high levels of existing infrastructural development and maintenance, high quality data, abundant levels of scientific and administrative skills, long term planning perspectives, relatively high stakeholder involvement and their desire to pursue issues surrounding quality of life and of the environment (Schulze, 2007). In many countries of the ‘South’, which do not have the economic foundation and human capacity for establishing and maintaining monitoring programmes of this sort, the realisation of IWRM and IUWM which embody systems, integration, management, stakeholder, participatory and sustainability approaches is much harder to achieve.

The case of Singapore is an exemplary model of IUWM – they diversified their water resources; reduced unaccounted-for-water (UAW) from 11% in the 1980s to 4.4% in 2007; lowered domestic water consumption from 176 ℓ/c.d in 1994 to 157 ℓ/c.d in 2007; and reduced flood-prone areas from 3200 ha in the 1970s to 238 ha in 2000). Singapore has been successful in its water and wastewater management because of its concurrent emphasis on supply and demand management, wastewater and stormwater management, institutional effectiveness and an enabling environment. A reconstituted Water Agency has full authority for the urban water management system and is responsible for sewage treatment and reuse, flood control, water resources and supply, plus control over the entire water cycle. Singapore’s water management has also involved the integration of land use planning with water resource management as well as close involvement with Housing, Environment, Transport and other governmental agencies, Public acceptance of the reuse of wastewater (NEWater; i.e. reclaimed wastewater treated with a combination of conventional and advanced technologies, such as microfiltration, reverse osmosis and UV disinfection) is high because there was open engagement on, and good marketing of, the necessity of accepting reclaimed water to supplement the water supply (30% of Singapore’s water needs by 2011). The term ‘used water’ replaced ‘sewage’ to encourage the public to consider water as a renewable resource (Chen *et al.*, 2010).

2.2.2 Water sensitive cities

Faced with the increasing significance and impacts of climate change and population growth, urban communities are seeking to ensure resilience, specifically with respect to future uncertainties with water supplies. The concept of IUWM has thus been taken a step further with the notion of ‘water sensitive’ cities, which can be characterised by three key attributes: access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure; provision of ecosystem services for the built and natural environment; and socio-political capital for sustainability (Wong & Brown, 2008). The

transformation of cities to include these sustainable urban water management concepts requires not only the integration of the components of IUWM and the various disciplines associated with the provision of water services, but also a paradigm shift in urban design so as to bring in aspects of ‘sensitivity to water’ and create landscapes that have “*intrinsic ecological functions related to the community and environment*” (Wong & Brown, 2008). This shift in thinking is summarised in the transitions framework shown in Figure 2.2 (Brown *et al.*, 2008).

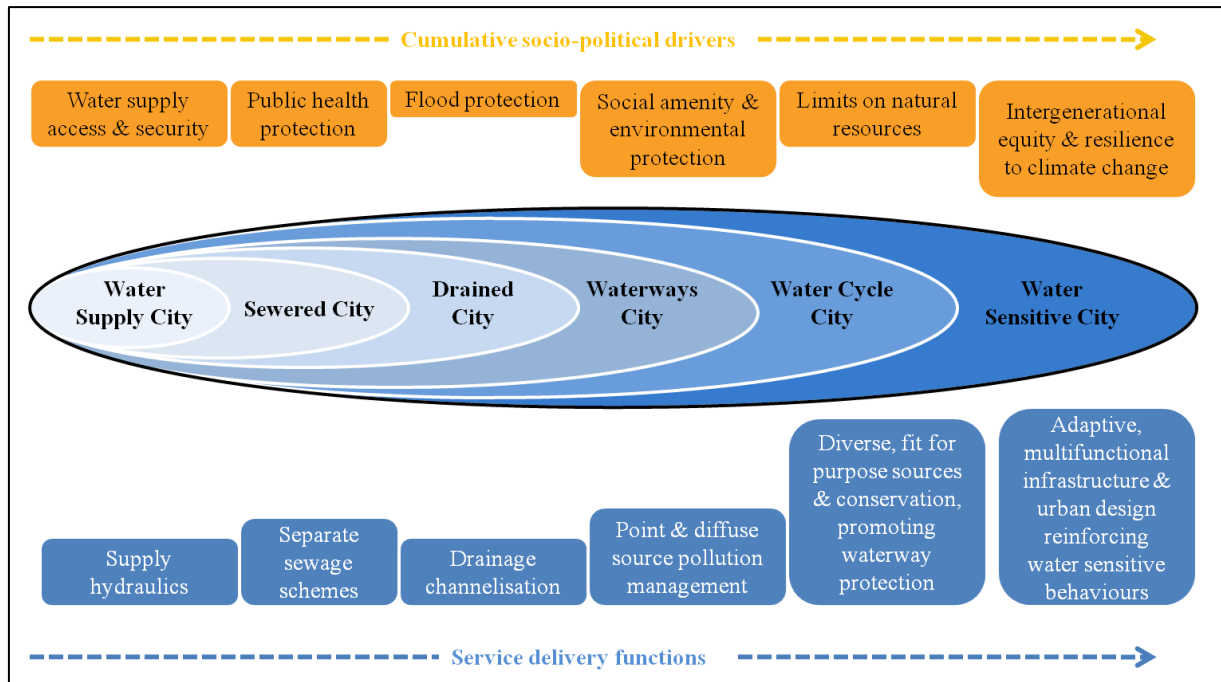


Figure 2.2: Urban water management transition framework (Brown *et al.*, 2008)

The framework identifies six urban water transition states and their associated socio-political drivers and service delivery functions. It highlights the concept of a ‘hydro-social contract’ between the various stakeholders which is continually influenced and shaped as cities transition from one state to another. Brown *et al.* (2008) propose that the hydro-social contract in the Water Sensitive City is underpinned by a flexible institutional configuration, and diverse infrastructure which is supportive of sustainability goals. The notion of sustainable urban water management concepts in this regard – such as Sustainable Drainage Systems (SuDS) and Water Sensitive Urban Design (WSUD) – will be further discussed in Section 2.4.2.

2.3 Concepts of sustainability and sustainable development

“...*the art of living well within ecological limits*” (Jackson, 2009)

The term sustainability, derived from the Latin *sustenerere* (*sus* – up, *tenere* – hold), basically means ‘the capacity to endure’. In ecological terms, it relates to how biological systems remain diverse and productive; in social or human terms, it is the potential for long-term maintenance of well-being, and depends on the responsible use of natural resources. Bell & Morse (2008) have a philosophical view of sustainability as “*a combination of a call to action, a task in progress and a goal for the future*”, equating to a situation where the quality of a system remains the same or increases. In recent years, sustainability has become one of the most-used policy terms worldwide, and is described as a ‘boundary term’ – one where science meets politics and politics meets science (Gieryn, 1999).

Concerns about population growth and its consequences for the consumption of resources and impact on human development started surfacing as early as the 18th century when Thomas Robert Malthus published his “*Essay on the principle of population as it affects the future improvement of society*” (Malthus, 1798). The emerging challenges of living within a finite world were again highlighted by Hardin (1968) in his paper entitled “*The tragedy of the commons*”, in which he questioned the potency of technical solutions for the so-called ‘wicked problem’ of over-population. Rather, he argued for a revision of human values or change of ethics, as essential prerequisites for dealing with this sort of class of problems (Corker, 2011). Then in the early 1970s, the well-known report of the Club of Rome, a group of eminent economists and scientists, was published as *The limits to growth* (Meadows *et al.*, 1972), concluding that the Earth had a limited supply of physical resources and that exceeding the limits of exploitation could lead to catastrophe. By the 1990s multiple versions of the sustainability concept had been tabled, and terms like ‘triple bottom line’, ‘natural capital’ and ‘ecological footprint’ became commonplace. All of these challenged the unrestricted economic growth being placed on the political agenda, suggesting that the accepted notions of progress, growth and development were no longer feasible; a new, morally defensible paradigm was needed. This was formulated in what is now known as sustainable development, emerging as a compromise between unlimited economic growth and conservation (du Pisani, 2006). The 1992 Rio Conference on Environment and Development, convened by the United Nations, was aimed at heightening awareness and realising sustainable development ideals on key environmental issues by way of implementing policy at a global scale (Scoones *et al.*, 2007).

Sustainable development (SD) has been described as the process through which specific targets are set, actions planned and strategies implemented in order to deliver on current needs in a manner that is responsive to the earth’s capacity to replace ‘used’ resources and absorb ‘generated’ wastes, being conscious of the needs of future generations (Goodland & Daly, 1996). It is an evolutionary process, an evolving ideal of development efforts which acknowledges change (Bagheri & Hjorth, 2007b); one which recognises and acts on the

interconnections between the economy, society and the natural environment (UN, 2012). Put simply by the Brundtland Commission, “...*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (WCED, 1987), sustainable development has two key concepts:

- i) the concept of **needs**, particularly in respect of the essential needs of the world’s poor, to which priority should be given.
- ii) the idea of **limitations** imposed by the state of technology and social organisation on the environment’s ability to meet present and future needs.

Whilst these two imperatives of SD are accepted, questions have been raised about such static notions of needs and limits given the complex and dynamic contexts of sustainability (Scoones *et al.*, 2007). There is also some ambiguity in this generalised definition of SD, particularly in respect of the trade-offs it requires between socio-cultural, economic and ecological developments that can be valued and weighted differently, resulting in some scholars rejecting the concept of sustainability / sustainable growth as an oxymoron (e.g. Daly, 1993; Weaver & Rotmans, 2006; Davidson, 2010). In fact, Daly (1993) defines sustainability as the “*cultural adaptation made by society as it becomes aware of the emerging necessity for non-growth*”. It is thus difficult to articulate one practical meaning – it is better to seek a context-specific interpretation of sustainability that is acceptable to a range of stakeholders, and based on a clear vision of what this means to them. This is particularly relevant in developing nations where the greatest challenge is the alleviation of poverty – to which almost all other challenges are related, e.g. strengthening democracy, eliminating conflict, health services provision, food security, biodiversity conservation etc. It would seem that in order to be sustainable in this context, economic growth has to be specifically targeted to the needs of the people as well as being sensitive to the needs of the environment, with sufficiency being the goal as opposed to economic efficiency (du Pisani, 2006).

These principles are expanded further in the definition by Swilling (2005) to include social equity aspects, i.e. sustainability is the long-term viability of both the natural systems within which social systems are embedded, and the social systems themselves that depend on the services provided by the natural systems. Ideas of sustainable development cannot be separated from the notion of ethics; i.e. the equitable distribution of benefits now and into the future (thus ensuring a reasonable quality of life). Sustainability and equity are fundamentally similar in their concern for distributive justice and should therefore be considered jointly (UNDP, 2011). This does not necessarily require that the two concepts always be mutually reinforcing however; in many instances there will be trade-offs required to achieve sustainable human development, defined as follows: “*Sustainable human development is the expansion of the substantive freedoms of people today while making reasonable efforts to avoid seriously compromising those of future generations*” (UNDP, 2011).

At the heart of the concept of sustainable development is the fact that socio-economic systems are products of, and are dependent on, ecological systems. There is however a huge

gap between the theory of sustainable development and what passes for development planning. Together with concerns about resource constraints, ecologists have for some time now also considered the stability and resilience of ecosystems through assessing their responses to shocks and stresses. In these terms, sustainability can be defined as the ability of a system to bounce back from shocks and adopt a stable state (Holling, 1993). The ‘sustainable livelihoods’ (SL) framework is an alternative way of linking social and ecological aspects. It is aimed at understanding how poor people live, and looks at stresses (chronic) and shocks (acute) on their livelihoods by recognising the numerous influences on people, and the multiple actors who are involved in the various dimensions of sustainability (DFID, 1999). It aims to reduce risks to people’s livelihoods, thereby improving the quality and performance of poverty-focused development activity. Indicators of progress should therefore include qualitative information such as impact on people’s lives (vulnerability) and environmental impacts – understanding the impact of different policy and institutional arrangements upon people / households and upon the dimension of poverty they define is an essential dimension of the SL approach (DFID, 1999). One of the problems with SD is that it speaks volumes at the level of an individual, but loses much when brought to politics and policy. As Curwell & Cooper (1998) put it: “*Thus the essential paradox of a sustainable society is the conflicting requirements of providing the flows of production and consumption needed to maintain a good quality of life for all humankind, while simultaneously sustaining the local and global environment and biodiversity.*”

The sustainability paradox has been addressed to some extent through broadening the two main concepts of sustainability, namely: reduction of environmental impact, and preservation or enhancement of natural capital, to include a third one: preservation or enhancement of adaptive capacity, i.e. resilience (Brinsmead & Hooker, 2005). The resilience concept focuses on the adaptive capacity of a system to preserve core functioning in the presence of shocks and long-term changes (Milman & Short, 2008); i.e. it creates the ability to withstand disorder. It is aimed at developing adaptive sustainability policy strategies – determined through options assessments – so as to enable the future to be confidently faced despite the existence of inevitable uncertainties. There are subtle differences between the notions of sustainability and resilience; sustainability focuses on a system being able to continue indefinitely without fundamentally altering the relationship with the planet; resilience aims at finding ways to withstand shocks and create opportunities for change. Resilience is a useful concept in countries where the existing level of development allows for a focus on future uncertainties like flood risks and climate change impacts. It is possibly not as relevant in a developing country context where the principal focus is on access to services, poverty alleviation and immediate issues to do with socio-economic vulnerability. Davidson (2010) suggests that environmental issues are driven by processes of inequality and domination, and that unequal access to resources is equated with exposure to environmental harm; in this context, sustainability should be more concerned with addressing these inequality issues. To make the definitions even more complex, some scholars (e.g. Pezzey, 1992) have raised the notion of a distinction between survivability (requires welfare to be above a particular threshold at all times) and sustainability (requires welfare to be non-decreasing at all times). Sustainability is now recognised as a

concept that contains aspects of both security and survivability, and makes redundant any approaches solely aimed at one or the other (Rogers, 2006).

Scoones *et al.* (2007) argue that sustainability is not only an objective concept referring to a system's ability to maintain particular standards of social equity, economic well-being and environmental quality, but is also a normative concept open to different framings by specific actors. Thus, sustainability (beginning with a lower case 's') implies the maintenance of system properties in a general sense, while Sustainability (beginning with an upper case 'S') refers to those properties valued by particular groups in the pursuit of particular goals (Scoones *et al.*, 2007). The relevance of this in sustainability assessment will be discussed in more detail in Section 2.6, particularly as applied to the notion of developing sustainability visions through an analysis of contexts, systems and their properties. Sustainable development is complicated by the fact that it demands far-reaching outcomes but is often limited by the short-term perspectives adopted by many decision-makers and politicians. A long-term perspective must be reinforced in decision-making and planning, to encourage aspects such as research and development for both technology and organisational structures so that they are better able to meet sustainability challenges, as shown in the conceptual model of sustainable development (Figure 2.3) adapted from Palme (2007).

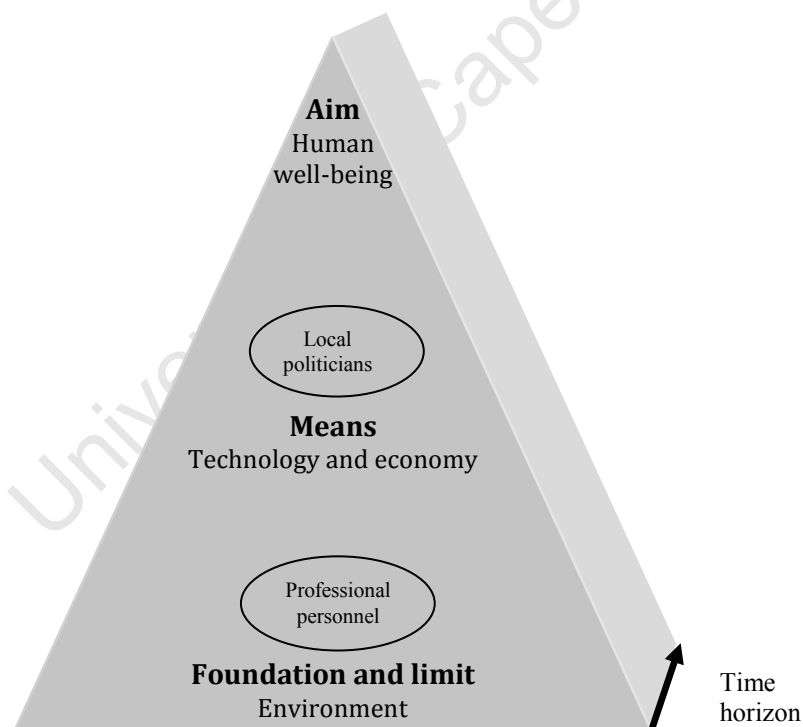


Figure 2.3: Conceptual model of sustainable development (Palme, 2007)

This model has the environment as the foundation and limiting factor, technology and the economy (including institutional / political) providing the means, and social aspects (human well-being) as the aim. The 3-D depiction represents the long-term (50 to 100 years) time

perspective that provides stability; an essential feature of SD. Professional personnel work with the technical aspects of urban water systems in both the short and long term. Politicians on the other hand are seen to belong at the top of the pyramid, concerned mainly with social aspects, usually with a comparatively short term perspective (as influenced by their terms of office). The pyramidal shape not only depicts the importance of the ecosystem foundation (if the foundation is eroded, the entire system will collapse), but also represents the concept of Maslow's hierarchy of human needs in which unmet physiological needs overshadow 'higher-order' needs. This has implications for SD as, for example, people cannot be expected to consider the environment as long as they are deprived of food and water.

Sustainable development can thus be viewed as 'prosperity with growth' (using the concepts of sustainable consumption) as opposed to 'resource-intensive growth without constraints'. It implies a linking of problems of consumption and poverty with pollution; resource degradation and conflict; and interaction with politics, policy and governance; i.e. balancing the limits to growth and the need for development. Valentin & Spangenberg (2000) identify these imperatives and the processes that link them in the form of a useful conceptual diagram depicting a prism with four dimensions of sustainability on its corners (Figure 2.4).

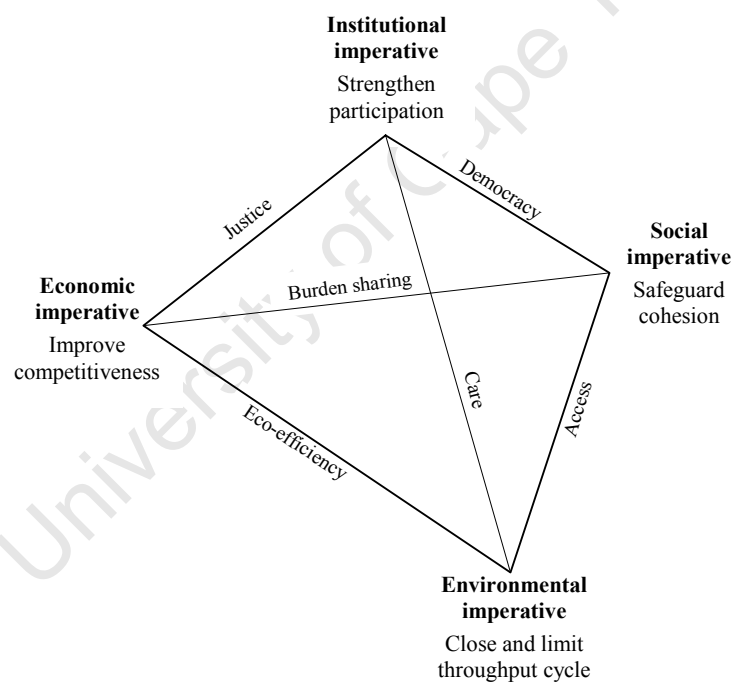


Figure 2.4: Prism of sustainability (Valentin & Spangenberg, 2000)

While the specific goals of sustainability are not identified, various processes are suggested that might be pursued in order to: establish fair access to resources; create conditions and opportunities for meaningful participation; establish a society that is willing to share the burdens of others; ensure social justice; take responsibility for the environment; and use

efficient technologies and practices to minimize the impact on the natural resource base. The prism concept also provides a dynamic foundation for analysis of sustainable development, and again highlights the fact that sustainable development is a “*process with certain qualities rather than a certain state to reach*” (Sundberg *et al.*, 2004).

Solutions to issues of ‘un-sustainability’ will require novel linkages between science, politics and society (Goffman, 2005), particularly in respect of the looming global crises to do with water shortages, peak oil predictions and climate change impacts; as well as the dwindling availability of other essential natural resources such as phosphorous. To achieve this, an effective framework of strengthened institutional governance and decision-making processes at local, national and global level needs to be developed, one with better accountability towards sustainable development goals (UN, 2012).

2.4 Sustainable urban water management (SUWM)

Whilst the various definitions of sustainability and sustainable development set the stage for research of this kind, they fail to address the contextual setting of cities and urbanised settings, those areas that exhibit development of a sufficient scale to raise sustainability concerns (De Carvalho, 2007). It is estimated that the world’s population will grow from about 6 billion in 2000 to almost 9 billion by 2050, with nearly all future population growth in cities (UN-DESA, 2010). It is important therefore that attention is focused on the sustainability of the complex dynamic systems in these dense urban environments.

The definitions also need to be contextualised for integrated water management in urban settings, which includes the operations, management, finance and governance aspects of water supply, urban drainage, sanitation, wastewater treatment and solid waste handling. It is acknowledged that, as with sustainability, a clear definition of the term sustainable urban water management (SUWM) will be difficult to pinpoint.

More direct efforts in respect of sustainability – including the minimisation of resource use (water, energy, nutrients) and waste generation (through minimising pollution and maximising reuse); the protection of public health and assurance of equitable access; and the provision of water services at the lowest cost to society – are required to move towards SUWM. White & Turner (2003) describe these sustainability objectives as “*satisfying water related needs ... at the lowest cost to society whilst minimising environmental and social impacts*”. Similarly, Brown *et al.* (2007) propose the following ideal qualities as underpinning the SUWM philosophy (summarised):

- Consideration of the water cycle as an integrated, inter-connected system including the protection of water resources.
- Water used for multiple purposes (human and environmental).
- Consideration of environmental, economic, social, cultural and institutional perspectives.
- Inclusion of public participation in planning and decision-making.

- Utilisation of long-term timeframes for programs, projects and policies.
- Use of inter-disciplinary approaches (e.g. engineers, environmental scientists, social scientists, economists, and planners).

A key feature of SUWM is the synergy of government, environment, economy and community, with ten fundamental principles aimed at meeting these various dimensions of sustainability, as shown in Table 2.3 (Wong, 2006). The framework for SUWM is provided by the clearly-defined responsibilities of Government as the regulator, water authorities as providers, and the public as customers.

Table 2.3: Principles of sustainable water management (adapted from Wong, 2006)

Key principles	Assumptions and objectives	Sustainability dimension
1. 'User pays' principle	Water as an economic good / cost recovery Water as a public good	Economic Environmental
2. Appropriate technology	Supply-side management (adequate water supply) Environmentally-friendly technology	Social and technical Environmental
3. Clear boundaries	Clearly defined property rights	Economic and environmental
4. Key stakeholder involvement in decision making	Respecting indigenous knowledge Including marginal groups Negotiating appropriate water-related rules and roles	Social Social Institutional
5. Clear rules and roles	Providing incentives to reduce free-riding behaviour Negotiating access to water	Social Social
6. Monitoring	Infrastructure asset management Incentives for water efficiency	Technical Social
7. Sanctions	Punishing non-compliance	Institutional
8. Conflict resolution	Resolving conflicts by negotiation and regulations	Social
9. Community participation	Enhancing project sustainability by sense of ownership Providing alternative cash and manpower support	Social Social
10. Decentralisation	Recognising power dimensions / local conditions Reducing bureaucracy / Government as regulator only	Institutional

Traditional goals of urban water management have been to provide a safe and adequate drinking water supply, collection and treatment of wastewater so as to prevent disease and limit environmental impacts, and flood control (Marsalek *et al.*, 2008). These systems may meet the social and subsistence needs of the people they serve, but they are not necessarily sustainable, as evidenced by the fact that they have a limited capacity to recycle nutrients and handle the pressures posed by climate change and by the increasing amounts of chemicals in the environment (Palme, 2007; Wilsenach, 2010). The conventional linear paradigm of 'damming,

treating, using, treating, discharging' (i.e. fast-conveyance drainage infrastructure) is now viewed as a major impediment to sustainability, and SUWM is viewed as a system with feedback loops (e.g. by way of reuse, water demand management and alternative treatment technologies) where demand is discretised to provide more nuanced consumption approaches; large, centralised systems are replaced by smaller, decentralised ones; and collaboration allows for meaningful engagement (Novotny & Brown, 2007). For example, it is anticipated that in the city of the future, urban drainage systems will be designed to mimic the natural hydrological cycle – e.g. recharging aquifers with reclaimed rainwater; returning the base and flood flows of streams to predevelopment levels (ibid). There has also been a shift in thinking towards recognising the potential for recovering water – for both non-potable and sub-potable uses – from wastewater; provided that there is effective treatment of wastewater to meet water quality objectives for water reuse applications, and protection of public health (Asano, 2006). It is important however to consider and maintain investment in water efficiency – the most valuable forms of effluent reuse are those that offset potable demand and reduce the costs of infrastructure by shifting costs from transport of water and sewage towards treatment (White & Turner, 2003).

There are various barriers inhibiting the adoption of more sustainable practices in urban settings – the majority of which are social and institutional / political rather than purely technical (Brown *et al.*, 2007); such as receptivity to alternative (e.g. ecological or urine diverting) sanitation options, or willingness to make use of recycled wastewater / greywater in the home. A transition to sustainable urban water systems will likely require technological development as well as greater individual and community responsibility, and will demand integrated approaches which encompass all aspects of urban planning. It is also suggested that an equal focus on aspects of both technical design (e.g. optimum storage, peak flow attenuation, pollution control and effluent discharge) and on the management of existing infrastructure – including rehabilitation, reconstruction, upgrading and maintenance – is required to sustain urban water services.

Pahl-Wostl *et al.* (2011) suggest that decision-making and planning processes are more complicated as a result of these changes in the way in which urban management is envisioned. There is therefore a need to develop an understanding of water resources and their management as *complex adaptive systems*, as will be discussed in more detail in later sections. The authors claim that recent changes to the way knowledge is generated and used in the context of natural resources management have started to undermine basic assumptions on which traditional approaches to water management are based – both in terms of mankind's ability to predict and control water systems, as well as the fact that complexity and human (social) dimensions are receiving increasing attention. They argue that the extent of innovation required to successfully address contemporary water management challenges (e.g. governance crises, climate change uncertainties, implementation of approaches such as IWRM and adaptive management (AM), use of source control and polluter-pays principles etc.) requires a paradigm shift from the traditional methods used to address development and sanitation objectives. Legitimacy now depends on shared visions, where the notion of government as the single decision-making

authority has been replaced with the concept of multi-level, polycentric governance (Pahl-Wostl *et al.*, 2011). The contribution of many actors in different institutional settings to policy development and implementation is the backbone of such a reflexive and adaptive governance system.

The new water paradigm thus implies a change from a ‘command and control’ approach to one that is systemic and integrative, such as is provided for in IWRM / IUWM concepts (Lai *et al.*, 2008). For example, social adaptive capacity is acknowledged as one of the primary responses to issues of water scarcity, by realigning population-induced demand with a maximum level of sustainable supply (see also Turton, 1999). The challenge here is that the capacities and skills required to effect integrated adaptive strategies are lagging far behind the theory that has been developed (Lai *et al.*, 2008). A lack of coordination of governing policies and regulations (plus fragmented administrative frameworks with a lack of attention to institutional learning) is cited as an impediment to SUWM, and it is important that consideration is also given to issues of leadership / commitment; public participation; transparency / accountability; coordinated data access; evaluation and action learning (Fletcher & Deletić, 2008). There are four schools of thought in the conceptualisation of sustainable urban water systems (Palme, 2007):

- i) By way of the three dimensions of sustainability – social, economic, environmental – as used in the development of indicators for sustainability assessment by authors such as Lundin (1999) and Hellström *et al.* (2000).
- ii) Systems approaches; i.e. looking at urban water as part of a bigger picture, with linkages to agriculture, energy, waste management etc. (e.g. Sundberg *et al.*, 2004 – “*A system cannot be judged as sustainable without consideration of its surroundings*”).
- iii) Approaches aimed at introducing flexibility as a means of increasing the resilience of urban water systems.
- iv) Approaches using alternative technologies such as source separation and decentralisation.

The method and definition adopted in this research for conceptualising sustainability in urban water systems in South Africa is a combination of the first two of these approaches, as will be discussed in further detail in Chapter 4. Some examples of SUWM approaches – in no particular order – and their influence on society and the environment are described in the following sections, 2.4.1 to 2.4.3. In comparison, sections 2.4.4 to 2.4.6 provide details on the impacts of climate change, health and economic perspectives on SUWM.

2.4.1 Water conservation and water demand management

Accounting for water is an important challenge underlying efficient and equitable management (Sullivan, 2006). Ideally, water resources management is about striking a balance between water availability and legitimate water demand, but often this is not achievable owing to the geographical and/or climatological characteristics of a particular region, as well as its socio-

economic features (Kampragou *et al.*, 2011). During the last few decades, water resources management has evolved through a series of paradigm shifts, driven by increases in population and water demand (see Figure 2.5). The realisation that there are limits to renewable and non-renewable water use (as with groundwater use beyond normal recharge rates) – the concept of ‘peak water’ – has led to the development of innovative technologies for water treatment and reuse (Gleick & Palaniappan, 2010).

Traditional supply-driven urban water management is not sustainable, as it leads to over-use of resources, over-capitalisation and pollution (Sharma & Vairavamorthy, 2009). It is thus vital that both water conservation measures and the management of water demand are included in any water resource management system. Water conservation (WC) encompasses the minimisation of loss or waste of water, the care and protection of water resources, and the effective and efficient use of water (Tsatsi *et al.*, 2010). It includes limiting water losses / wastage from urban supply systems – this is known as non-revenue water (NRW) and comprises apparent and real losses, plus the proportion of authorised consumption which is not billed. In South Africa a significant proportion of this is Free Basic Water, as will be discussed in Section 2.8.2. Water demand management (WDM) refers to the adaptation and implementation of a strategy by a water institution or consumer to influence the water demand and the usage of water in order to meet socially beneficial objectives (Tsatsi *et al.*, 2010), and is one of the strategies adopted for utilising limited water resources as efficiently as possible.

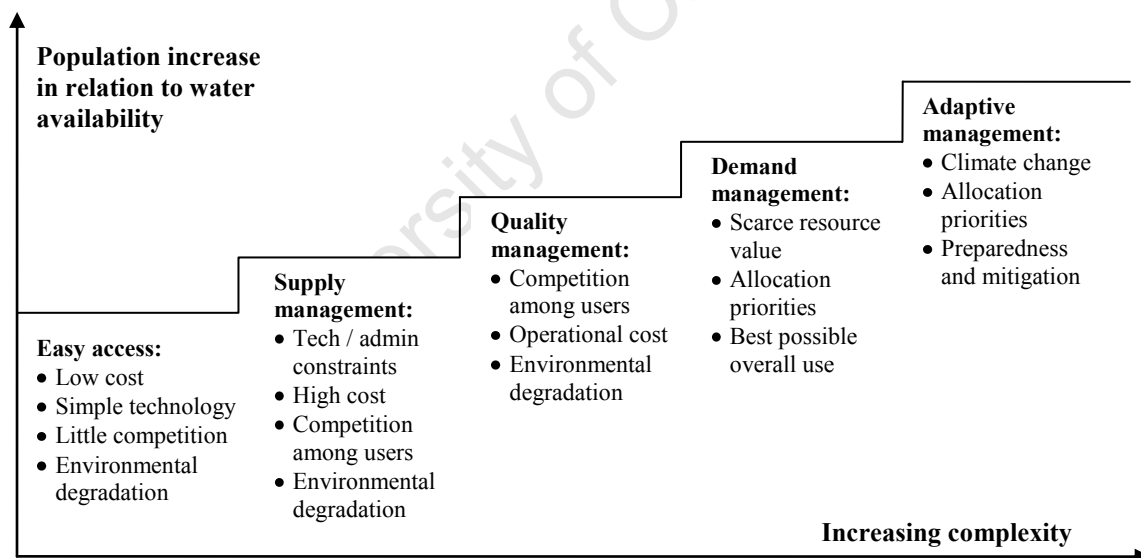


Figure 2.5: Paradigm shifts in water management (Kampragou *et al.*, 2011)

Socially specific, flexible and dynamic (i.e. context-driven) urban water management strategies will need to be developed if long-term water stability is to be attained throughout cities. WDM approaches in particular offer multiple benefits – for example, reductions in demand make available additional water for supplying the un-served, and treatment costs and energy

requirements are reduced. These approaches can be grouped into three main categories (Sharma & Vairavamoorthy, 2009):

- i) Structural / technical measures – NRW and leakage control, water-efficiency and saving devices, meter management, conservation measures, alternative water sources (e.g. rainwater harvesting, water recycling, treated wastewater reuse).
- ii) Economic / financial measures – pricing, taxes, incentives.
- iii) Socio-political measures – legal frameworks, regulations, education campaigns, demonstration projects.

Developed countries use various technological and management measures to reduce urban water demand as part of their IUWM strategies, but these measures are often not adopted in developing countries due to, *inter alia*, manpower and technology constraints; political preferences for high-visibility, supply-oriented projects; under-pricing of water; lack of legal frameworks; and poor water distribution system management. Urban water systems in developing countries are often characterised by water resource scarcity, poor quality plumbing, ageing infrastructure, high rates of growth of population and water demand, high water losses in the distribution system (NRW rates varying between 20 and 70%), low cost recovery and high subsidies. This is certainly the case in South Africa – a report by the Water Research Commission of South Africa (WRC) suggested that total water losses from water reticulation systems throughout the country represent almost 30% of the total system input (Tsatsi *et al.*, 2010), and potential water savings of approximately 500 million m³ per annum could be achieved with water conservation and demand management measures.

The main aim of water conservation and water demand management is to improve the distribution efficiency of a municipal water distribution system by reducing non-revenue water. It is suggested that a low rate of NRW is a one of the best overall indicators of a successful water utility and WDM is an important measure to be considered by countries aiming to meet the MDGs with respect to water supply coverage – if properly implemented, it has the potential to reduce water shortages in urban areas in many developing countries. An integrated approach using combinations of structural and non-structural WDM measures suited to local conditions could help to achieve sustainable urban water supply systems. One of the key elements for successful strategy implementation is sound project management based on appropriate management information systems (MIS) that provide the necessary data, including progress and performance indicators. An example of this is the IWA indicator system that has been developed for the performance assessment of urban infrastructure services (Garzón-Contreras & Agredo-Perdomo, in Cabrero & Pardo, 2008).

2.4.2 Sustainable drainage systems (SuDS) and Water Sensitive Urban Design (WSUD)

Drainage is very often the forgotten or neglected service in urban water management. This is particularly evident in areas where stormwater is discharged separately to sewage; in these instances the management of drainage is often the responsibility of Roads Departments. There is therefore very little in the way of integrated management of stormwater with other water services, which is particularly problematic in low-income and informal settlements where other services (especially sanitation) are lacking or dysfunctional and local flooding problems are common. Drainage does not have a high profile. As Reed *et al.* (2001) put it: “*Water supply and sanitation are important issues – they are normally tackled directly, rather than taking a wider view of the problem. Thus, for example, solid waste in drainage channels requires that the channels be cleared, rather than the solid waste problem being addressed first*”. Even though various authors have referred to this problem for some time now, there still appears to be a disconnect between what is being said and what is happening on the ground. For example, the 2nd IWA development congress in Kuala Lumpur held in November 2011 had as its two major themes, ‘Urban water supply service provision’ and ‘Urban sanitation and wastewater service provision’, with nothing on stormwater or drainage.

The characteristic feature of sustainable drainage systems (SuDS), as opposed to traditional urban drainage, is that integrated planning perspectives are adopted to handle quantity and quality issues together with social amenity aspects (Stahre, 2006). The goal is to maximise the positive impacts that drainage facilities can have on city environments (biological, environmental, educational, aesthetic, recreational and cultural) with infiltration to the local environment as the ultimate aim. There are various best management practices (BMPs) / SuDS approaches that can be used, including source control on private land, on-site control on public land, slow transport and downstream control (*ibid*). Most of the problems with SuDS are more institutional than technical by nature, and concern cooperation and communication between different municipal departments – it is critical that stormwater issues are highlighted at a very early stage in the planning process for developments, e.g. since drainage corridors for stormwater are often combined with park and recreational purposes, it is essential to take all the various interests (recreational, ecological, environmental etc.) into account at the start of the process.

The relatively recent notion of Water Sensitive Urban Design (WSUD) takes stormwater management to another level through its combination of the two key concepts of IUWM and urban design. It is aimed at ensuring that water is given due prominence within the urban design process through the integration of design with the disciplines of engineering and environmental sciences associated with the provision of water services and the protection of aquatic environments in urban areas (Wong & Brown, 2008). Community values and aspirations govern these urban design decisions, and key elements for WSUD therefore include aesthetics, functionality / flexibility, usability; and public perception / acceptance.

WSUD is not only about stormwater management however, and city-wide WSUD strategies should take into account all parts of the water cycle so as to incorporate aspects such as resource efficiency and climate neutrality, using integrated approaches with respect to energy, waste and water. Integrated approaches to sustainable urban planning and development are required in order to attain a level of water sensitivity in cities (Ranhagen *et al.*, 2007) so that all possible connections with the various city systems can be utilised and exploited. In particular, an overview of a city's environmental situation, including key issues and objectives for further improvement, should be used as the basis for dialogue with stakeholders regarding any future transition to sustainable urban development. Ranhagen *et al.* (2007) state that a sustainability review such as this can be initiated either by way of a multi-disciplinary approach where a city or system is analysed from a number of perspectives in order to identify synergies in the planning framework, or through a sectoral approach where specific aspects (e.g. water, waste, transport) are analysed in detail.

This is also the premise of the recently-initiated (project duration 2011 to 2015) European Union Seventh Framework Programme (FP7) project “Transition to urban water services of the future” (TRUST), which aims to use innovative systems metabolism modelling to provide a detailed understanding of the performance of urban water services in nine demonstration cities throughout Europe (TRUST, 2011). It is suggested that sustainability assessment as the basis for the transitioning process to water sensitive cities is also particularly important in a developing country context (such as in South Africa) in order to highlight key issues for improvement and allow a detailed exploration of the ways in which these improvements could be made.

2.4.3 Sustainable sanitation options

Many of the water crises in urban areas are based not so much on the availability of water but rather on a failure to manage how water is used (Del Porto, 2006); and as noted previously, conventional approaches for the design of water and wastewater systems are increasingly being criticised owing to the fact that they do not properly take into account sustainability issues of resource use and depletion – potable water is used for non-potable uses like toilet flushing, and ‘waste’ is disposed rather than used as a resource. The role of nutrient pathways in the provision of sustainable urban water services has also been neglected (White & Turner, 2003); separating nutrients at source to minimise effluent treatment requirements and maximise the use of this valuable resource should be considered.

Ecological sanitation (Ecosan) is widely touted as a more holistic approach to sustainable sanitation in that it regards human excreta as a resource and not simply a waste product destined for disposal. Ecosan technologies take cognisance of the principles of environmental sanitation; i.e. keeping the environment safe and clean and preventing pollution, whilst using recycling concepts. Ideally they enable the complete recovery of all nutrients from sewage to the benefit of agriculture; minimise water pollution; and maximise the economic use of water (Earle, 2001). For Ecosan to be sustainable in higher density settlements however, some form

of institutional support for the disposal of faecal matter, organic waste and greywater is required (e.g. in the form of neighbourhood composting stations managed by municipal cleansing services), as reuse on-site is generally not feasible (Austin *et al.*, 2005; Holden, 2010). There are also concerns about the potential health risks from a poorly-managed Ecosan system in dense settlements; the management of the recycling practice in particular is crucial and the precautionary principle needs to be applied. Holden (2010) takes this notion a step further and suggests that, given the current state of knowledge, waterborne sewage remains the most realistic solution in dense urban settlements.

There are various alternatives to waterborne sewage systems in different types of settlements, depending on income levels, household densities, costs, and the level of water supply service available. Table 2.4 outlines some of these options, as suggested by Mara (2008) as ‘good practice’, specifically in an effort to meet MDG targets. It is clear that sanitation cannot be considered in isolation from other water services as all have an impact on each other, especially in high-density urban areas where problems with the functioning of one service can have serious knock-on effects in terms of environment and population health. Brazil is an example of a country that has recognised this and has made provision for it; according to the National Sanitation Law of 2007, sanitation is defined as ‘water supply + sanitation + solid waste + stormwater drainage’, so that policy decisions and investments are made with an integrated service in mind (Beveridge & Diamond, 2010).

Table 2.4: Sustainable sanitation options for different settlement types (Mara, 2008)

Settlement type	Sanitation option
High-density, low-income areas	Simplified sewerage, low-cost combined sewerage / stormwater drainage; and community-managed sanitation blocks
Medium-density urban areas	Simplified sewerage, low-cost combined sewerage / stormwater drainage, alternating twin pit VIP latrines and pour flush (PF) toilets, urine diverting (UD) alternating twin vault ventilated improved vault (VIV) latrines, biogas toilets, Ecosan toilets
Medium- to low-density rural areas	Simplified sewerage, single pit VIP latrines and PF toilets, UD alternating twin vault VIV latrines, biogas toilets, Ecosan toilets

Note: Greywater management systems should be included in options for medium and medium-low density areas

2.4.4 Impacts of climate change

The way in which urban water services are managed has enormous implications on how the potentially disastrous impacts of climate change can be avoided. There is a pressing need for more holistic planning and governance towards sustainable urban water management. Three main aspects should be considered when linking SUWM with climate change: 1) adaptation to and mitigation of climate-change induced risks; 2) resource constraints, specifically the impacts on water resources due to changing climatic conditions and the effects of global warming; and

3) the water – energy nexus, and the impacts of energy constraints on water sector, and *vice versa*.

Global climate change is a reality confirmed by the 0.74°C increase in the global average temperature over the past century (Richardson *et al.*, 2009), and is already affecting water resources and placing increasing demands on urban water management systems worldwide. As UN Secretary-General Ban Ki-moon put it at the Opening Ceremony for the Copenhagen Climate Summit in December 2009, “*The evidence assaults us: melting ice caps, advancing deserts, rising sea levels.*” Yet, there are still concerns that water has not featured significantly on the climate change agenda. Moreover, it is postulated that the attention that is being focused on climate change mitigation worldwide is diverting attention (and funding) from water management (Muller, 2011). Various governments from developing nations raised these concerns at the climate change meeting in Mexico in December 2010, noting that “*Almost 2/3 of the world’s population will experience stress by 2025....sound management of water underpins every aspect of development. It is a cross-cutting concern. It is everywhere, yet nowhere in our discussions.*” There is thus a call for water resource management to be recognised as an important strategic response, and for some of the huge amounts of money being mobilised to tackle climate change to be spent on adaptation and strengthening water resource management, i.e. improving monitoring and planning tools, and building capacity and infrastructure (Muller, 2011).

The most vulnerable to climate change impacts are the urban poor, since they often live in hazardous locations (e.g. on flood plains), and in poor quality housing. The challenges which water professionals face on a daily basis – increasing water demand, access to services, worsening pollution levels, environmental protection etc. – should therefore be tackled in the context of a highly variable climate (Box 2.1). Dineva & McKay (2012) describe such climate change adaptation in water management as finding the right mix of the three I’s: Information, Institutions and Infrastructure, in order to achieve the desired balance between the three E’s: Equity, Environment and Economics.

Box 2.1: Excerpt from Centre for Water Sensitive Cities Newsletter - Issue 2, 2011

(<http://www.watersensitivecities.org.au/news-and-events/e-newsletters/>)

“We watched with growing disbelief the floods and then cyclone Yasi in Queensland, flooding in country Victoria and high intensity storms in Melbourne, the bushfires in Perth and record-consecutive-over-35-degrees-C-days in Sydney: A reminder of the highly varied climate we live in and, perhaps, also a sign of things to come with a changing global climate. We are reminded frequently that the way we manage urban water can influence so many aspects of our urban environment and quality of life. In striving for resilient, liveable and sustainable cities and towns, we are becoming increasingly aware of the need for significant departures from the conventional approaches to the management and provision of urban water services”.

Vulnerability in urban water systems stems from both natural disasters (droughts, floods) as well as the impacts of climate change and human-induced disasters such as over-exploitation of supplies, terrorist activities etc. (Mays, 2009). Owing to uncertainties in the predictions of

future precipitation and temperatures, the level of uncertainty concerning the hydrologic responses of catchments has increased, resulting in fears about future water resources. The impacts of climate change are therefore becoming increasingly important for the design, construction and maintenance of water sector infrastructure (Danilenko *et al.*, 2010). Even without these impacts, urban water utilities face many operational stresses around basic water management and service delivery; and dealing with short-term issues like flooding often interferes with the utility's ability to plan for future impacts associated with climate change. For example, most responses rely on immediate strategies to reduce water consumption and non-revenue water losses rather than focusing on comprehensive planning for the long-term consequences of climate change. Yet, climate change could render obsolete the current modes of managing water resources and the associated infrastructure, and comprehensive planning will be required to assess the vulnerability and adaptive capacity of existing systems and to address the long-term economic, social and environmental impacts. In particular water utilities will have to find ways of diversifying their water sources as good quality surface water supplies decrease and urban demand increases. The World Bank recommends a two-stage framework for adaptation to climate change – identifying the risk factors to existing water systems, and assessing the technical and institutional complexity of adapting to those risks (Danilenko *et al.*, 2010). Adaptation measures are classified by how they respond to five areas: climate monitoring, water availability, water quality and distribution, wastewater collection, and wastewater treatment / effluent discharge. Sustainable urban water management provides a unifying concept for addressing issues of climate, hydrology, land use, infrastructure and ecology in urban areas; adaptation strategies in this regard should integrate climate and water responses with development and poverty eradication (Jimenez & Rose, 2009).

Water utilities themselves account for a significant share of total energy consumption as well as approximately 2–5% of worldwide greenhouse gas (GHG) emissions, including direct emissions from production processes, as well as indirect emissions from electricity consumption, chemicals, waste and replacement of infrastructure (Howe *et al.*, 2010; Frijns, 2012). They therefore need to apply a broader sustainability approach to the design of adaptation strategies so as to balance the cost and reliability of water services against social and environmental consequences. This includes the use of renewable and/or carbon-neutral energy sources, alternative water supplies (e.g. in the form of treated wastewater), and intensive water demand management efforts. An adaptation approach to sustainability such as this also warrants the characterisation of direct and indirect water and energy linkages across the whole urban water system including water use, energy demand and GHG emissions, so as to enable improved understanding of water strategy management choices related to this (Howe *et al.*, 2010). Many water utilities worldwide are becoming increasingly concerned with not only improving energy efficiency, but also reducing its carbon footprint (see Glossary for an explanation of the term), towards the achievement of climate change reduction targets (Frijns, 2012).

Further details on climate change impacts and the water-energy nexus in a South African context will be provided later in Section 2.8.3.

2.4.5 Health and the environment

The link between disease and poor living conditions is well known. As early as 1842, Edwin Chadwick published a report on his investigation of the influenza and typhoid epidemics in Britain in the 1830's, entitled *Report on the sanitary conditions of the labouring population of Great Britain* (Chadwick, 1842). This document was the catalyst for the emergence of the fields of urban planning and public health, and the implementation of interventions such as sewerage, waste collection / disposal and rodent control (Corburn, 2004). More recently, the impact of water, sanitation and hygiene (WASH) interventions on health have been outlined in a World Health Organisation (WHO) publication highlighting the profiles of environmental burden of disease for 192 countries (Prüss-Üstün *et al.*, 2008) in which it is stated that almost one tenth (9.1%) of the global disease burden, measured in disability-adjusted life years (DALY's), or 6.3% of all deaths, mainly in developing countries, could be prevented by improvements in the way water is managed. Children are the most affected, particularly those in low-income countries – contributing to 22% of the disease burden and 25% of the total deaths. This figure may also be an underestimate owing to the fact that there was insufficient evidence on several diseases related to WASH. Furthermore, the impacts of global climate change are likely to create upwards pressure on these figures through extreme events, such as floods and droughts. In South Africa, it is estimated that 2.6% of all deaths (about 18,000 in 2002) can be attributed to WASH-related diseases – mainly diarrhoea (12,000 deaths) and malnutrition-related illnesses (2500 deaths). This relates to 4% of all DALY's associated with WASH-related diseases.

Ensuring access to safe drinking water and adequate sanitation also has significant direct and indirect economic benefits – it is estimated that the economic return of investing in universal access to improved water and sanitation services is ten-fold (Prüss-Üstün *et al.*, 2008). Effective interventions include improvements to hygiene, sanitation, water supply and water quality. The report notes that a Basic level of service (average 20ℓ/c.d at 100–1000m distance) results in a 'High' level of health concern and that this reduces to 'Low' as the service level increases to Intermediate (50ℓ/c.d close to point of use). To a considerable extent, the underlying causes of many forms of ill-health can be traced back to the policies, discussions and practices in the non-health sectors, including urban planning and water and sanitation (Mathee & Naicker, 2011). There is thus a greater role for collaboration between these non-health sectors to ensure health gains from development initiatives.

The concept of sanitation as it relates to health interventions is based on a rigorous separation of wastewater and water for consumption, municipal use or recreation. With the advent of IUWM this strict separation begins to be broken down as reuse and recycling of water becomes part of the water supply solution – and this can have major health implications (Fletcher & Deletić, 2008). Similarly, developments in UWM under the influence of drivers such as sustainability have resulted in more sophisticated reuse systems, which can result in increasing contamination of water supplies. This is especially relevant in situations of water scarcity where reuse initiatives by way of purification of wastewater, as in the Singapore

example of ‘NEWater’ are being implemented (Chen *et al.*, 2010). In water-constrained countries water can be traded as a commodity through advanced treatment, recycling and reuse (e.g. in Windhoek, Namibia – see Magnusson & Van der Merwe, 2005), as well as through alternative strategic reuse options such as in aquifer storage (Persson, 2011). This is also termed the ‘soft path for water’ – focusing on the improvement of the overall productivity of water rather than continually seeking new supplies (Gleick, 2003).

A thorough understanding of the impacts of increased water demand on the urban water cycle and management of the associated health risks will require appropriate strategies and measures. For example, appropriate technology has to be sourced to deal with effluent treatment issues, and specifically to deal with pharmaceuticals and other contaminants such as endocrine disrupting chemicals (EDC’s) found in, *inter alia*, pesticides, fertilizers, personal care products and industrial chemicals, that occur in minute concentrations and can be difficult to remove with conventional wastewater treatment processes. EDC’s mimic some of the natural hormones in animals, and may disrupt or modify the normal function of these hormones, resulting in carcinogenic and toxic effects on exposed organisms (Genthe & Steyn, 2008). It has also been found that hormone-disrupting chemicals can undermine neurological and behavioural development and the subsequent potential of individuals exposed in the womb, resulting in adverse changes to human reproduction systems and sex change effects in other species (Cadbury, 1997). Effluent reuse systems would therefore require stricter monitoring requirements because of the possibility of increased levels of risk (Turton, 2010), although research is ongoing in this regard (Box 2.2, referring to the risks from pharmaceuticals in drinking water).

Box 2.2: Pharmaceuticals in drinking water. Public Health and Environment Water, Sanitation, Hygiene and Health (WHO, 2011)

In the last decade, traces of pharmaceuticals have been reported in the water cycle, including surface waters, wastewater, groundwater and, to a lesser extent, drinking water. Advances in analytical technology have been a key factor driving their increased detection. Their presence in water, even at very low concentrations, has raised concerns among stakeholders regarding the potential risks to human health. Published literature has shown that concentrations of pharmaceuticals in surface water and groundwater sources impacted by wastewater discharges are typically less than 0.1 µg/l, and concentrations in treated drinking water are usually well below 0.05 µg/l. This is unlikely to pose risks to human health because of the substantial margin of exposure or margin of safety between the concentrations detected and the concentrations likely to evoke a pharmacological effect. Routine monitoring of pharmaceuticals in water and the installation of specialised drinking-water treatment infrastructure are not currently deemed necessary given the limited additional health benefits. Human exposure to pharmaceuticals through drinking-water can be reduced through a combination of preventive measures, such as take-back programmes, regulations, public guidance and consumer education to encourage proper disposal of unwanted pharmaceuticals and minimise introduction of pharmaceuticals to the environment.

As noted by Jimenez & Rose (2009), urban water security is a complex concept, involving water availability, security of water supplies, public health threats and water hazards. Managing risks is crucial, and the mitigation thereof should be based on closing the loop of the urban water cycle and adapting to the uncertainties posed by global changes.

2.4.6 Economic perspectives for sustainability in urban water management

A key requirement for sustainability in urban water management is that the costs incurred are recovered – with costs viewed in a broad sense as all resources utilised in the provision of these services including monetary, environmental and social costs (Abey Suriya *et al.*, 2008). The sustainable recovery of these costs implies that monetary costs are quantified and revenues are raised through charges to users; environmental impacts are restricted, and societal impacts are explicitly addressed through deliberative public participation processes. Investment thus needs to be accompanied by improvements in governance arrangements, the reform of policies and the development of partnerships with the private sector (UNEP, 2011).

Historically, water policy has reflected the dominant economic policy trajectory of a particular era (Nleya, 2008). Current global water policy values water as an environmental resource which underpins economies and societies (Bergkamp & Sadoff, 2008). This shift towards a water paradigm that aims at protecting resources whilst being based on market approaches followed the adoption of a set of four principles at the 1992 International Conference on Water and the Environment (The Dublin Principles), of which No. 4 stated: “*Water has an economic value in all its competing uses and should be recognised / managed as an economic good; in order to achieve efficient and equitable use, and encourage conservation and protection of water resources*” (UN, 1992). The economic principles applied to recover costs for urban water and sanitation services are mainly based on this new water economics paradigm, with its emphasis on ‘full cost pricing’, and on the ‘user pays’ principle (Abey Suriya *et al.*, 2008). Wise management of water is thus an economic imperative – but this requires inclusive and transparent decision-making, investments in new technologies to enhance water use efficiency and productivity, and alignment of economic signals and incentives. If water is to be managed sustainably, it needs to be seen as a form of capital or commodity, i.e. the value of water resources does matter, and the availability, quality, and timing cannot simply be assumed. Total Economic Value (TEV) is one way of capturing both market and non-market values of natural resources (Bergkamp & Sadoff, 2008). Macroeconomic policy instruments are often described as the most effective tools for poverty alleviation, and various approaches have been adopted in the water distribution sector. These include flexible water allocation schemes, water trading and transferable rights. The needs of the poorest of the poor have not been fully resolved through these measures, however – mainly as a result of weaknesses in theoretical frameworks and in terms of procedural failure (Sullivan, 2006).

Some scholars argue that the market-based approach with its ideological commitment to costly, large-scale systems is limited in its capacity to effectively recover the costs necessary to support sustainable water services, particularly in developing countries (Abey Suriya *et al.*, 2008; Daly & Farley, 2003). Ecological economics is aimed at addressing these concerns by: 1) facilitating cost recovery aligned with sustainability; and 2) specifying the use of technological processes (e.g. decentralised and small-scale infrastructure) that limit entropy gain and keep environmental impacts within the carrying capacity of ecosystems (Daly & Farley, 2003). The authors postulate that additional benefits can be derived from the various output products from

decentralised processes (like nutrient recycling) which can potentially create a number of revenue streams for the recovery of costs. Abey Suriya *et al.* (2008) contend that a further expansion of the economic perspective for water services is the adoption of Buddhist economics principles which brings ethics to the centre of economic activity. It implies participatory, inclusive dialogue among stakeholders in deciding on water, sanitation and hygiene (WASH) arrangements, in line with environmental protection principles.

There is a growing body of evidence on the economic impacts of access to water and sanitation that shows that investments in the water sector generate economic benefits that considerably outweigh their costs, and make a significant contribution to poverty alleviation and human development (SIWI, 2005). These investments in water supply and sanitation can be quantified as part of a transition to a ‘green economy’, which recognises the role of water in maintaining biodiversity and ecosystem services and seeks to minimise the impact of economic activity on the environment (UNEP, 2011). Similarly, the provision of water, sanitation, drainage and other infrastructure components can be a catalyst of change of itself, resulting in knock-on benefits with respect to community-building and poverty alleviation (Parikh, 2008). Additionally, Parikh notes that, *“Integrated infrastructure interventions have a positive influence on the inherent resource mobilisation potential of low income communities, encourage self-reliant partnerships and result in a multiplier impact which helps local communities overcome resource constraints and external aid dependence.”*

The links between the economic growth of a nation and its water situation – expressed in terms of improved water access, institutional capacity to sustain access, use of water, and environmental factors which impact on water quality – have been analysed by Shah & Kumar (2008). Using a modified Water Poverty Index (discussed later in Section 2.5.1.5), as originally developed by Lawrence *et al.* (2003), they showed that the overall water situation of a country has a strong influence on its economic growth performance as well as on indicators of human development such as health, education and income. This means that, in order for a country to remain on a sustainable growth path, appropriate and effective policies need to be put in place. While the natural water endowment (both quantitative and qualitative) cannot be improved through ordinary measures, the water situation of a country can be improved through legal, policy and administrative measures that support efficient development and use of water. The authors postulate that this will result in improved access to water for all sectors, enhanced levels of water use in different sectors, reduced pollution, and building of technological and institutional capacities to tackle new challenges in the water sector (Shah & Kumar, 2008).

2.5 Measuring sustainability / sustainability assessment

“Sustainability should not be interpreted as some precise state or condition that could be scientifically defined. It is rather to be seen as a qualitative concept like e.g. freedom or justice. Thus, it seems more reasonable to develop instruments for direction analysis, which could tell us whether we are moving towards less or more sustainability.” (Hjorth, 1996)

After the 1992 Rio Conference on Environment and Development (UN-DESA, 1992), commissions were established and national action planning processes initiated for a global reporting system on sustainability. At the same time, a more localised, community-led process known as Agenda 21 was conceived which envisaged sustainability being established through local initiatives by local governments (Scoones *et al.* 2007). The result of this was an exponential growth in the development of planning approaches, analysis frameworks, measurement systems and the like, all framed to critically assess economic, environmental and social sustainability.

The Bellagio Principles (Box 2.3) were developed to guide policy makers in deciding which actions should be taken towards sustainable development, and to outline the general principles of sustainability assessment in this regard (Hardi & Zdan, 1997).

Box 2.3: Bellagio Principles for sustainable development (Hardi & Zdan, 1997)

- i) Establishing a vision
Principle 1: Establishing a **guiding vision** of sustainable development and clear goals that define it
- ii) Content of assessment and merging the system with current priority issues
Principle 2: Keep a **holistic perspective**, including ecological, social and economic components
Principle 3: Consideration of **essential elements** such as equity and disparity within the current population and future generations
Principle 4: Have an **adequate scope** - including long time horizon, large enough study space, and building on historic and current conditions to anticipate future conditions
Principle 5: Progress towards sustainable development should have a **practical focus**, based on the standardised measurement of a limited number of indicators
- iii) Process of assessment
Principle 6: **Openness** - accessibility of methods / data, explicit judgements / assumptions
Principle 7: **Effective communication** designed to address needs of users and engage decision-makers, using clear and plain language
Principle 8: **Broad participation** of key stakeholders is required
- iv) Establishing a continuing capacity for assessment (importance of time and spatial scales)
Principle 9: **Ongoing assessment** including developing capacity for repeated measurements, iterative methods, allowing for adjusting of frameworks and indicators, and promotion of collective learning
Principle 10: **Institutional capacity** should provide ongoing support in decision-making process, and for data collection, maintenance and documentation.

As a generic process, assessment is concerned with measuring and evaluating the qualities of an object of interest; sustainability assessment includes the following elements: the system of interest characterised by a persistent problem giving rise to concerns; the sustainability objective; indicators and metrics linked to required criteria; and an overall decision basis defined by an agreed conceptualisation / interpretation ('vision') of sustainability in the specific context (Weaver & Rotmans, 2006). The authors postulate that unless this decision basis is

made transparent by way of a process that engages with stakeholders, the sustainability assessment risks being inconsistent and illegitimate.

The concept of sustainable development has been incorporated into multiple levels of society in recent times, and the field of sustainability science is increasingly seen as combining work in the area of environmental science with work in economic, social and development studies to better understand the complex dynamic interactions between them (Ness *et al.*, 2007). It recognises complexity as a phenomenon that exists as a consequence of interactions between system components, and which gives rise to properties that emerge as a result of these interactions (Burns & Weaver, 2008). In the context of sustainability assessment, sustainability science focuses on the fundamental character of interactions between nature and society as well as on society's capacity to guide those interactions along more sustainable trajectories, by endeavouring to provide answers to the following research questions (Kates *et al.*, 2001):

- i) How can current operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition towards sustainability?
- ii) How can today's relatively independent activities of research planning, monitoring, assessment and decision support be better integrated into systems for adaptive management and societal learning?

Sustainable development necessitates the continuous consideration of all system levels (Palme, 2007). Assessment tools are categorised based on their approaches and temporal focus, namely: indicators and indices (generally retrospective approaches), product-related assessment tools with a focus on material and/or energy flows, and integrated sustainability assessment (ISA) approaches, which are generally prospective (Figure 2.6). Integrated assessment tools are often based on systems theory concepts (see Glossary) and are capable of integrating nature-society systems into a single evaluation, e.g. the Environmental Sustainability Index.

Ecosystems, economic sectors, and cities are considered as 'social-ecological systems' that are both complex and adaptive, with properties that are not fully explained by an understanding of their constituent parts. This is due to the fact that interrelations between the parts are deemed to have a significant effect on overall behaviour, or progress towards sustainability (Gallagher & Appenzeller, 1999). ISA focuses on policy change or project implementation and is a cyclical, participatory process through which a shared interpretation of sustainability for a specific context is developed in order to explore solutions to problems of unsustainable development (Weaver & Rotmans, 2006; Tàbara *et al.*, 2008).

In theory, the principles of sustainability need to be agreed upon by all stakeholders before they can be unpacked into more specific criteria (see Glossary of terms) upon which judgements can be made about the relative (un)sustainability of a set of options or behaviours. Criteria are not directly quantifiable however, and indicators are thus used to measure performance and to set standards against which future performance can be assessed (Butler,

2003; Gibson, 2005). Indicators can be scored or quantified by comparing it to an objective, and can indicate whether an objective has been achieved or the extent to which a criteria has been achieved (Van der Steen, 2011). Sustainability indicators and composite indices are increasingly recognised as useful tools for performance measurement and policy making and for realising sustainable development; however, before developing the indicator methodology, a clear definition of the policy goals towards sustainability is required (Rogers, 2006; Palme, 2007; Singh *et al.*, 2009), as well as the concept of sustainability itself in the required context. As Davidson (2010) notes: “A failure to provide a clear operational definition of sustainability means that there is no conceptual launch pad for the measurement of sustainability.”

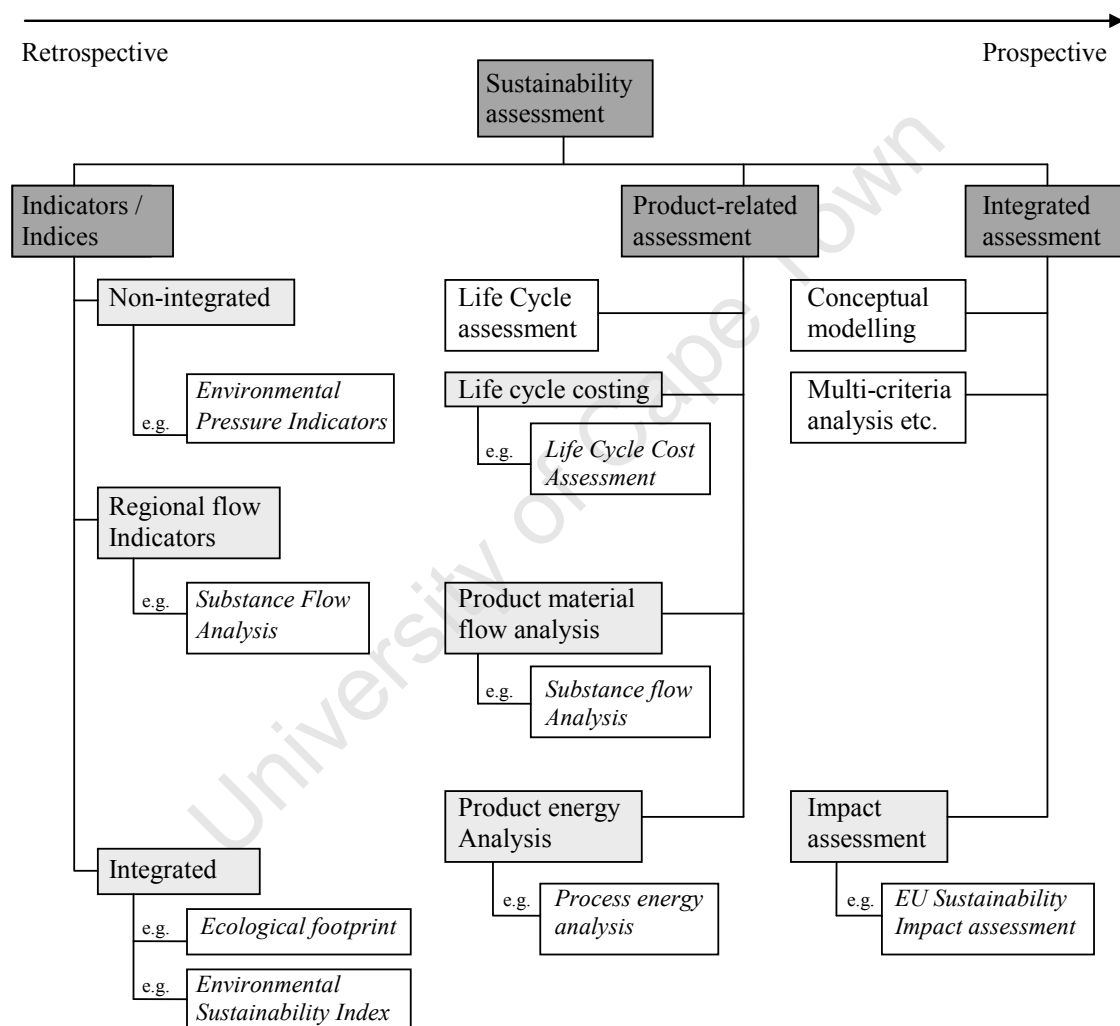


Figure 2.6: Framework for sustainability assessment tools (from Ness *et al.*, 2007)

It has been claimed that “the way societies have defined and measured progress has had a profound effect on world history” (Talberth, 2008). Sustainability assessment efforts can therefore be used, not only for evaluation and implementation purposes, but also as stimulus for

clarification of policy goals (Hamdouch & Zuindeau, 2010; Farsari & Prastacos, 2002; Pope *et al.*, 2004). In other words, sustainability assessment can aid in the shift towards sustainability by clarifying what it constitutes. Maintaining credible sustainability measurement is a proven strategy for business success; for example, it has been noted that the mere reporting of sustainability metrics like recycling rates, energy usage and water intensity is a key driver of change (Talberth, 2008).

2.5.1 Sustainable development / sustainability indicators

“Indicators are bits of information that highlight what is happening in a larger system...small windows that together provide a glimpse of the big picture.” (Sustainable Seattle, 1998).

There has been a proliferation of indicators-based research into sustainable development over recent decades. Indicators help to simplify complex information so that it is quantifiable, in order that it can be understood and communicated. The need for clarity and ease of understanding means that indicators often condense large volumes of data into brief overview and reduce complexities into simple messages (Faures & d’Almore, 2006). There are two main approaches to indicator development: 1) composite indices, where information is aggregated into a single variable, and 2) sets of indicators (often related to performance measurement), including many variables, that in their entirety capture the various dimensions of sustainability.

Palme (2007) defines sustainability development indicators (SDIs) as *“any performance indicator conveying information regarding any dimension of sustainable development except purely financial ones, and connected to a sustainable development vision or goal”*. This vision can also be referred to as a sustainability criterion (environmental / economic / social), and is the yardstick against which an indicator is measured. Sustainable development indicators are generally concerned with selected issues contributing to sustainable development – often in particular areas of concern, e.g. transport, energy, leisure and tourism, trade, land use, water resources etc. – in order to give a simplified quantification of trends over time with a particular measure (i.e. indicator of change). They are usually linked to and contribute specific information about key macroeconomic objectives such as human development, social equity, transition to renewable energy, protection of natural capital etc. Sustainability indicators on the other hand are chosen based on their collective impact on an integrated system and are usually assessed as a composite score. Both types of indicators incorporate several dimensions of sustainable development, connect to limits, and are designed to include linkages with surrounding systems. They are useful for monitoring and measuring the state of the environment by considering a manageable number of variables or characteristics and monitoring relative changes against given criteria over a period of time; i.e. they can assess the ability of a system to adapt to change and continue to function over a long time span (Sahely *et al.*, 2005; Milman & Short, 2008). As has been noted, sustainability is about ensuring that human society lives within the environment’s limits, and that the economy meets society’s needs; indicators used to measure sustainability must thus take these two notions into account.

Levett (1998) stresses that neither of these is optional – they must be achieved together, rather than at the expense of the other, for sustainability to be achieved. Nardo *et al.* (2008) compiled a handbook which provides technical guidelines on the methodological approach for the design, development and dissemination of composite sustainability indicators. A step-wise procedure based on systems thinking is advocated, from developing the model and building the theoretical framework, through indicator selection and assessment, weighting, aggregation and robustness analysis, to interpretation and dissemination of the index (see Section 3.2 for a detailed description of how this methodological approach was adopted in this research).

The most important function of sustainability indicators is to promote learning and to structure understanding as part of increasing transparency in the decision-making process, rather than simply providing rational direction on management and planning (Booher & Innes, 2006; Palme, 2010; van der Steen, 2011). One of the ways in which this has recently been done is by way of an indicator set which gives equal weight to economics, ecology, culture and politics whilst placing sociality at the centre of all sustainability question, called ‘Circles of Sustainability’ (Scerri & James, 2010). In this respect, the intention of the authors was to take quantitative approaches beyond the abstract task of measurement and to engage stakeholders in actively negotiating how to put sustainability into practice. As will be discussed later, it is however this process of public engagement and enabling of the learning process which is one of the biggest challenges to sustainable water management (Pearson *et al.*, 2010).

Indicators are simple measures, most often quantitative, that represent a state of economic, social and/or environmental development in a defined region; when indicators are aggregated in some manner, the resulting measure is a composite index (Ness *et al.*, 2007). The Office of Development Studies at the United Nations Development Programme (UNDP) conducted a survey of 178 composite indices being used to measure countries’ performance in a diverse set of topics including competitiveness, governance, social aspects, human rights, the environment, security and globalisation (Bandura, 2008). It is worth noting that only 12 of these indices make any reference to water, and none are specifically geared towards urban water management. The following sections briefly describe a few of the better known examples of these composite indices, in no particular order.

2.5.1.1 Human Development Index (HDI)

The HDI provides a measure of achievement towards the MDGs by tracing the level of development in nations across the globe through the analysis of three components: 1) life expectancy at birth, 2) education levels, measured as school enrolment and adult literacy rates, and 3) standard of living, as per capita Gross Domestic Product (GDP) at Purchasing Power Parity (PPP). As an example, in the most recent United Nations Development Programme’s Human Development Report (UNDP, 2011), South Africa ranks 123rd out of 187 countries, with an index of 0.619, and is classified ‘medium human development’ (Figure 2.7).

The South African figures have not followed the general upward trend of medium developing countries however, reflecting both the political upheavals in the country as well as

the catastrophic effect of HIV/AIDS on life expectancy. Interestingly, this has happened at the same time as the country's move to full democracy along with significant increases in the GDP. This shows that human development requires focused interventions in infrastructure, health and education; i.e. investments that improve equity – and that economic growth is not the only factor in development.

The *Human Poverty Index* (HPI) makes improvements on the HDI by incorporating additional variables which provide a better indication of the level of deprivation amongst the nations of the world (UNPD, 2006). This has been expanded even further into the *Multidimensional Poverty Index* (MPI), which measures deficits in health, education and living standards, looking at both the number of deprived people and the intensity of their deprivations (UNDP, 2011). Other variations of the HDI account for inequalities in HDI dimensions (e.g. the Inequality-adjusted Human Development Index and the Gender Inequality Index).

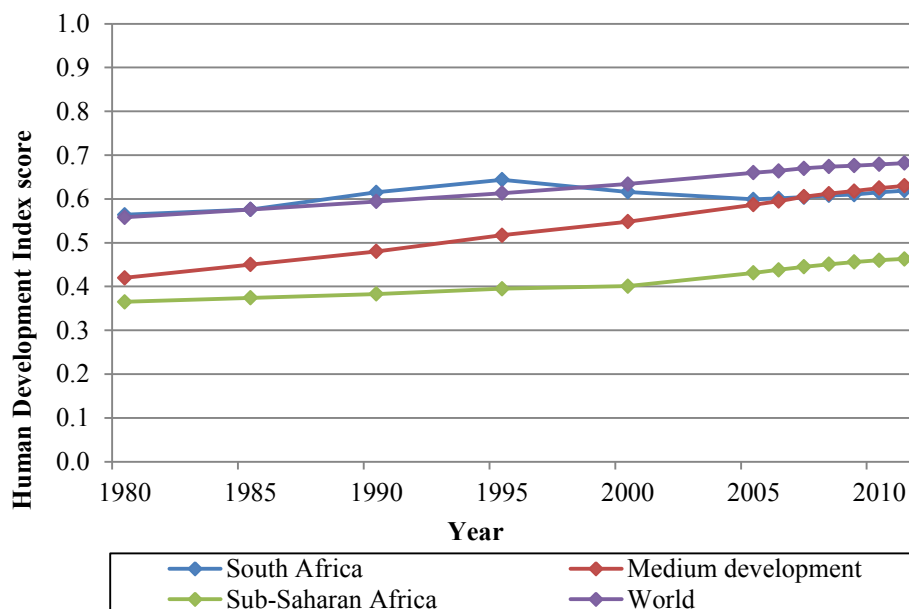


Figure 2.7: Human Development Index trends; 1980 – 2011 (UNDP, 2011)

The HDI is not considered to be a measure of sustainability in that it masks gross inequities in the distribution of resources and fails to register declines in well-being stemming from loss of community, culture and environment. In addition, there is a poor (often negative) relationship between the HDI and classic measures of sustainability, such as the Ecological Footprint (EF) and the Environmental Performance Index (EPI), leading to an assertion on the part of Fuentes-Nieva & Pereira (2010) that the human development process itself is unsustainable. This view is supported by Togtokh (2011) who notes that the HDI mostly ignores sustainability issues, and in fact celebrates rich nations that are often 'developed' at the cost of the environment (e.g. loss of biodiversity), based on their influence on global warming. He suggests incorporating per capita carbon emissions into the calculation of a revised Human Sustainable Development

Index. Using this calculation, countries that value moderation (traditionally the Nordic countries), and those that are not dependent on intensive oil use, score highest.

2.5.1.2 City Development Index (CDI)

The CDI was developed by UN-HABITAT under the Urban Indicators Programme (UN-DESA, 2005); this is a composite index which allows for development comparisons at city level rather than national level to allow for differences within the country. It consists of five components with the weightings for each indicator calculated using Principal Components Analysis, and makes use of three of the same indices as the HDI, i.e. Health, Education and City Product, plus two added indices to account for waste treatment (Waste) and environmental improvements (Infrastructure). Each sub-index is a combination of several indicators that have been normalised to give a value between 0 and 1. The CDI is calculated according to the formulae for the 5 sub-indices shown in Table 2.5. The Infrastructure, Waste and Education indices are based on the percentage access (expressed as a decimal) to the services / development indicator described. Each indicator is given equal weighting in the Infrastructure and Waste components, such that they add up to 100. The Health index considers actual figures for life expectancy and child mortality, while the City Product (defined as the product consumption per capita) is calculated by using GDP PPP US\$ estimates. The separate sub-indices scores are averaged in the final calculation to form the overall CDI score.

Table 2.5: Components of the CDI (Parikh, 2008)

Sub-indices	Formula
Infrastructure	$25 \times \text{Water connections} + 25 \times \text{Sewerage} + 25 \times \text{Electricity} + 25 \times \text{Telephone}$
Waste	$50 \times \text{Wastewater treated} + 50 \times \text{Formal solid waste disposal}$
Health	$(\text{Life expectancy} - 25)(50/60) + (32 - \text{Child mortality})(50/31.92)$
Education	$25 \times \text{Literacy} + 25 \times \text{Combined enrolment}$
City Product	$(\text{Log City product} - 4.61) (100/5.99)$
City Development Index	$(\text{Infrastructure} + \text{Waste} + \text{Education} + \text{Health} + \text{City Product}) / 5$

The City Development Index (CDI) was identified as a potential tool for measuring the impacts of poverty in urban areas in South Africa (SACN, 2002), but was never implemented fully. This is probably based on the fact that, if applied at city level, this index can conceal wide variations in the nature and severity of poverty in specific settlements or pockets in the city; it is therefore far better suited to assessing specific impacts at settlement level (SACN, 2002). It was in this respect that Parikh (2008) applied the CDI to settlements in India and South Africa in an attempt to highlight improvements in housing stock brought on by settlement residents after the provision of certain infrastructure. She was able to show that there are improvements in the CDI values for serviced settlements and that even though the GDP index remains similar, other components such as infrastructure and waste increase, leading to a better quality of life for the settlement residents.

2.5.1.3 Ecological Footprint (EF)

The Ecological Footprint is essentially an accounting tool that assumes that each human activity uses resources and has waste flows which can be converted to a biologically productive area necessary to provide these functions (Wackernagel & Rees, 1996). It is a measure of how consumption may affect the environment by taking account of food and fibre production, energy use, and human use of land for living space and other purposes. It aggregates across different forms of stress by converting them all to a hypothetical number of hectares of land and sea area at global average levels of productivity that would be needed to renew current levels of resource consumption (Dietz *et al.*, 2007). Through this assessment of relative consumption, the tool serves to educate people regarding their consumptive patterns and create awareness of the overall impacts on the environment. Ultimately the EF attempts to change behaviours through better information and knowledge dissemination, and as such it is a strong social tool and can be used as part of a sustainability assessment process. According to the latest Living Planet Report (WWF, 2012), South Africa's EF increased from 2.32 hectares per capita (ha/c) in 2010 to 2.59 ha/c in 2012. On a per capita basis, there is an available bio-capacity of 1.21 ha, resulting in an ecological deficit of 1.38 ha/c. This is mainly as a result of the country's reliance on carbon fuels for electricity. South Africa is ranked 66th highest out of 150 countries worldwide, and has the 4th largest EF in Africa, following Mauritius, Mauritania and Botswana.

2.5.1.4 Environmental Sustainability Index (ESI)

The ESI provides a benchmark for the environmental performance of nations through an assessment of the degree to which they undertake environmental protection and preservation, as well as the level of commitment to subsequent issues at global, national and local scales. This is achieved through the integration of 76 variables which aggregate into 21 indicators and further into five components, which ultimately inform the final index (Yale, 2005). The *Environmental Performance Index* (EPI) follows on the methodological footsteps of the ESI, but provides a valuable addition – the use of targets to assess progress towards concrete goals. This is crucial because benchmarking in isolation is not sufficient to determine whether there is indeed progress towards sustainable development.

2.5.1.5 Water Poverty Index (WPI)

This index attempts to indicate the degree to which water resources availability impacts the human population and sustainable livelihoods, and aims to “*produce an integrated assessment of water stress and scarcity, linking physical estimates of water availability with socio-economic variables that reflect poverty*” (Sullivan, 2002). The premise is that people who have good access to water are able to use it for productive purposes such as food production, cottage industries etc., while the labour availability for income generation purposes in households who are poorly served is much reduced due to the time needed to collect water for basic needs. The WPI's core theoretical framework encompasses five components: water resources availability, sustainable access to water, use of water for productive purposes, capacity to manage the water

resources, and environmental factors which impact on the ecology which water sustains. It can be used as a monitoring or decision-making tool to express the water situation in a community or to prioritise needs at government level, and it can be applied at a variety of scales. Basin scale assessments are specifically aimed at providing information towards the objective of IWRM, through the development of more adaptive management strategies. The *enhanced Water Poverty Index* (eWPI) was developed as an extension to the WPI by Giné-Garriga & Pérez-Foguet (2010) by combining a pressure-state-response (PSR) function (as will be discussed in the following section) with the original framework to produce a holistic tool for policy making. PSR provides a means of selecting and organising indicators in the context of a causal chain – and highlights the cause-effect relationships and interconnections between the variables. In this way, a tool such as the eWPI can be used to reflect the challenges related to the provision of water, specifically in rural areas in low-income countries. The index is aimed at allowing resource managers to determine and target priority needs in the water sector, whilst assessing development progress.

2.6 Performance measurement / benchmarking and sustainability assessment in urban water management

Governments and donors are increasingly expected to put in place uniform and consistent systems to monitor the impacts of water-related management and initiatives – both for advocacy purposes as well as for fine-tuning strategies and policies. The use of performance indicators (PIs) and benchmarking techniques has thus become common practice in the water industry worldwide with the main aim of verifying the quality of public service in terms of efficiency, effectiveness and economy in order to improve system performance (Alegre *et al.*, 2006). The implementation of a PI system is usually the result of a wider approach to management which links objectives, strategies and critical success factors within a water undertaking.

There are subtle differences between benchmarking / performance measurement and sustainability assessment in the urban water sector. The primary objectives of benchmarking are: 1) to provide a set of Key Performance Indicators (KPIs) related to a utility's managerial, financial, operational and regulatory activities that can be used to measure performance and provide managerial guidance, and 2) enable an organisation to compare its performance with those of other utilities to identify areas needing improvement and to formulate company goals on an ongoing basis (Van den Berg & Danilenko, 2011). There are two types of benchmarking, both of which use indicators as quantitative, comparable measurements of a specific type of activity or output:

- Metric benchmarking – involves systematically comparing the performance of one utility with that of other similar utilities, and tracking performance over time.

- Process benchmarking – a normative tool with which one utility can compare the effectiveness of its processes and procedures for carrying out various functions (e.g. a billing system) to those of selected peers.

Main *et al.*, in Cabrera & Pardo (2008) assert that benchmarking is not easily applied in the public sector owing to the fact that public agencies have a much broader set of objectives than the private sector, including performance on social, environmental and financial matters (often with competing goals). It requires a collaborative effort – with the willing sharing of performance data and measurement of a wide range of indicators against set management goals. Benchmarking in urban water services is usually by way of measuring performance in each of the separate functions, e.g. water, wastewater, and stormwater, and is therefore unable to provide an integrated sustainability analysis of the whole urban water system. It represents an important tool for those developing and implementing water policy however – by using empirical procedures for performance comparisons, analysts are able to identify performance gaps and make comparisons across utilities, thereby informing improved management in the sector (UNESCO-IHE, 2009).

Benchmarking has historically focused on the efficiency of water and sanitation utilities (in respect of indicators such as non-revenue water, operational costs, etc.), without specifically taking into account the provision of services to poor people in urban and peri-urban areas, many of whom are not supplied by these utilities. In response to this, the UNESCO-IHE Global Partnership for Water Education and Research (POWER) formed a coalition of knowledge centres to build capacity for the sustainable management of water and delivery of water and sanitation services, and commenced (in 2009) with a research project on benchmarking for pro-poor water services provision, entitled PROBE (UNESCO-IHE, 2009). The specific focus of the research is to promote the accelerated expansion of drinking water supply and sanitation services to the urban and peri-urban poor and thus contribute to the achievement of the Millennium Development Goals, specifically Targets 10 and 11. As such, it will concentrate on three areas: 1) mapping of poor people in need of services, 2) development of contextual and operational indicators for pro-poor service provision, and 3) service provision best practice.

The International Benchmarking Network for water and sanitation utilities (IBNET) is a performance benchmarking initiative which forms part of the Water and Sanitation Programme of the World Bank, and provides information on 3000 water utilities worldwide, including selected cities in South Africa (Van den Berg & Danilenko, 2011). It focuses on three different aspects of performance, i.e. operational, financial and social, through the use of six indicators: water supply coverage, sewerage coverage, non-revenue water, collection period, operating cost coverage ratio, and affordability of water and wastewater services – and produces Apgar scores (Box 2.4) for water utilities. These scores are intended to help in identifying ways to improve urban water and wastewater services. As would be expected, the Apgar scores of utilities in low-income countries tend to be lower than those in middle-income countries, and similarly, smaller utilities tend to have lower scores than the larger ones. “*By tracking progress in and quantifying and assessing the water supply and sanitation sectors, IBNET helps meet the*

goal of providing safe, sustainable and affordable water and sanitation for all” (Van den Berg & Danilenko, 2011).

Box 2.4: The Water Utility Apgar score (Van den Berg & Danilenko, 2011)

The term *Apgar score* was developed by physician Virginia Apgar, for assessing the health of newborn infants quickly and summarily by measuring them on five simple indicators, giving them a score from zero to two for each, and classifying the total result according to a set scale. The Apgar score for water-supply and sewage utilities does something similar, assessing the utilities’ operational, financial, and social performance based on five or six indicators depending on the type of service provided: (i) water supply coverage; (ii) sewerage coverage; (iii) non-revenue water; (iv) collection period; (v) operating cost coverage ratio; and (vi) affordability of water and wastewater services. Each criterion is rated on a scale from zero to two, and the results are totalled. For utilities providing only water, the score is normalised (the maximum score for water utilities is 10; for water and wastewater utilities, 12).

In contrast to benchmarking, urban water sustainability assessment requires a multi-dimensional and integrated systems approach, where the state of the system (in general terms, an entity that reacts to certain inputs and produces outputs) can only be assessed in relation to its surrounding systems and the system of which it is a part – e.g. a city, which is a part of a region etc. (Bagheri & Hjorth, 2007a; Bertrand-Krajewski *et al.*, 2000; Palme, 2007; Sundberg *et al.*, 2004).

It has been stated that there are no known cases in which a genuinely integrated monitoring programme across the entire urban water cycle has been undertaken (Fletcher & Deletić, 2008), but sustainability assessment processes are used as part of a framework for tracking progress towards sustainability (Figure 2.8).

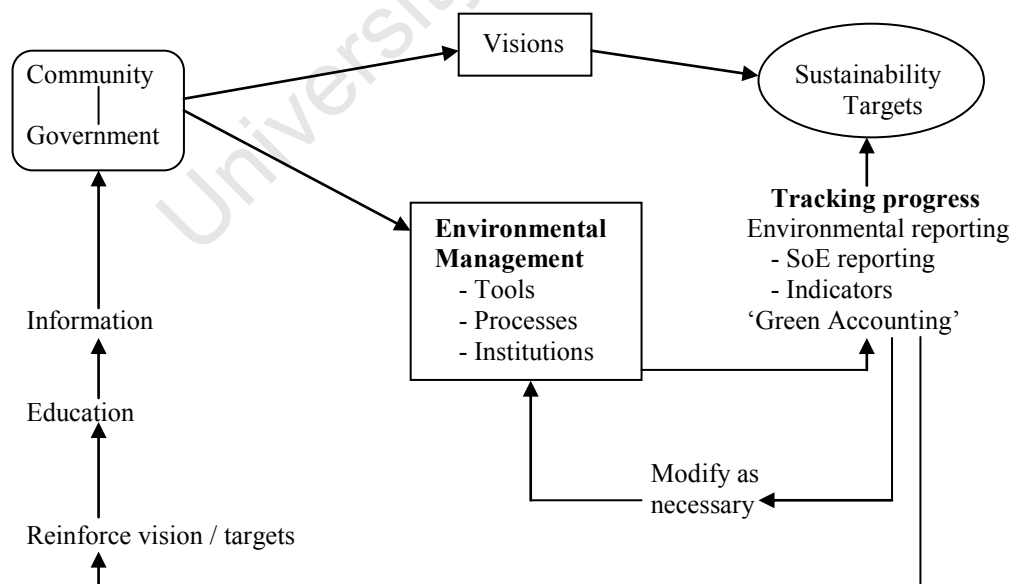


Figure 2.8: Tracking progress towards sustainability (Fletcher & Deletić, 2008)

Quantitative frameworks are commonly used for assessing the long-term sustainability of water infrastructure relating to: (i) decision-making, investment planning and asset management; (ii) environmental factors; and (iii) efficient service provision to maintain and enhance quality of life (e.g. Sahely *et al.*, 2005). An important aspect is the need to use a systematic (often weighted multi-criteria) approach to properly assess the impacts of engineering activities – a method more inspired by an organised learning systems approach than by systems engineering (Sundberg *et al.*, 2004). Indicators should reflect the system’s ability to handle influences from, as well as its impact on, all related systems.

Palme (2007) noted that sustainability indicators (SIs) have an important role to play in supporting sustainable development in water organisations provided that:

- Sustainability is defined in terms of a vision rather than a set of SIs (particularly in respect of what kind of water system is required to meet the challenges of *inter alia* population growth, increased chemical pollution and climate change).
- A decision is made regarding whether to use the SIs for planning and control or primarily as learning / conceptualisation tools. Careful consideration should be given to whether they be assigned a leading role (as in benchmarking or sustainability reports) or a more subordinate position as in monitoring targets and scenario analysis, specifically in terms of the SI function and data needs.

Numerous sets of sustainability indicators have been created for use in water utilities and urban water systems, but there are few reports dealing with the practical application of these indicators / indices in water organisations around the world. This prompted the research by Palme (2010) which investigated preconditions for the application of sustainable development information systems such as these, and explored the key factors influencing the application of sustainable development indicators (SDIs) in Swedish water authorities; the most important of these were the attitudes of organisations to SDIs, issues of trust / conflict and communication, and the national water sector objectives and regulation.

Another important aspect to be considered the way in which benchmarking results and sustainability assessment knowledge gets disseminated – and how useful these measurement initiatives are. This will be discussed in further detail in Chapter 7.

2.6.1 Theoretical and methodological frameworks

“The major difficulty in developing indicators to track progress towards sustainable development is not the lack of data but rather the lack of frameworks to organise and synthesise existing information.” (OECD, 2000)

As discussed previously, sustainability indicators have become popular as tools for assessing sustainability in the urban water sector, but they are mainly focused on technical systems’ performance in the various different sectors, i.e. drinking water, wastewater and stormwater

(Sundberg *et al.*, 2004). Although the value of indicators to monitor progress towards sustainability is widely accepted, the selection and development of indicator sets for specific contexts can be a daunting task. Since one single indicator cannot describe sustainable systems, the use of “*a basic conceptual structure organised around a theory*”, i.e. a theoretical framework (CREDE, 2002), should be developed to encapsulate clearly defined phenomena so as to provide the basis for the selection and combination of single indicators into a meaningful composite indicator under a fitness-for-purpose principle (Nardo *et al.*, 2008; Davidson, 2010). In this way, sustainability indicators can help in understanding the interrelated forces driving change (Davidson, 2010). Frameworks are also useful in that they suggest logical groupings of related sets of information in order to promote interpretation and integration, and help to identify data collection needs and gaps (Walmsley, 2002). Various types of framework have been developed, mostly falling under the categories of economic, physical environmental, systems analysis and adaptive management frameworks.

2.6.1.1 Economic frameworks

Economic frameworks are based on the concept of attempting to place a financial value on resources and assets (including environmental) and include systems such as Integrated Environmental and Economic Accounting, Measures of Wealth, and Genuine Savings (OECD, 2000). An example of one of these frameworks is the World Bank’s Wealth of Nations – this is a tool for measuring sustainable development through the measurement of natural resources (natural capital), produced assets (man-made capital) and human resources (human capital) – the World Bank has determined the dollar value of these for 192 countries using mostly existing data and traditional measurements. Economic frameworks have limited use in contexts such as urban water management, however, as they do not sufficiently account for the inter-linkages between the various aspects of the water system.

2.6.1.2 Physical environmental frameworks

More appropriately, physical environmental frameworks measure the interaction between humans and the environment. Owing to the fact that they are systematic, they are useful as a means of organising physical data from a range of subject areas and sources. Some of the commonly-used frameworks are detailed as follows (Farsari & Prastacos, 2002; Walmsley, 2002; Walmsley *et al.*, 2001):

- **Hyogo Framework for Action (HFA)** – The HFA was developed by the United Nations (UNISDR, 2007) in order to assess the social vulnerability of people and their response to water infrastructure, and emphasises institutional coping capacities and disaster risk reduction. Social vulnerability and coping capacity are examined by developing *indicators* for selected key *outcomes* in order to monitor leading goals or *statements of intent* for these outcomes and signify a level of vulnerability for a particular case study area; e.g. a key outcome could be ‘reducing vulnerability through infrastructure’, the statement of intent, ‘increase quality of drinking water’, and the indicator, ‘number of qualified operators employed at water treatment works’.

- Barometer of Sustainability** – Developed in 1997 by Robert Prescott-Allen, the Barometer of Sustainability offers an aggregate indicator of sustainability and assesses a region's progress towards sustainability through the systematic integration of economic, biophysical and social health indicators to give a visual depiction of human and ecosystem wellbeing (IUCN, 1997). It is viewed in two axes – one for ecosystem wellbeing and one for human wellbeing (Figure 2.9, left). The judgement of overall sustainability is based on the axis with the lower score in order to prevent trade-offs being made between human and ecosystem well-being (both are prerequisites for sustainable development). This dual element approach also conceptualised in the 'Egg of Sustainability' (Figure 2.9, right) implies a sense of interdependence – i.e. a society is more likely to be sustainable if human wellbeing is high and ecosystem stress is low.

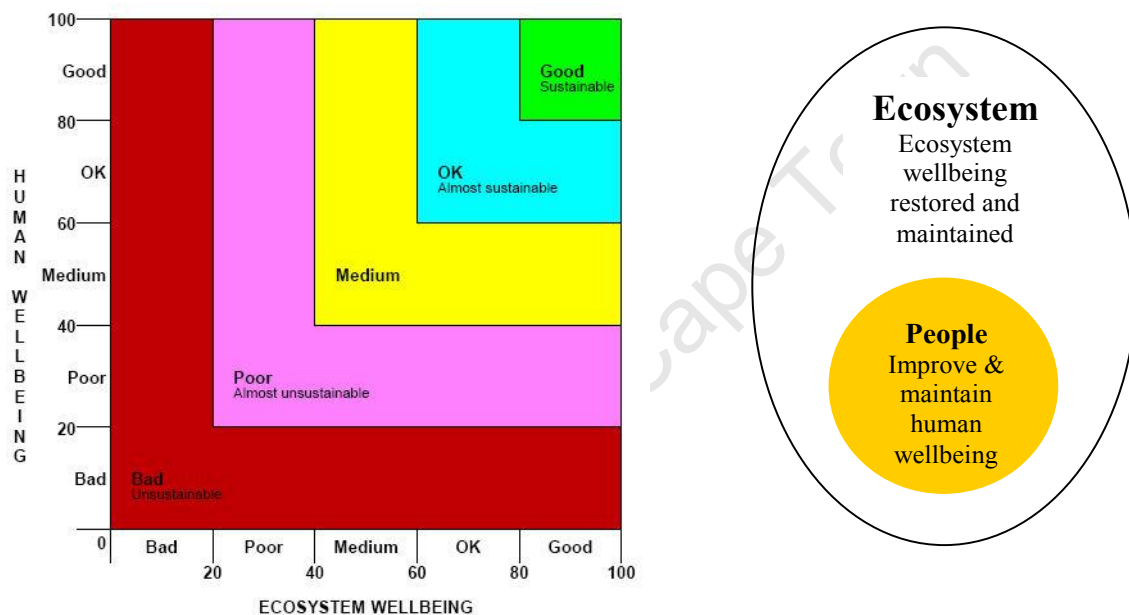


Figure 2.9: Barometer of Sustainability (left) and Egg of Sustainability (right)
(IUCN, 1997)

- OECD's Pressure-State-Response (PSR) framework** – The PSR framework for SD is based on the concept of causality; human activities exert pressures on the environment and change its quality and the quantity of natural resources (the state). Society responds to these changes by way of environmental, economic and sectoral policies (the societal response). The latter form a feedback loop to pressures through human activities (OECD, 1993). Indicators are developed in line with these three concepts. The framework was expanded by the UN into the DPSIR framework, which includes the additional category of impacts to describe the results of pressures on the current state (Walmsley, 2002). Impact and state indicators are the primary measure applied to sustainability projects, but

drivers, pressure and response (DPR) indicators may be developed at a later stage in order to help to understand what the state & impact indicators are describing and what their drivers are (Bell & Morse, 2008). Both PSR and DPSIR frameworks have been used extensively in the development of environmental indicators (e.g. State of the Environment reports), as they deal more specifically with the influence of humans on the environment. The UN has subsequently abandoned the DSR frameworks in favour of an issues-based or theme (poverty, governance, health etc.) and sub-theme (income inequality, life expectancy at birth etc.) approach. Elements of urban water systems are also subject to cause-effect relationships; Figure 2.10 provides an example of a DPSIR framework adapted for urban water management in South Africa, and shows how it can be utilised to identify indicators in a sustainability assessment process.

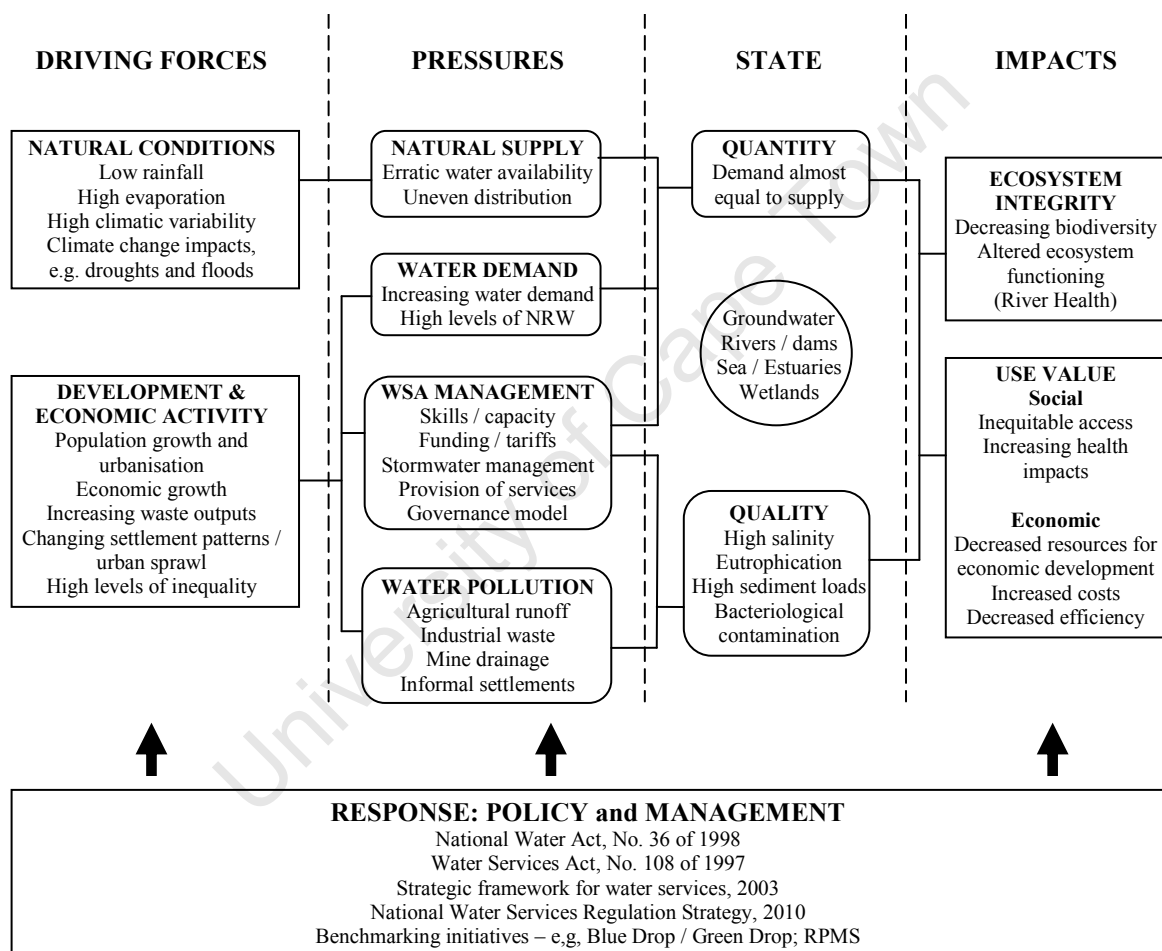


Figure 2.10: DPSIR linkage diagram showing key characteristics of South Africa's urban water management challenges (adapted from Walmsley, 2002)

2.6.1.3 Systems analysis frameworks

Systems analysis frameworks reflect the interactions between the various subsystems, parallel systems and the external environment so that indicators can be selected to evaluate opportunities and impacts, and reflect on the system's sustainability (Sundberg *et al.*, 2004; Bagheri & Hjorth, 2007a). Many of these frameworks are based on the model for the assessment of complex systems by Robèrt *et al.* (2002), as shown in Figure 2.11.

Level 1 defines the overarching system, the ecosphere, by establishing its constituents and guiding ecological, economic and social principles. At Level 2, principles for sustainability are proposed in line with the definition of sustainability adopted. Stating the desired goals leads to identification of the process to be taken towards the achievement of such and ultimately a plan of action geared towards it (Levels 3 and 4). Establishing a system of monitoring and auditing (Level 5) is essential in assessing the soundness of the actions taken and the progress towards the goals stated. The structure provided by this model provides a clear way of going about the assessment of urban systems and identifies the level at which tools can more effectively be introduced (De Carvalho, 2007).

Level 1	System constitution
Level 2	Goals and outcomes: Principles for sustainability (end state)
Level 3	Process: Principles for sustainable development (goal)
Level 4	Actions
Level 5	Tools: Monitoring and Auditing

Figure 2.11: Systems model (Robèrt *et al.*, 2002)

A common strategy for defining indicators for sustainable systems is within the different aspects of sustainability, i.e. social, economic and environmental; or through division into smaller sectors, e.g. water resources, wastewater, or stormwater (Sundberg *et al.*, 2004). Reactive and unplanned approaches to environmental problems have complicated the transition to more sustainable urban water systems where the reuse of water and nutrients is advised. Using the vision of SUWM as a management system which results in “...*water and its constituents being safely used, reused and returned to nature*”, Hellström *et al.* (2000) developed a systems analysis framework as part of the Swedish Foundation for Strategic Environmental Research (MISTRA) on sustainable urban water management, using a set of sustainability criteria and associated indicators.

Environmental sustainability indicators were developed by Lundin & Morrison (2002) to measure and describe different aspects of sustainability in urban water systems through the development of an iterative procedure combining empirical results with a theoretical framework based on environmental life cycle assessment (ELCA) methodology (see Glossary). Case studies on specific technical options provided the results for specific aspects of water infrastructure, which defined the most important indicators for the system being studied and also helped to reveal information gaps and problems concerning availability and quality of data. ELCA is a complex method, requiring high data inputs and the technical skills necessary to interpret results and propose sustainable applications. Lundin & Morrison (2002) noted specifically the difficulties encountered with respect to access to information in the case study in South Africa (King William's Town), highlighting challenges with this type of sustainability assessment specifically in developing countries. Together with other similar assessment methods using environmental sustainability indicators (e.g. Balkema *et al.*, 2002; Lundie *et al.*, 2005), this type of process is considered to be useful for assessing the performance of a specific part of an urban water system, rather than its contribution to sustainable development. The advantages of an analysis such as this are that it assists in determining sustainability priorities and identifying less-obvious indicators; it therefore provides a solid framework for the development of SIs. For this reason, and as will be discussed in more detail in Chapter 3 (see Figure 3.1), the ECLA methodology was adapted for use as part of a step-wise approach to the preliminary indicator development as part of this current research.

It has been suggested that there are some drawbacks with the use of the ECLA frameworks for the overall assessment of sustainable development owing to the fact that they are based either on the different sectors of urban water management or the different aspects of sustainability and therefore have limited systems definition (Sundberg *et al.*, 2004). A re-framing based on systems theory, which focuses on general systems characteristics rather than on specific impact assessments of different technological options or management processes allows for consideration of the various systems interactions and influences. The theoretical framework for the development of the Sustainability Index for Urban Water Management thus makes use of an integrated systems model for sustainability (see Section 4.1.1 for further details in this regard).

2.6.1.4 Adaptive management frameworks

As has been discussed, integrated urban water management often adopts a measurement approach focused around the development of systems tools or models which provide an understanding and analysis of the managed water systems in urban areas. Many of these approaches deal only with water quantity and quality (Hellström *et al.*, 2000), but another important area is the incorporation of social issues to address sustainability, i.e. 'social learning'. It has been argued that the most important process in system management is this process of learning, and that by involving stakeholders, systems are capable of adapting to change, and moving towards sustainability (Bagheri & Hjorth, 2007b). Strategic planning approaches by way of adaptive management are suggested as an alternative to systems analysis

(Malmqvist *et al.*, 2006) and include the use of strategic choice approaches (SCA) which facilitate linking problems with options, for example: water shortages to demand management and wastewater management; willingness-to-pay to fair consumption fees, efficient organisation and service reliability; or groundwater pollution to improved wastewater management.

Adaptive management, encompassing reflexive institutional approaches, is thus developing as the strategic approach to urban water management, whilst IUWM is the operational approach. In both approaches the inclusion of systems thinking that includes transformative knowledge and learning – through monitoring / evaluation and stakeholder engagement – is critical for macro (strategic) and micro (operational)-level urban water management (Scoones *et al.*, 2007; Pearson *et al.*, 2010).

As will be described in further detail in Chapter 4, the conceptual framework model on which the development of the SIUWM was initially based was adapted by De Carvalho (2007) from the systems analysis model for the selection of environmental sustainability indicators by Lundin & Morrison (2002), coupled with the step-wise methodology proposed by Nardo *et al.* (2008) for the use of indicators and aggregation into a composite index.

2.6.2 Sustainability visioneering / envisioning

“A sustainable future will require purpose-driven transformation of society at all scales, guided by the best foresight, with insight based on the hindsight that science can provide, i.e. visioneering” (Kim & Oki, 2011)

Left to its own devices, the earth is a sustainable system – however the accumulated impacts of human activity threaten our continued well-being. The Natural Step framework addresses this by way of a systems approach, such that what happens in one part of a system affects every other part (The Natural Step, 2010). It bases its planning approach on the concept of backcasting, where planning for the future starts with a concise description (‘vision’) of a desired future in mind; i.e. planning for success. This vision of a sustainable future is defined by four guiding principles (or system conditions) for achieving sustainability, i.e. what should / shouldn’t be done in order for sustainability to be a reality:

- i) Materials from the Earth’s crust should not be systematically increased in the Earth’s environment – i.e. fossil fuels should not be extracted faster than their re-deposit.
- ii) Materials produced by society must not be systematically increased in the Earth’s environment – i.e. waste material should not be produced faster than it can break down.
- iii) Ecosystems should not be manipulated such that biodiversity is threatened.
- iv) There must be fair and efficient use of resources with respect to meeting human needs.

Having a vision is not enough however – it is only the first step towards the sustainability goal, which also requires relevant information, models and implementation. Making sustainability operational thus requires integration of a practical, shared vision with appropriate methods of analysis and instruments for implementation (Costanza *et al.*, 1996). Sustainability visioning is considered as a combination of 1) governance – the process of providing the vision and resolving trade-offs; 2) management – operationalising the vision through goal and indicator setting; and 3) monitoring – providing feedback as a source of learning towards sustainability (Kim & Oki, 2011). As such, visioning makes it possible to enhance the resilience of whole systems and improve the functioning of systems frameworks as it calls for diverse groups of people to join the processes of collaborative learning and action with stewardship – “*it is the magnet for commitment, the key to unity, and the determinant of destiny*” (ibid).

In the context of urban water management, establishing a vision is critical to any sustainability assessment process. The recently-completed Sustainable Water management Improves Tomorrow's Cities Health (SWITCH) project in the European Union's 6th Framework (FP6) was founded on a systems approach to urban water management – with the aim of showing how an interdisciplinary and integrated approach might accelerate change towards a more sustainable future (Howe & Van der Steen, 2008). Key to this is strategic planning based on the notion of ‘Learning Alliances’ (see Glossary), where researchers and local stakeholders work together to create shared visions, analyse options and develop new strategies for the management of urban water systems. The state of the urban water system is monitored in order to evaluate the effectiveness of the strategy and its implementation; based on the formulation of a number of individual indicators, decision-makers can evaluate whether a city is moving towards its vision for a sustainable water system or not (Van der Steen, 2011). This integrated approach is in line with the basic hypothesis of the SWITCH project: “*Design and management of the urban water system based on an analysis and optimisation of the entire urban water system will lead to more sustainable solutions than optimisation of elements of the system*” (SWITCH, 2010).

2.6.3 Indicator selection and data manipulation issues

The main function of indicators in urban water management is simplification, quantification, comparison of different aspects, and providing information on the system or process under consideration (Vrba & Lipponen, 2007). Sustainable development, and the protection and management of water resources act as guiding principles for indicator selection. There are a number of ways of identifying sustainability indicators (SIs), but one of the emerging premises is the use of Systemic Sustainability Analysis (SSA) which is defined as the participatory deconstruction and negotiation of what sustainability means to a group of people, along with the identification and method of assessment of indicators to assess that vision of sustainability (Bell & Morse, 2008). The process of identifying SIs can be achieved by way of an explicit ‘Kolb’ learning cycle, as shown in Figure 2.12.

One of the final steps is to get the message out to the right audience such that policy can be influenced through the identification of preferred indicators, potential consumers, and a suitable means of conveying the message (Bell & Morse, 2008). In a sense the process of developing SIs is part of a ‘virtuous’ cycle, with the SI itself encouraging sustainable practices and reflecting the results of such practice. In this case the SI becomes the means to an end as well as a simplified description of the context end itself.

Using this approach, the initial selection and unpacking of indicators is often based on the identification of specific urban water management challenges, as well as existing indicator initiatives to which these challenges can be linked. In this way some of the key indicators can be highlighted (e.g. Lundie *et al.*, 2005; Ranhagen *et al.*, 2007; Guio-Torres, 2007). The general steps to be taken by a local government or utility in order to select and implement a set of indicators to monitor, plan and manage the urban water system have been described in some detail in the training manual for process facilitators of urban strategic planning processes that was one of the final outputs of the SWITCH Project (Van der Steen, 2011). These indicators are specifically geared towards scenario planning for transitioning to selected integrated urban water management approaches in different types of cities, and not necessarily as part of an integrated sustainability analysis – as will be discussed in more detail in Chapter 4.

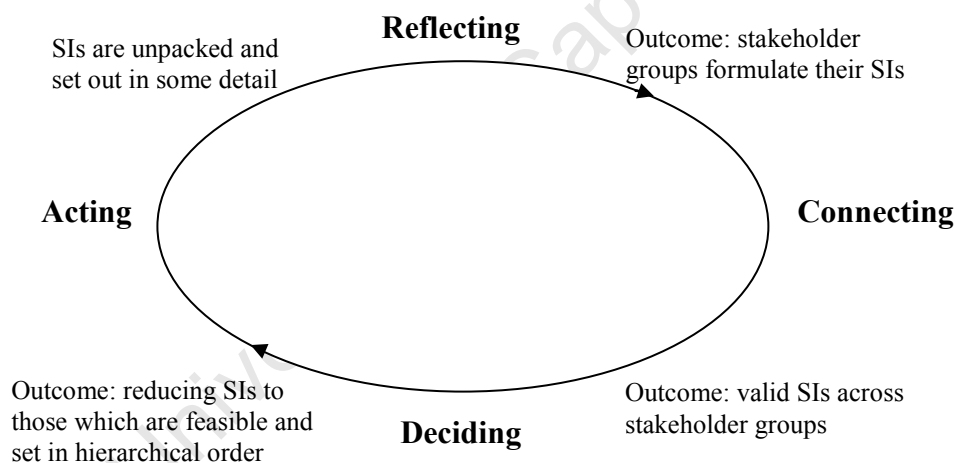


Figure 2.12: The SI learning cycle (Bell & Morse, 2008)

Sustainability indicators should be developed / adopted based on the quality and availability of their data backup – confidentiality and ‘defensive’ treatment of water-related data can seriously affect good indicator development. Likewise the dependence of indicator development on data can lead to a situation in which data availability drives the selection of indicators, which in turn reinforces the collection of data (Vrba & Lipponen, 2007). Data is defined as information output representing facts, concepts or instructions in a formalised manner (Faures & d’Amore, 2006), and is classified as primary (data obtained directly from field measurements), secondary (obtained from compilation of lower level data), or tertiary (international data compiled from

international sources). The United Nations World Water Development Report 3 notes the consequences of poor data availability and the lack of systematic processes for updating information as follows: “Data on almost every subject related to water issues is usually lacking, unreliable, incomplete or inconsistent. We have learned that merely collecting data is not enough. It must be brought together, analysed and converted into information and knowledge, then shared widely within and between countries and stakeholders to focus attention on water problems at all scales. It is only when the data has been collected and analysed that we can properly understand the many systems that affect water (hydrological, socio-economic, financial, institutional and political alike), which have to be factored into water governance” (WWAP, 2009).

The development of indicator sets is thus very often limited by data availability, rather than on what can reasonably be collected (cost, effort and time), and indicators selected for data availability rather than validity (Davidson, 2010). Walmsley *et al.* (2001) suggest that if a core indicator set is developed that takes into account the physical system as well as the policy and management goals, the collection of data should be important enough to warrant implementing monitoring programmes, thereby ensuring adequate data availability. Data for a large number of variables is often expensive, difficult and time-consuming to obtain however, making comparison between cities very difficult (Fan & Qi, 2010). An ideal sustainability index should have only a few representative variables (in the dimensions of economy, environment and social equity), which are already widely adopted in city-level statistics (*ibid.*).

A full description and critique of the indicator selection and data management processes that were adopted as part of this research will be provided in Chapters 4 and 5.

2.6.4 Limitations to sustainability measurement

Whilst Integrated Sustainability Assessment (ISA) is seen as part of a new paradigm for urban water decision making, it is acknowledged that this is a difficult task because the definition is vague and multi-dimensional (Lai *et al.*, 2008). Sustainability science encompasses the need to address a wide set of issues over different time and spatial scales, and thus inevitably accommodates opinions from diverse branches of knowledge and expertise. Common quantitative approaches to measuring sustainability have many limitations, both theoretically and practically, due to the complexity and ‘fuzziness’ in the concept, and there are various arguments against the use of these approaches (Munda, 2005; Gasparatos *et al.*, 2009). Much of decision-making in the real world takes place in an environment in which the goals, constraints and consequences of possible actions are not known precisely – fuzzy set theory (an extension of classical set theory where elements have varying degrees of membership) is a way to handle this type of uncertainty, imprecision and vague information (Lai *et al.*, 2008). For instance, Khatri *et al.* (2011) acknowledge that performance indicators used to characterise complex infrastructure systems are not always quantitative in nature. They propose a multi-criteria analysis framework to compute urban infrastructure performance by way of a fuzzy set

approach. This can then be used by decision makers to formulate appropriate strategies for infrastructure planning on the basis of performance and the required costs of investment.

Another example of an approach geared towards dealing with this type of complexity is that offered by way of analytical hierarchy processes (AHP) which provide a basis for making complex decisions by arranging criteria into a hierarchy. The relative importance of the criteria are determined through pair-wise comparison and converted into a set of weights. Criteria are then compared by incorporating judgement and personal values, thus increasing AHP's capacity to be a framework for engaging stakeholders, particularly with respect to the selection of indicators and the determination of their weights (Bagheri *et al.*, 2006; Lai *et al.*, 2008; Khatri *et al.*, 2011; Ocampo-Duque *et al.*, 2006). This will be discussed in further detail in Section 4.4.

Despite the availability of these alternative approaches, progress towards sustainability is usually assessed through the development and use of single metrics, such as composite sustainability indices. The advantage of these tools lies in the fact that they can reduce and integrate the diverse issues affecting progress towards sustainability to a small set of numbers. This can be invaluable to policy makers as the results can be used to understand various natural and human systems and summarise large volumes of information, thus simplifying the decision-making process. Weighting and aggregation can be particularly problematic however – weights do not always retain their status as value judgements in composite indices (where one indicator has the ability to compensate for a lower performance in another), and aggregation of indicators to a single index number can result in a loss of information. The applicability of reductionist approaches has thus been criticised both for not describing complex systems and for not offering sufficient policy recommendations to facilitate progress towards sustainability. The adoption of methodological pluralism and increased stakeholder participation (i.e. supplementing reductionist approaches with an integrative agenda) is envisioned to culminate in better informed policy making (Gasparatos *et al.*, 2009).

In a study of urban water systems in Sweden, Palme (2007) investigated whether and how the use of sustainable development indicators (SDIs) could make these systems more sustainable, by firstly gaining an understanding of how SD is defined and then by investigating how the indicators are applied. She noted that there are divergent views of sustainable development as well as whether and how SDIs are useful. The most obvious differences found between the various conceptions of SD concerned time – researchers and professionals stressed the importance of long-term thinking, while politicians were more concerned with the short-term consequences of actions taken. In terms of the varied thinking around the indicators themselves, the researchers' emphasis was on a multidimensional approach to SD (environmentally biased), while practitioners were more focused on technology and economic factors (including aspects such as customer service, tariffs and environmental performance), and politicians on the economic factors that reflect well-being, such as tariffs. Without the establishment amongst SDI users of a common vision of SD, how SDIs should be established, and what function they should fulfil, there is a risk of stalling development towards

sustainability. Palme (2007) concluded that many important aspects of sustainable development are captured in existing indicators, but there is room for improvement – SDIs rarely connect to actual limits, they do not incorporate all the dimensions of sustainable development, and they are not systematically designed to capture connections with surrounding systems.

Milman & Short (2008) claim that indicators used to measure urban sustainability tend to focus narrowly on describing the current state of the urban system rather than analysing whether that system state can be maintained over time; i.e. how resilient it is. They proposed the development of a new indicator to incorporate resilience into urban water management, specifically to assess whether access to safe water can be maintained over time – the Water Provision Resilience (WPR) indicator. An iterative process is used to identify key stresses that influence water supply system resilience, translate them into indicators, and develop an accounting system to evaluate the response. In this way, areas of weakness are identified so that action can be taken to increase system resilience. As will be discussed further in Section 2.8.6.5, however, this is geared more towards strategic self-assessment (of risk) by municipalities rather than an appraisal of the overall sustainability of the urban water system.

2.7 Governance and institutional aspects

Governance in UWM refers to the institutional systems, policies and procedures that are developed and put in place by relevant government departments mandated with managing specific activities that impact on the hydrological cycle. Local government, as the sphere of government closest to communities, has to create a balance between development objectives which focus on service delivery as well as sustainability of the hydrological cycle. The consequences of poor governance in water management – including issues such as low investment, low quality of service and low investment – can be life threatening (Karamouz *et al.*, 2010). Good governance is thus characterised by a set of principles that guide decision-making processes and management practices, with public safety being of paramount importance; examples of these are reflected in initiatives such as the Dublin Principles and Agenda 21. Brown (2008) postulates that the inertia associated with administrative and governance systems – including institutional fragmentation, limited political incentives, and poor community capacity to participate – is the most significant obstacle to advancing SUWM. To be effective, water governance needs to be based on a comprehensive framework of principles and practices that address issues in an integrated fashion (Grigg, 2010, Box 2.5).

The principal challenge with respect to the governance and management of sustainable urban water systems does not so much concern the technological aspects of water supply and sanitation, but rather the social and institutional components (Rouse, 2007; Grigg, 2010 and WWAP & UN-HABITAT, 2010), including:

- Leadership and commitment towards transparency / public participation.

- The need for an appropriate, integrated policy environment and legal / regulatory frameworks; particularly in respect of risk management (e.g. drinking water quality standards, water safety plans etc.).
- Stimulating improved performance and capacity development of service providers (sometimes termed ‘empowerment’).
- Innovative planning, financing and cost recovery mechanisms.

Box 2.5: Governance requirements for sustainable water systems (Grigg, 2010)

Elements of water governance — policy, control, and empowerment — must be applied at different levels in different places. Governance needed in a developed country may look entirely different from that required in a low-income / developing country which lacks basic institutions. However, certain attributes of water management and governance are valid across the spectrum of settings. These include government policy that recognises needs for all water purposes and stakeholders and sets out mechanisms for control and empowerment to provide for them. They include appropriate control levers through regulation, planning, and coordination that respond to the most urgent and important scenarios. Equally as important are the empowerment mechanisms provided through governance that respond to the needs of organisations and workforces to build the institutional, technical, and individual capacities needed for sustainable water management.

Institutional frameworks have been found to have a strong influence on attitudes towards the implementation of sustainable development in organisations (Palme, 2007). The increased use of indicators and management-by-objective practices in municipal activities represents part of the transition towards a more business-like management approach in the public sector – and potentially increased planning capabilities, specifically with respect to the organisational aspects related to integration in urban water management.

2.8 South African context

The following sections will attempt to provide a context for urban water management and its associated challenges in South Africa (SA), as well as a justification for the municipal-level sustainability assessment approach that has been adopted as part of this research. Whilst SA is classified as an ‘upper middle-income’ country, the majority of its people live in poverty – in fact, it has the dubious honour of being classified as one of the most unequal societies in the world, with a Gini coefficient of 0.72 (anything above 0.6 is classified as extremely high inequality), and the lowest 20% of the population accruing only 1.4% of total income (StatsSA, 2008). South Africa’s political history has played a large role in these issues of social inequity; the 17th Century colonisation of the country by the Dutch and later the British laid the basis for segregation between racial groups, and this was institutionalised through the processes of apartheid which was Government policy from 1948 to 1994. The apartheid policies in particular adversely altered the nature of South Africa’s urban environments, separating urban spaces based on racial characteristics. As described by Turok (1994), “*Apartheid planning was*

an instrument of crude social engineering which embedded racial inequality and marginalisation into the physical urban form". One of the factors that defines the country is therefore its legacy of these spatially differentiated and segregated urban areas; the grinding poverty of unplanned, informal settlements where people live in deplorable conditions with limited access to any form of municipal services is in sharp contrast to the formal residential areas, many of which are opulent in the extreme. Does sustainability have a different meaning in this context? Is it possible to ensure that economic and social development continues without further environmental degradation resulting from *inter alia* surface water pollution, service delivery backlogs, and poor maintenance of infrastructure?

The attainment of democracy in 1994 brought the possibility for SA to address poverty and inequality and to restore the dignity of its citizens. South Africa's democratic Constitution, adopted in 1996 and praised as a model social rights charter, put in place new policies to improve people's quality of life – including access to housing, health care, water etc. (RSA, 1996). This entailed a systematic effort to dismantle the social and economic relations of apartheid and create a society based on equity, non-racialism and non-sexism. The resultant Reconstruction and Development Programme (RDP) outlined its key objectives as meeting basic needs, building the economy, democratising the state and society, and developing human resources and nation-building; however, translating these objectives into practical policies has been shaped by the twin challenges of dealing with apartheid legacies as well as integrating the country in a rapidly changing global environment (SA Presidency, 2008).

Section 24 of the Bill of Rights in the SA Constitution states that, "*Everyone has the right to an environment that is not harmful to their health or wellbeing; and to have the environment protected for the benefit of present and future generations through reasonable legislative and other measures that prevent pollution and ecological degradation, promote conservation and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*" (RSA, 1996). The principle of sustainable development is thus embodied in this statement as it conveys the need for integration of environmental, social, economic and governance systems which can only be achieved through equity and a shared public responsibility. The Constitution also outlines the objectives of local government (Clause 152), and notes that a municipality must strive, within its financial and administrative capacity, to achieve the following:

- Provide democratic and accountable government for local communities.
- Ensure the provision of services to communities in a sustainable manner.
- Promote social and economic development.
- Promote a safe and healthy environment.
- Encourage the involvement of communities and community organisations in the matters of local government.

The SA Constitution has thus sought to turn the different tiers of government formed under Apartheid into a more coherent system – by devolving appropriate functions to provincial and local levels and linking these administrative bodies to political representation, thereby making them accountable to all citizens. To this end, the pre-1994 sub-national government structures have subsequently been consolidated into nine provincial governments, six metropolitan districts, and 278 municipalities (from the previous 843). One of the first major restructuring exercises in the ‘new’ South Africa was that of local government – resulting in a quantum increase in the areas served by municipalities and particularly in the services required as many of the newly adopted areas were generally under or un-serviced (Lawless, 2007; Box 2.6).

There were several key challenges with this approach including specifically the relationship between responsibility and institutional capacity and the lack of attention given to shortages in skills and staffing capacity (RSA, 2011a; Smith, 2009). Instead of building capacity to deal with the issue of skills shortages, many engineering departments were rationalised and significant numbers – up to 85% in the case of local authorities (Herold, 2011) – of highly experienced technical and managerial public sector staff left the service. Legislated affirmative action employment policies to redress equity issues has worsened the situation – according to these policies, preference for filling posts is given to designated previously-disadvantaged groups, i.e. black people, women and people with disabilities (DoL, 2008). As a result it has been difficult to fill professional engineering posts at local and national government level – for example, in 2011 the Department of Water Affairs (DWA) only had about 20% of its required engineering posts filled (Herold, 2011).

Box 2.6: Capacity constraints in the SA civil engineering field (Lawless, 2007)

In the late 1980s there were 2500-3000 engineering professionals in 250 municipalities throughout SA (about 21 civil professionals per 100,000 people). By 2007, the total number of civil engineering staff in local government had dropped to less than 1400, for 284 municipalities serving a population of 47 million, i.e. less than 3 civil professionals per 100,000. Research carried out in 2004 and 2005 also indicated that there were 83 municipalities with no civil engineering professionals at all, while the rest had vacancies ranging from 40 to 60%. If a model of 5 to 8 civil professionals per 100,000 (modest by world standards) was adopted, about 3500 engineers would be required country wide to make up the shortfall. *“As long as capacity is inadequate and organisations are not geared up for service delivery, it is those with little or nothing who suffer most. Hiding behind the skills gap as a reason for not appointing staff will mean that millions will remain trapped in poverty with no means of escape”* (Lawless, 2005). Capacity building is not only about training and human resource development – it requires an institutional and organisational environment conducive to and supportive of these capacities. To be effective, capacity building must include human resource development, organisational development and institutional development.

The recent Diagnostic Report of the National Planning Commission (NPC) set out SA’s achievements and shortcomings since 1994 – the country has made remarkable progress, but there are still major developmental challenges, stemming mainly from the fact that too few people work, and the quality of education available to the majority of people is of a poor quality (RSA, 2011a). Inadequate infrastructure, a resource-intensive economy, a failing public

health system, poor quality public services and high levels of corruption are further evidence of the fact that the country has failed to meet key targets in the RDP (RSA, 2011b). The NPC believes that this is as a result of a failure of coordination within government – often with different departments working at cross purposes – and a lack of coordination between the public sector, the private sector and civil society. It is acknowledged that the country needs to approach development needs differently: *“It requires shifting from a paradigm of entitlement to a development paradigm that promotes the development of capabilities, the creation of opportunities and the participation of all citizens”* (RSA, 2011b).

2.8.1 South African water resources – quantity and quality

As briefly noted in the introduction to this thesis, South Africa has low rainfall by international standards (450 to 500 mm/year) – approximately 60% of the world average of 860 mm/year – and one of the lowest ratios of Mean Annual Precipitation (MAP) to Mean Annual Run-off (MAR) in the world; less than 9% of all rainfall reaches rivers, compared to an average 31% worldwide (RSA, 1999). Rainfall is seasonal and highly variable; and is generally higher in the north and east, decreasing significantly in the south and west of the country. SA is currently recognised as ‘water stressed’ (defined per the Falkenmark indicator – see Section C3.1 in Appendix C for further details in this regard) in terms of its total actual renewable water resources (TARWR), which were estimated at 1007 m³ per person per year in 2008 (UNEP, 2010). Added to this is the fact that South Africa uses 31% of its TARWR, a high figure by international standards, and an indicator that water availability is a real constraint (Muller *et al.*, 2009).

The following extract from the conclusions to the SA National State of the Environment Report (RSA, 1999) attest to the difficulties the country faces in meeting water demand: *“At present population growth and economic development rates, it is unlikely that the projected use of water resources in South Africa will be sustainable. Water supply will become a major restriction to future economic development.... Water resources are already almost fully-utilised.....imperative that South Africa develop both a water-efficient economy together with a social ethic of water conservation and ultimately a culture of sustainability of resource use”*. Several key messages in this regard emerged from the recent DWA report on Integrated Water Resource Planning for SA (DWA, 2010d), as shown in Table 2.6.

South Africa currently gets the bulk (77%) of its water from surface resources, 14% from return flows, and 9% from groundwater (DWA, 2009b). Proportional water use is currently: 62% to agriculture; 27% to domestic (23% to urban and 4% to rural areas); 2.5% to mining; and 10% to industry. In parts of the country, both surface and groundwater resources are almost fully utilised, with the Orange-Senqu basin identified as one of the four major hot spots of water risk around the world (WRI, 2011). Cloete *et al.* (2010) have gone so far as to state that SA is heading for a ‘water crisis’, in terms of both quantity and quality. They note that in order to allow for fluctuations in rainfall and runoff as well as the impact of climate change, current water demand needs to be reduced by 15 to 30%, so as to match it with supply and ensure long-

term security. Muller *et al.* (2009) provided a more measured position in their report on Water Security in South Africa; they concluded that, whilst the country faces many challenges as a result of the limited and variable nature of its water resources, there is no reason why SA should experience a water crisis provided that existing systems are managed effectively. The current challenges (as highlighted in Table 2.6) should, however, be addressed as a matter of urgency.

Table 2.6: Key messages – Integrated Water Resources Planning for SA (DWA, 2010d)

Challenges	Opportunities / Actions
<ul style="list-style-type: none"> Water quality deterioration through pollution from agricultural, industrial and mining activities, and poor urban wastewater management 	<ul style="list-style-type: none"> Treatment and reuse of poor quality water to solve supply and quality issues Increasing technical skills
<ul style="list-style-type: none"> Meeting new demands from storage and transfer schemes may prove too costly for SA in the future 	<ul style="list-style-type: none"> Assessment of how water is used by different sectors Investing in WC/WDM Exploring new and unused resources, and changing uses – groundwater, effluent reuse, desalination
<ul style="list-style-type: none"> The energy sector requires water at the highest assurance of supply 	<ul style="list-style-type: none"> Managing growth in line with available water resources Addressing forward planning and implementation
<ul style="list-style-type: none"> Irrigated agriculture is SA's biggest user of water 	<ul style="list-style-type: none"> Additional ways of making water available to small-scale farmers, such as rainwater harvesting
<ul style="list-style-type: none"> Ecological Reserve not being met in many areas 	<ul style="list-style-type: none"> Water to be taken from existing users, or provided from newly developed resources
<ul style="list-style-type: none"> Climate change impacts 	<ul style="list-style-type: none"> Monitoring water resources – hydrology, climate, availability and use

The deteriorating water quality of SA's river systems, storage reservoirs and groundwater resources is particularly problematic as these supply systems underpin social and economic development in the country. Increased pollution from industry, urbanisation, afforestation, mining, agriculture and power generation has resulted in increased salinity levels, nutrient enrichment and the acidification (Box 2.7) of many water resources (CSIR, 2010).

Box 2.7: Acid mine drainage in South Africa (CSIR, 2010)

The pH of natural water is predominantly determined by geological, soil and atmospheric influences. Freshwater resources in South Africa are relatively well buffered. However, human-induced acidification – from industrial effluents, mine drainage and acid rain – can cause a lowering of the pH over time, resulting in a deterioration of water quality and mobilisation of elements such as iron, aluminium, cadmium, cobalt, copper, mercury, manganese, nickel, lead and zinc, which may accumulate in fruits and crops. The Witwatersrand region in the Gauteng Province of South Africa is famous for its gold production. The groundwater within the mining district is severely contaminated however, has elevated concentrations of heavy metals and is acidified as a result of oxidation of pyrite (FeS₂) contained in waste rock and tailings dumps. The polluted groundwater discharges into streams, causing a lowering of pH in the water while most of the metal load is precipitated. This acid mine drainage (AMD) has been linked with several health-related consequences. Groundwater contaminated with AMD might be consumed by individuals without them being aware of it, with treatment often ineffective by the time that the effects materialise.

2.8.2 Urban water cycle - processes and interactions

The discussion on the urban water cycle from Section 2.2.1 has been expanded here for the South African context and to illustrate the three major services concerned with urban water management, i.e.: water supply, sanitation, and stormwater. The interconnectedness of the urban and natural water cycles is shown in the simplified depiction in Figure 2.13, with the urban water system representing a subsystem of the natural water cycle. This makes it possible to identify linear functions and inefficient practices with the ultimate aim of closing the loops and maximising functionality and use of resources. A balanced urban water system encourages trade-offs, substitutions, and where possible elimination of current unsustainable practices through a holistic approach to planning, implementing and maintaining water services (De Carvalho, 2007). Furthermore, it underscores the importance of demand and supply management; education, awareness creation and stakeholder consultation; and all of this within an environment supported by appropriate regulation and policy (Mitchell, 2006).

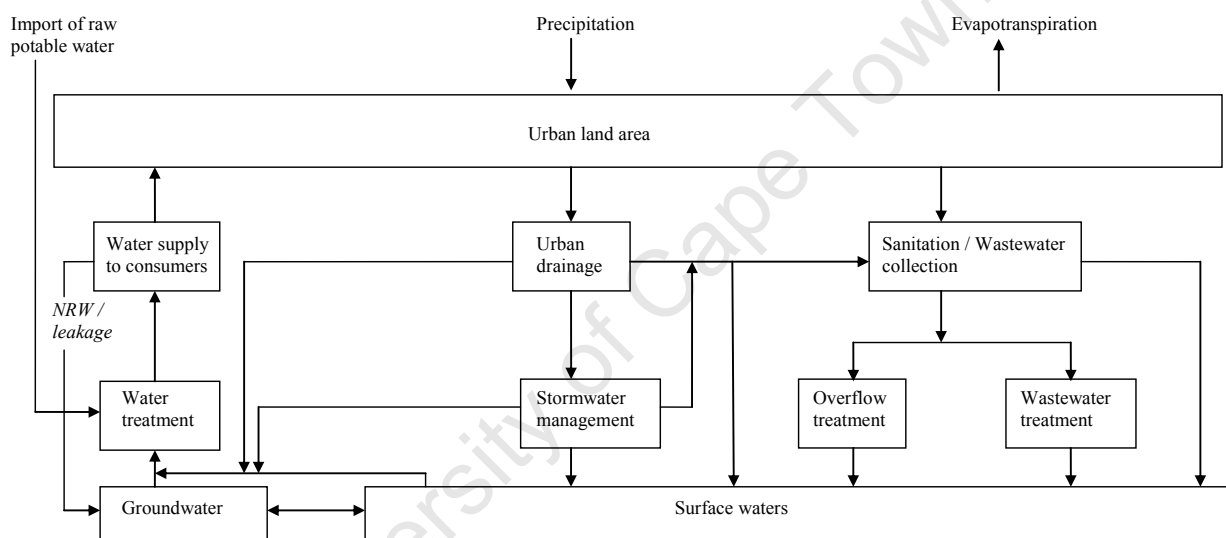


Figure 2.13: Urban water cycle (adapted from Marsalek *et al.*, 2008)

In the South African urban water system, most of the water directed to consumers is accounted for throughout the distribution network, with a small percentage lost to evaporation. A considerable amount of this water is not billed however, i.e. Non-Revenue Water (NRW) that accounts for as much as 40% in many municipalities throughout the country (Muller *et al.*, 2009). There are two major components to NRW; the first is Unaccounted for Water (UAW), which includes all water that leaves treatment facilities accounted for, but does not get registered or metered (and therefore billed) at the consumer end. This may be due to leakages in the network, illegal abstractions or vandalism. The second is the Free Basic Water (FBW) component, which is specific to the South African context, and sets a precedent in terms of free provision of an essential and often unaffordable service in an environment of extreme poverty and inequality. The FBW policy is discussed in further detail in Section 2.8.5.2.

Aside from water supply via the formal network, consumers may access other sources including direct abstraction from boreholes, springs, rivers etc., and collection and use of rainwater. Less conventional sources of water also include reuse of greywater (treated or untreated); reuse of treated or untreated wastewater from on-site or decentralised systems; as well as reuse of treated wastewater from centralised treatment systems. A percentage of on-site wastewater may seep into the soil and into the groundwater; part of it evaporates and the remainder is either used or conveyed to formal drainage systems as runoff.

Water supplied to and used by consumers can be discharged as greywater, directed to separate stormwater and wastewater networks, or simply discharged into the environment. The type of sanitation system and the combination of wastewater and stormwater systems employed will determine the volume of bulk water abstracted which has gone through the system. This will either undergo treatment before it is returned to the environment or will be discharged directly, leading back to the various water sources, hence completing the full urban water cycle.

2.8.3 Climate change impacts and the water – energy nexus in South Africa

“Climate change adds one more layer of uncertainty to an already challenged water sector, and has the potential to worsen existing systemic water shortages over the medium to long term” (RSA, 2011a)

As already highlighted, SA is a water stressed country with a highly variable climate that is likely to be significantly exacerbated by the effects of climate change. While there is still a degree of uncertainty as to the net effects of climate change on water availability, rainfall is expected to become more variable and it is predicted that the interior and western parts of the country will become drier while the eastern parts will be wetter. There is also likely to be an increase of extreme events such as flooding and droughts. Based on current projections SA will exceed the limits of economically viable land-based water resources by 2030 (DEA, 2011). The water sector must therefore balance the allocation of these limited resources amongst major users (agriculture, domestic urban and industry), whilst addressing the need to ensure fair access to water for all people, as well as a sufficient ecological allocation to maintain the integrity of ecosystems and the services they provide. In the short term the development of a climate change response for the water sector is proposed, by way of the National Water Resource Strategy (DWAF, 2004), to balance water balance reconciliation strategies for water management areas. In the medium to long term the Water for Growth and Development (WfGD) framework (DWAF, 2009a) aims to balance the critical role of water between poverty alleviation and economic development. This will include focused monitoring and research in order to provide high quality data and tools to analyse this data so as to ensure the efficacy of water adaptation approaches over the long term.

Aside from the direct impacts of climate change on water scarcity, SA also faces an uncertain future with respect to the impacts on water systems as a result of increasing energy requirements (Potgieter, 2010). SA depends greatly on fossil fuels for energy generation and

consumption and is among the top 20 emitters of greenhouse gases (GHGs) in the world due to relatively high values being derived from the concentration of emissions per capita (GCIS, 2011). Thermal energy is used to generate the majority of the electricity needed in SA and the principal energy source used for this process is coal (accounting for approximately 90%), with the rest being made up of gas, nuclear, diesel, water and heavy oil. Coal is used to heat water and convert it into steam which is released to turn large turbines to create power. The growing economy and increasing population have put considerable strain on the electricity supply and distribution system, and the resultant unscheduled (or scheduled through load shedding) interruptions in supply have at times caused appreciable pollution of water sources from, *inter alia*, break-downs at wastewater treatment facilities and sewage overflows at pump stations (Potgieter, 2010). Ironically, the two new coal-fired power stations currently being constructed to alleviate electricity shortages, will also impact on water resources quality and quantity.

The extensive use of coal for power generation results in significant negative impacts on water resources owing to: high water consumption (about 2ℓ per kWh) for cooling purposes; and the degradation of water quality, including acid-runoff. The principal electricity supplier, Eskom, currently uses over 90 million tons of coal per annum and about 325 million m³ water (2% of total water use in the country) to produce the energy required (Winter, 2011). Without water Eskom would not be able to produce the country's electricity. Likewise, SA's water sector is heavily reliant on a constant supply of energy to ensure that water and wastewater treatment facilities are able to safely and efficiently treat and distribute potable water.

The water-energy nexus in SA can thus be viewed as a 'double-edged sword'. The energy sector has high water requirements for its generation process, whilst the water sector uses significant quantities of energy to extract, treat and distribute water, and to finally treat and dispose of wastewater. It is thus heavily reliant on a consistent supply of energy, particularly the wastewater treatment processes which can use up to 1800 kWh/Mℓ (Winter, 2011). This is in line with international figures which also show that wastewater treatment has the largest carbon footprint (almost 70%) in the water sector and that energy consumption is the greatest contributor (over 50%) to the carbon footprint (Frijns, 2012). There are particular energy requirements within each portion of the water value chain. With so many variable factors contributing to the amount of energy consumed in the water value chain – such as the location of the plant, quality of water / wastewater, treatment technology – it is difficult to quantify exactly how much energy is being consumed in total. However, it is possible to provide a range of values (Winter, 2011) in terms of the energy consumed by each process, as follows:

- Abstraction: 0 – 100 kWh/Mℓ.
- Water treatment: 0 – 350 kWh/Mℓ.
- Water end users: 150 – 650 kWh/Mℓ.
- Water and wastewater reticulation and water distribution: 0 – 350 kWh/Mℓ.
- Wastewater treatment: 200 – 1800 kWh/Mℓ.

It is thus clear that the water supply chain will be impacted to varying degrees in the event of power outages. Water security for end users is directly influenced by electricity failures on the abstraction, distribution and water treatment points of the supply chain – manufacturing and mining are examples of two economic sectors that would not be able to operate without a consistent supply of water. Wastewater treatment is very energy intensive, and hence particularly vulnerable to power outage events. Plant characteristics dictate impact levels, and whilst plants with back-up power supply and overflow dams are generally not impacted by electricity outages, less prepared facilities can experience significant environmental, economic, health and social impacts (Winter, 2011).

2.8.4 Institutional and legal frameworks

Issues of governance have a major impact on sustainable water management, but cannot be assumed to be the same for all countries, particularly as relates to decision-making power within different nations. The South African governance system has varied greatly over time, resulting in a complex body of laws and policies that do not easily align with current frameworks for good water governance (Swatuk, 2010). Water management in SA falls under the jurisdiction of the DWA (known as the Department of Water Affairs and Forestry (DWA) until 2009), which is responsible for the provision of water services at a national level. Since 1994 various pieces of legislation concerning national water affairs and local government sectors have been promulgated in SA (Table 2.7). The National Water Act, No 36 of 1998 (RSA, 1998), provides the overarching legal framework for the management of water in the country and, together with the Water Services Act, No. 108 of 1997 (RSA, 1997), is aimed at creating mechanisms to protect and manage the quality of South Africa's water resources to ensure their sustainability for the benefit of all water users.

The Water Services Act in particular requires municipalities to prepare and implement policies with respect to access to water services, setting of service levels and tariffs for water services. The Act states that *“every WSA has a duty to all customers...to progressively ensure efficient, affordable, economic and sustainable access to Water Services”*. This is achieved by way of the legislated formulation of a 5-yearly plan for water and sanitation services, the Water Services Development Plan (WSDP), which is guided by the following:

- The availability of water resources in a region and local characteristics such as topography and environmental factors.
- Equitable allocation of resources to consumers and regulation of resource provision.
- Payment for services.
- Conservation of water resources.
- Appropriate measures to deal with non-compliance with policies and regulations.

The WSDP encapsulates all water service delivery tasks and is closely aligned with the local authority's Integrated Development Plan (IDP) which informs specific municipal activities and is used as the core strategic document for planning, budgeting and management. It does not spell out local government's role in water resources protection or its responsibilities with respect to IWRM however, and an integrated approach is advocated if IWRM is to be implemented in the context of the current legal framework for water services (Haigh *et al.*, 2010).

Table 2.7: Selected legislative, policy and strategy arrangements relating to water services provision in South Africa (DWA, 2011a)

Legislation / Strategy	Act no. / Year	Function
Constitution of South Africa	Act 108 of 1996	Assigns responsibility of ensuring access to water services to local government; the role of national and provincial government is to support, monitor and regulate
National Water Act (NWA)	Act 36 of 1998	The Act states that water is an indivisible national resource for which national government is the custodian
Water Services Act (WSA)	Act 108 of 1997	Defines municipal functions of ensuring financially and environmentally sustainable water services provision
National Environmental Management Act (NEMA)	Act 107 of 1998	Provides overarching framework for environmental management by providing for "co-operative environmental governance...and ensuring the control of activities which are likely to have a detrimental effect on the environment"
Municipal Systems Act (MSA)	Act 32 of 2000	Defines how local government should operate; stipulates formulation of IDPs; allows for various types of partnership arrangements a municipality may enter into to ensure delivery of services
White paper on water supply and sanitation policy	1994	Provides historical background regarding water supply and sanitation development; explains the development approach used to guide policy formulation
White paper on basic household sanitation	2001	Highlights the impact of poor sanitation on health and the environment; articulates government policies on improvement strategies aimed at addressing the backlog; and provides a framework for municipality-driven implementation programmes
Strategic Framework for Water Services (SFWS)	2003	Sets out institutional framework for water service provision in SA; emphasis on progressive improvement of levels of service
Drinking Water Quality Regulation Strategy	2005	Provides DWA and WSAs with understanding of regulation strategies, to ensure high quality drinking water

The National Water Act (NWA) is seen as a policy based on strong social and environmental justice principles which could allow South Africans to realise their individual and collective potential to advance sustainable development (Burns & Weaver, 2008). In order to achieve this, there has in recent years been an increased focus on regulation in the water sector, and especially on compliance monitoring and enforcement. The Strategic Framework for Water Services (SFWS) set out the national framework for the water services (water supply and

sanitation) sector (DWAf, 2003) and outlined Government's commitment to eliminating the backlog in basic water services and to progressively improving levels of service over time. In the short term this meant providing everyone with access to at least a basic water supply – defined as 25ℓ of potable water per capita per day (ℓ/c.d) within a 200m cartage distance – by 2008, and basic sanitation – defined as on-site dry latrines (Ventilated pit latrines (VIPs) or similar) – by 2010. The DWA reports annually on key strategic issues as well as progress of the sector against these short and medium to long term targets as set out in the SFWS.

South Africa has generally followed the international trend towards decentralisation of water services and, since 2002, local government – through the setting up of Water Service Authorities (WSAs) in terms of the Water Services Act (RSA, 1997) – has taken over some of the functions of the Department of Water Affairs (DWA) so as to be fully responsible for water and sanitation delivery throughout the country. There are three categories of local government in South Africa:

- i) Metropolitan Municipalities (MM) – managing the 6 major metropolitan areas or 'Unicities' in SA.
- ii) District Municipalities (DM) – 47 DMs share responsibilities with several local municipalities within their jurisdiction.
- iii) Local Municipalities (LM) – 231 LMs are located within the areas of the DMs.

At present there are 169 WSAs in SA that have executive authority for ensuring access to efficient and sustainable water services within their area of jurisdiction by way of the selection, management and regulation of water services providers (WSPs). A WSP is an entity that has a contract with a WSA – in accordance with the Constitution, the Water Services Act and the by-laws of the WSA – to assume operational responsibility for providing water services to one or more end users within a specific geographic area. WSPs can include Municipalities and Municipal entities; Water boards; Community-based Organisations; and private operators. The DWA has the mandate to act as the Water Services National Regulator by monitoring the performance in the water sector. The process of deciding what institutional arrangement is responsible for water and sanitation provision within a municipality is known as a Section 78 assessment process (governed by Section 78 of the Municipal Systems Act), and describes the process of formally appointing a WSP. The move from DWA as WSP to local municipality as WSP has shifted the financial and technical burden of water and sanitation service delivery to local municipalities (Tissington *et al.*, 2008).

The management of WSAs requires a broad strategic understanding of service provision, its objectives and the legal framework within which it is undertaken. The WSP requires a more operational set of competences as well as the ability to interface with and respond to the regulatory framework as well as to engage with service users (Muller, 2009). One of the key objectives of efficient WSAs / WSPs is that of protecting the health and well-being of communities and supporting their social and economic development. Water services support to

municipalities is a high priority for the Department of Water Affairs in order to assist the sector to realise its vision (“*Water is life; sanitation is dignity*”) and the goals of the SFWS. DWA has therefore implemented various initiatives in an attempt to address the poor performance of municipalities in both the delivery of infrastructure and in the provision of water services, including the National Water Services Regulation Strategy (DWA, 2010a). As will be discussed in more detail in Section 2.8.6, three priority programmes have been put in place in order to mitigate key risks to the successful implementation of the SFWS and to build the foundation for more effective regulation, as follows:

- i) A regulatory effort to address compliance and performance issues in municipalities, particularly where risks pose threats to health and environment (the ‘Regulatory Performance Measurement System’, RPMS).
- ii) A national drinking water quality regulatory initiative (‘Blue Drop’ System).
- iii) A national effluent quality regulation initiative (‘Green Drop’ System).

Annual reporting on sector performance is carried out based on reporting by WSAs on key regulatory performance indicators, financial reporting to National Treasury, and reporting by water boards, citizen report cards, water services backlog data etc.

2.8.5 Water service delivery progress in South Africa

“Providing high-quality public services is the single most important thing that can be done to overcome the inequalities of apartheid” (RSA, 2011a)

The public water and sanitation sector in South Africa is organised in three different tiers, i.e. national Government as the regulator and policy setter, represented by the Department of Water Affairs (DWA) and the Department of Human Settlements (DHS); Government-owned Water Boards (13 in SA) which operate dams and bulk water-supply infrastructure and some wastewater treatment plants; and municipalities (or water services authorities), which provide most water services and own some of the bulk supply infrastructure. In areas where a Water Board is not active, for example in the City of Cape Town, a WSA (in this instance the City of Cape Town itself) is responsible for the bulk water supply function. Water Boards typically purchase raw water from DWA, treat the water and then distribute it to end users.

The post-apartheid government introduced a comprehensive policy framework which focuses on providing the entire population with potable water, and this has provided an enabling environment for municipalities to deliver sustainable water services. In terms of the constitutional allocation of roles and functions, responsibility for service provision lies with local government, and the programme of service provision has been made part of the broader programme of local government development (Muller, 2009). As has been mentioned already, however, this was done without consideration of factors such as investment in managerial and technical skills, and in establishing effective, accountable and transparent governance. As a

result, concern has been expressed that the quality and reliability of water services is inadequate in many areas of SA, specifically in poor communities. As this process continues, therefore, the challenge of operating and maintaining services for which infrastructure has been provided has become more critical. As Cloete *et al.* (2010) put it: “*Urgent attention must be paid to putting in place the appropriate policies and institutional capabilities to deliver water services today without undermining the ability to do so tomorrow*”.

A water services sector support programme called Masibambane (meaning “*let’s work together*”) was initiated in the late 1990’s by DWA in partnership with the Department of Provincial and Local Government (DPLG) and the South African Local Government Association (SALGA), with the support of donors including the European Union, the Swiss Government and Irish Aid. Now in its third 5-year phase, it has marked a shift from nationally driven water and sanitation delivery to the building of a decentralised sector with improved integration and coordination. Masibambane’s current focus is on developing the water sector and ensuring that resource management and the provision of water services meet economic and social priorities. This is being achieved by way of a sector-wide approach (SWAP), and the development of coordinated inter-governmental strategies for the sector (including water services delivery), as well as building capacity and ensuring accountability through improved reporting. Masibambane has also assisted in the formation of the Water Information Network of South Africa (WIN-SA) which facilitates knowledge exchange and collaboration.

In many aspects of service delivery, and particularly in water services, responsibilities are held jointly; national government is largely responsible for providing leadership, formulating policy and determining the regulatory framework, while local government are the implementers. Many of the problems that arise relate to finances – municipalities frequently complain about unfunded mandates and having to deliver services with insufficient funding. Local governments either raise revenue through property rates and fees for services, or rely on transfers from national government – this results in significant variation in performance between the major metropolitan areas (with large cities and expansive tax bases) and the smaller, rural municipalities where many people are too poor to pay for services; as will be discussed in further detail in Section 7.3. In an effort to address these issues the SA cabinet recently approved the Municipal Systems Amendment Bill which, it is hoped, will herald a landmark period in the delivery of service infrastructure for the country (de Beer, 2010). The bill has been written specifically to depoliticise municipal bureaucratic administration and will ultimately ensure that provincial and local governments are able to appoint appropriately skilled technical personnel to senior management posts rather than political office bearers. It also aims at setting a platform for the establishment of uniform and consistent systems and procedures for municipalities, which have been a weak point in current years.

South Africa is among a few countries in the world that has access to water as a basic human right enshrined in the Constitution (and mandated in the Water Services Act, Act 108 (RSA, 1997). The provision of a safe water supply service has been hailed as one of the biggest achievements of the democratic, ANC-led government (Hemson & Owusu-Ampomah, 2005).

Table 2.8 shows that the proportion of people with access to clean water increased from 76.7% in 1993 to 89.3% (46.3 million people) in 2010. This has meant that the MDG with respect to the proportion of the population using an improved drinking water source (2015 target of 81%) has already been met (UNDP, 2010). Whilst significant progress has been made in ensuring greater access to water, backlogs do still exist, with some regions in the country faring worse than others. This has had some serious social consequences: *“In South Africa, urban and peri-urban dwellers are engaged in a never-ending cycle of service delivery protests, wherein access to potable water serves as a crucial symbol of the post-apartheid state’s Constitutional commitment to supporting human rights”* (Swatuk, 2010).

Table 2.8: Water supply delivery in South Africa – % of the population
(Nleya, 2008; StatsSA, 2011)

Water supply	Year								
	1993	1996	1999	2001	2003	2007	2008	2009	2010
Piped water (on / off-site)	76.7	82.0	83.4	84.5	88.3	88.6	88.5	89.3	89.3
Borehole / rainwater	10.4	5.9	4.7	3.0	2.4	3.2	3.8	3.7	3.1
Stream / dam / spring / other	13.0	12.1	11.8	12.5	9.2	8.2	7.7	7.0	7.6

Improvements in sanitation delivery have been less spectacular. Table 2.9 shows that access to sanitation improved from 49.8% with access to a flush / chemical toilet in 1993 to 72.1% in 2010. It is thus uncertain whether the MDG for proportion of the population using an improved sanitation facility (2015 target 79.2%) will be met (UNDP, 2010). Interestingly the percentage of those with no access increased from 6.1% in 2003 to 8.6% in 2007, most likely as a result of urbanisation and the growing numbers of unserved informal settlements in urban areas.

Table 2.9: Sanitation delivery in South Africa – % of the population
(Nleya, 2008; StatsSA, 2011)

Sanitation system	Year						
	1993	1996	1999	2001	2003	2007	2010
Flush / chemical toilet	49.8	55.0	55.8	53.8	59.3	60.8	72.1
Pit latrine	32.2	29.8	20.3	28.5	32.7	28.3	22.0
Bucket toilet	5.3	4.3	3.2	4.1	1.9	2.3	0.8
Other / none	12.5	11.0	10.6	13.6	6.1	8.6	5.1

The use of bucket toilets has been on a slow but generally steady decline (through the ‘Bucket Eradication Programme’) and this form of sanitation has been all but eliminated, except in some informal settlements – according to official statistics anyway. In reality, bucket systems in many informal settlements have been replaced with sanitation options such as container toilets which are dysfunctional for a variety of reasons, resulting in residents resorting to their

own version of a bucket toilet (e.g. plastic bags and/or night pails). There is a noticeable gap between SA Government policy on water provision and the long-term sustainable water management challenges for the country – whilst the water supply interventions are aimed at improving the health of individuals, no attention has been given to the resultant longer-term impacts on environmental health (e.g. from the disposal of greywater) in non-sewered areas (Carden *et al.*, 2007). There have also been problems with inadequate planning with respect to the increased bulk water supplies and wastewater treatment systems required with a higher level of sanitation service (Muller *et al.*, 2009). It is thus very difficult to gauge exactly what the numbers are of people in SA with access to functioning sanitation systems.

The sanitation function was transferred from DWA to the Department of Human Settlements in November 2009, with the aim of ensuring that municipalities coordinate the planning and implementation of housing with other decisions that relate to the broader sustainability of human settlements. Owing to shortcomings in the National Sanitation Programme, the Minister of Human Settlements established a Ministerial Sanitation Task Team (MSTT) to investigate irregularities and malpractices undermining its implementation within communities. One of the objectives of the MSTT was to investigate community concerns pertaining to sanitation service provision and report these to the Minister. A number of workshops are currently (2011/2012) being held around South Africa with affected parties to discuss these issues. Also being debated is the new National Sanitation Policy (DHS, 2011), presently in its 3rd draft (October 2011), with specific focus on definitions of the sanitation (and associated) services and how it should be implemented at national, provincial and local level.

2.8.5.1 Partnerships and service delivery

One of the main issues with urban water service delivery is access to adequate and sustainable sanitation in informal settlements – it appears that very few of those living in informal settlements have access to sanitation and of those that do, few would consider them facilities that meet the criterion of ‘sanitation as dignity’ (Carden *et al.*, 2007; Schaub-Jones, 2010). While national and local governments are primarily responsible for water and sanitation services, the integration required for the successful implementation of IWRM / IUWM at local authority level is difficult to achieve without the involvement of a dedicated coordinator and the formation of partnerships with, *inter alia*, the private sector, NGOs, user groups, research institutions, community-based organisations and others – to achieve the desired levels of service coverage. Experience has shown that collaborative approaches where government harnesses civil society and local private sectors can be effective in extending and sustaining services in difficult contexts – as reflected in the successes of various localised initiatives in South Africa (Schaub-Jones, 2010). Multi-stakeholder participation and community-led initiatives are especially important in planning, budgeting, technology choices and goal-setting (WWAP and UN-HABITAT, 2010).

The concept of partnerships helping to overcome the challenges of providing viable, affordable sanitation services to the urban poor was first mooted at the World Summit on

Sustainable Development in Johannesburg (UN, 2002). It is now widely acknowledged that partnership arrangements complement the work of governments in meeting the goals of sustainable development, and specifically the water and sanitation targets of the MDGs, by leveraging the combined strengths of government, civil society and non-government organisations / service providers (Eales, 2008). Whilst there has been substantial success in this regard in water supply schemes, the use of partnerships in urban sanitation schemes has proved far more challenging, mainly due to issues around settlement density and tenure insecurity. Wide-ranging policy reform is needed to acknowledge and eliminate the gap between existing policy and reality, to acknowledge the value of multi-stakeholder partnerships and service partnering arrangements, to support government improvements to service provision and to reassess public finance priorities.

2.8.5.2 Free Basic Services policies

Following the establishment of a democratic government in South Africa in 1994, a major programme was initiated to provide basic water and sanitation services to the large numbers of people in the country that were unserved. Owing to the fact that many people were too poor to take advantage of these services at cost, a policy decision was made to provide every South African with a basic water supply free of charge (Muller, 2008). This decision was influenced by two macroeconomic imperatives (Smith & Hanson, 2003):

- i) The national Growth, Economic And Redistribution programme (GEAR) which called for deregulation and privatisation of service delivery in order to redistribute resources.
- ii) The Municipal Infrastructure Investment Framework (MIIF) which differentiates service delivery according to household income level, e.g. poor households get water from communal taps (and face little prospect of acquiring the means to improve their water and sanitation conditions).

Whilst this was a controversial decision which ran contrary to conventional thinking about water being an economic good, the free basic water (FBW) policy was not only seen as a social welfare effort; the broader goals of the policy were to achieve equitable access to, and efficient use of, water in an environmentally sustainable manner. Thus, in 2001 the policy was implemented, whereby a basic quantity of water (a minimum of 6 kilolitres per household per month (kl/hh.m), based on the WHO standard of 25 l/c.d for 8 persons per household) was to be provided free to all citizens by way of targeted cross-subsidies and stepped tariff-setting. Despite the many challenges with the implementation of the policy, i.e. poor service delivery mechanisms and billing systems, limited funds available to some municipalities, services not reaching intended beneficiaries etc., by August 2010 more than 85% of all South Africans, rich and poor alike, had been served with free basic water, some with considerably more than the stipulated minimum amount (DWA, 2010c). Of the 169 water services authorities in the country, 29 are providing FBW to all residents, 136 provide to some (the poor), whilst only four are not providing FBW at all. By giving specific attention to the poor majority, the policy

is (mainly) considered by DWA to have been successful in terms of fulfilling its objective of being a key pillar of the social security framework. It has also been shown that the benefits of providing a minimum water services standard (6 kℓ/hh.m) considerably outweigh the costs, at a ratio of over 40:1 (Wagner & Manus, 2008). Benefits include reduction of poverty and increasing economic development.

The ultimate judgement of the efficacy of delivery of water should be based on whether SA residents are currently able to access clean, safe and affordable water, and the reality on the ground is often not the case. There have also been concerns about whether the 6 kℓ/hh.m free water offering is sufficient to meet the intended outcomes of improved public health, and poverty alleviation – if access to water is considered from a rights perspective rather than a more standard policy analysis, the focus shifts from delivery institutions to service recipients, and to issues of equity (Smith, 2009). More information is needed to understand the dynamics of household *access* to FBW rather than municipal *provision* of this water (Mosdell & Leatt, 2005). What has become clear is that the basic needs approach has created two distinct spatial patterns in the delivery of services, specifically to low-income settlements: a) the difference in levels of service between formal and informal, and b) the lack of infrastructure maintenance which consolidates existing patterns of inequality (Smith & Hanson, 2003). Cost-recovery methods associated with local government efforts to improve water provision to the poor have been undermined by a lack of attention to procedural equity. This issue was raised in a recent court case on the validity of pre-paid meters in Phiri township in Soweto, Johannesburg (Box 2.8) and highlights the fact that the differential needs and circumstances of service users must be taken into account when water authorities communicate with citizens.

Another issue that has been raised is the fact that in certain situations there may be difficulties reconciling current sanitation policies with a FBW strategy, which may have negative impacts on the provision of sanitation at local level. This issue of integration of a FBW policy with a Free Sanitation policy (to provide Free Basic Services, FBS) has been considered and current government policy requires that indigent households be given access to a Free Basic level of sanitation service (DHS, 2011). A Free Basic Sanitation Implementation Strategy has been developed and approved which aims at guiding WSA's in the provision of free basic sanitation to all citizens by 2014 (DWAF, 2008d). This includes recommendations on the sustainable operation and management of the sanitation service, as well as communication strategies on good sanitation and hygiene practices. The definition of a basic sanitation service (as described in the Glossary of terms) does not define the specific technology to be used in providing such a service (e.g. waterborne sanitation or on-site sewage disposal options) but rather focuses on the overall aim of the service itself.

Box 2.8: Judgement in the Phiri water case (Streicher, 2009)

Progress in the provision of water services to the poor in SA was put into question when the Supreme Court of Appeal (SCA) handed down judgement on the Phiri water case (Johannesburg Municipality). Operation Gcin'amanzi (OG) was introduced because of acute water losses experienced in Soweto coupled with the fact that the City was not recovering payment for water in the area. The judge declared that the pre-payment water meters used in Phiri in respect of water level 3 consumers (metered full pressure water connection and conventional waterborne sewerage to each stand) was unlawful because such use is not authorised in terms of the by-laws (suspended for 2 years in order for the City to be able to legalise its use). The SCA also declared that the City is constitutionally obliged to set aside the free basic water policy of providing 6kl free water per household per month and provide 42 litres free water per day to each resident who cannot pay (registered as indigent) for such water. The case then went to the Constitutional Court on appeal where the judgements were overturned; it was ruled that neither the Free Basic Water policy nor the introduction of pre-paid water meters in Phiri as a result of OG constitute a breach of Section 27 of the Constitution. The Constitutional Court was of the view that it is not appropriate for a court to give a quantified content to what constitutes "sufficient" water because this is a matter best addressed by the government. The national government has adopted regulations which stipulate that a basic water supply constitutes 25 litres per person daily; or 6 kilolitres per household monthly (upon which the City's Free Basic Water policy is based). The Court concluded that it cannot be said that it is unreasonable for the City not to have supplied more. On pre-paid water meters, the Court held (contrary to the High Court and the SCA) that the national legislation and the City's own by-laws authorise the latter to introduce pre-paid water meters. The Court concluded that the installation of the meters was neither unfair nor discriminatory. Accordingly, the appeals succeeded and the order made by the SCA was set aside, as was the original High Court order.

An unintended consequence of the free basic services policies has arisen from its departure from current international trends towards encouraging community contribution to the capital costs of infrastructure, as well as the recovery of operations and maintenance costs (Schaub-Jones, 2010). As a result of the undertaking by Government to fund the full costs of water service delivery, the incentive for residents to engage in community-based management schemes has been greatly limited. Services have thus become increasingly 'supply-driven' and less 'demand-led', with resultant impacts on the levels of collaboration in the sector – currently, most collaboration occurs at an intra-government agency level rather than between the State and external actors. This fact, combined with very weak public accountability mechanisms and political pressure to move households up the service delivery ladder faster than is optimal, is threatening to undermine the good intentions of the government with respect to water and sanitation service provision. Whilst the ultimate responsibility for the provision and management of urban water services lies with the public sector – as enshrined in the South African Constitution – it has been shown that demand-driven approaches that make use of cross-sector collaboration with civil society and the private sector can bring several advantages with respect to long-term sustainability of these services. It is only through a better understanding of how water services work that the public can effectively engage and help to drive the process, and local accountability mechanisms, mediated through community-based organisations (CBOs) and NGOs are likely to be effective in this regard (Schaub-Jones, 2010).

2.8.6 Sustainability and benchmarking initiatives in the SA water sector

During the period of Apartheid in South Africa there was a deliberate lack of accountability of public institutions towards the majority of people in respect of the provision of services. Through public policy and legislation, the post-1994 democratic government introduced improved mechanisms of public accountability and transparency which has required the implementation of performance management systems, and the use of performance indicators in municipalities, since 2000 (Moodley, in Cabrera & Pardo, 2008). Numerous indicator initiatives have been put in place in SA, mostly focused on general State of the Environment (SoER) reporting, for use at national, provincial, catchment and local levels. More recently, the Department of Performance Monitoring and Evaluation in the SA Presidency – responsible for publishing the Development Indicators Report (RSA, 2010) – was tasked with reviewing the data architecture of Government so that the required performance information is generated and used in intergovernmental planning and resource allocation towards improved service delivery (Chabane, 2010). The Development Indicators report quotes official statistics over the period 1994 to 2009 covering ten themes, namely: economic growth and transformation, employment, poverty, inequality, household and community assets, health, education, social cohesion, safety and security, international relations and good governance. The report is aimed at assisting in understanding the impact of various government policies and programmes on the country and its citizens (RSA, 2010). As outlined in the paragraphs that follow, performance measurement initiatives aimed specifically at the management of water services in South Africa have also been implemented. As will be discussed, however, some of these initiatives have been assimilated into parallel measurement systems and are no longer being run independently.

2.8.6.1 Development Bank of SA (DBSA) infrastructure barometer study

Infrastructure barometer studies were commissioned in 2006 and 2008 by the DBSA to try and determine the state of management of water infrastructure in the country, and particularly to measure the effects of provision and maintenance of infrastructure on the South African economy. The 2006 report concluded that *South Africa is generally well-endowed with water resources infrastructure and has plans to maintain a good level of investment and improved management of the scarce resource. Due to the dispersed and decentralised nature of municipal water services, substantive data is scarce on the condition of infrastructure assets, but the indications are that they are not in good shape outside the metropolitan and other large urban areas* (DBSA, 2006). The 2008 report added to this by highlighting the challenges being faced by local municipalities in extending and maintaining efficient water services – the major constraint to rolling out municipal infrastructure was cited as inadequate technical capacity to implement projects (DBSA, 2008).

2.8.6.2 National Benchmarking Initiative for Water Services (NBI)

The NBI was launched in 2005 as a joint initiative of the South African Local Government Association (SALGA), DWA and the Water Research Commission of South Africa (WRC). The main aim of the NBI was to promote annual benchmarking of key performance indicators

(ranging from access to basic water and sanitation supply, quality of services and affordability, to protection of the environment) for the provision of water services so as to improve performance through the development of processes for best practices in the municipal water sector in South Africa (Africon, 2007). The reporting process was suspended after submission of the 2007/08 report owing to data issues, as well as differences in focus by the two main players in the NBI; i.e. SALGA (most interested in the management aspects), and DWA (pushing for regulation). As a result, DWA put significant effort into the development of various other water sector monitoring and/or regulatory measurement initiatives between 2008 and 2011 (as is described in the following paragraphs). The NBI has recently (April 2011) been re-launched by SALGA, in collaboration with the WRC and the Institute of Municipal Engineering of Southern Africa (IMESA), with a newly appointed consortium of service providers who will be responsible for three years of reporting, until 2014. Now named the national Municipal Benchmarking Initiative (MBI), it offers a more introspective municipal performance benchmarking focus, separate yet ultimately supportive of regulatory objectives.

2.8.6.3 eWQMS

An on-line water quality monitoring system, eWQMS, was developed as a collaborative SALGA / IMESA venture to provide a strategic assessment of municipalities throughout SA by using water quality management (WQM) indicators relating to the progressive attainment of the provision of safe drinking water (Wensley *et al.*, in Cabrera & Pardo, 2008). eWQMS was developed to provide easy access to useful water quality tools and information – data loaded by municipalities is converted into WQM outputs in the form of reports to inform both the local authority concerned as well as the DWA national water services information system. Participation by municipalities in 2008 was about 90% showing “*remarkable progress with engaging with municipalities regarding sustainable drinking water quality management*” (Mackintosh *et al.*, 2009); however these efforts have largely been superseded by the development of a vulnerability-based municipal strategic self-assessment (MuSSA) tool, as well as the updated NBI and the DWA regulatory measurement processes (Section 2.8.6.5). The MuSSA process is a qualitative assessment specifically geared towards the assessment of vulnerability in the municipal business model (Wensley, 2012).

2.8.6.4 Blue Drop / Green Drop certification

South African drinking water quality is currently being regulated by way of the Department of Water Affairs’ Blue Drop certification scheme (DWAf, 2009c) – an incentive-based system aimed at driving continuous improvement in service delivery and drinking water quality, and at instilling confidence in tap water quality with the public. Municipalities’ water supply systems are judged on various indicators, such as skills levels, operation and maintenance, monitoring and analytical results, and are subsequently rewarded (or penalised) upon evidence of excellence (or failure) according to minimum standards.

The 2011 Blue Drop certification programme verified the status of drinking water quality and management of 162 municipalities throughout SA, with an average national score of

72.9%, and with 58.7% of the water supply systems scoring 50% or more (DWA, 2011d). The report shows that tap water remains safe to drink in most cities / towns in SA, with 66 local authorities being awarded full 'Blue Drop' status (score of 95% or higher). Water service authorities who fail or cannot provide the required information are subject to strict regulatory audits until improvements are seen. Table 2.10 highlights the variables that made up the Blue Drop certification process in 2010/2011 and their weightings.

Table 2.10: Indicators for Blue Drop system – 2010/2011 (DWA, 2010e)

Blue Drop	Variable	Weighting (2010/11)
Blue Drop	1. Water Safety Plan Process & Incident Response Management	15%
	2. Operations (process control), maintenance and management skill	10%
	3. Drinking water quality monitoring programme	15%
	4. Drinking water sample analysis credibility	5%
	5. Submission of drinking water quality results	5%
	6. Drinking quality compliance	30%
	7. Publication of drinking water quality management performance	5%
	8. Drinking water asset management	15%

A parallel incentive-based regulation effort has been undertaken for wastewater services ('Green Drop', see Table 2.11) – the aim of which is to acknowledge excellence in wastewater quality management (DWA, 2010b). Green Drop status is achieved if the WSA complies with wastewater legislative requirements with a score of 90% or higher – this is far more difficult to achieve than Blue Drop status however; mainly due to the fact that there are many more wastewater treatment facilities than drinking water systems in WSAs.

Table 2.11: Indicators for Green Drop system – 2010/2011 (DWA, 2010e)

Green Drop	Variable	Weighting
Green Drop	1. Operations (process control), maintenance and management skill	10%
	2. Wastewater monitoring programme	10%
	3. Wastewater sample analysis (credibility)	5%
	4. Submission of wastewater quality results	5%
	5. Effluent quality compliance	27%
	6. Wastewater quality failure response	10%
	7. Stormwater and water demand management	0%
	8. By-laws	5%
	9. Wastewater treatment facility capacity	10%
	10. Publication of wastewater management performance	5%
	11. Wastewater asset management	13%

There are approximately 821 wastewater treatment plants at 156 municipalities throughout SA, treating an average of 5258 Mℓ of waste every day. Of the 821 plants (100%) assessed in 2010, only 40 (4.9%) managed to achieve Green Drop certification, and only 361 plants (44%) scored better than 50% (DWA, 2011e). The national average Green Drop score was 45%. The results for the WSAs were no better – only 15 out of the 156 (9.6%) WSAs obtained one or more Green Drops for the facilities they are managing. The generally poor performance in the sector has been attributed to: skills shortages and poor levels of technical understanding; a lack of understanding of funding requirements; poor maintenance of infrastructure and outdated / inappropriate treatment processes; and a lack of information and monitoring.

2.8.6.5 Regulatory Performance Measurement System (RPMS)

The SFWS identified a number of key performance indicators (KPIs) to determine whether WSAs comply with national standards and regulatory frameworks with regard to the delivery of water services (DWA, 2003). DWA introduced the National Water Services Regulatory Strategy (NWSRS) in 2008, which set out a clear statement of intent regarding the regulation of water and sanitation services in SA with a view to improving business practice in water services delivery in local government. Part of DWA's mandate is to monitor, evaluate, report and publish the performance of WSAs and it does this by way of the Regulatory Performance Measurement System (RPMS), a web-based system managed by the Directorate of Water Services (Moshidi & Tompkins, 2009). The system measures performance in each WSA according to critical issues in each of 11 KPI areas from the Strategic Framework and against selected regulatory standards (or benchmarks, shown in light grey shading), as seen in Table 2.12.

The RPMS is currently aligned with other DWA regulatory initiatives, such as Blue Drop / Green Drop, and represents an evolution of the WSA checklist (DWA, 2011b). Other DWA initiatives have been aligned with the RPMS, including the NBI, eWQMS, the drinking water quality regulatory system (DWQRS), and the data acquisition management system (DAMS). It comprises two distinct aspects: 1) performance measurement, and 2) regulatory action, by tracking the response to non-performance through the issuing of Regulatory Actions against those non-compliant WSAs. A systematic approach to performance measurement such as this allows the regulator (DWA) to assess whether the actions that are instituted in response to non-compliance are effective in improving overall compliance in the WSA.

Not all of the variables making up the indicators are benchmarked for regulatory processes in each assessment period. Eight critical variables were chosen from KPIs 7 – 11 for this purpose in the latest 2010 analysis (DWA, 2011c), and benchmark targets provided as highlighted in bold in Table 2.12.

Table 2.12: Key performance indicators for RPMS – 2009/2010 assessment (DWA, 2011b)

Key Performance Indicator	Variable / Benchmarking indicator (shaded)	Weighting (2009/2010)	Benchmark target
KPI 1: Access to water supply	1. Backlog reduction rate - Water supply	40%	
	2. Households served - Water supply	40%	
	3. Project spending - Water supply	20%	
KPI 2: Access to sanitation	1. Backlog reduction rate - Sanitation	40%	
	2. Households served - Sanitation	40%	
	3. Project spending - Sanitation	20%	
KPI 3: Access to FBW	1. Poor households receiving Free Basic Water	100%	
KPI 4: Access to FBS*	1. Poor households receiving Free Basic Sanitation	100%	
KPI 5: Drinking water qual	1. Average Blue Drop score	100%	
KPI 6: Wastewater quality	1. Average Green Drop score	100%	
KPI 7: Customer service standards	1. % Service interruptions > 24hrs	30%	14%
	2. Customer Relations Management (CRM)	70%	
KPI 8: Institutional effectiveness	1. Institutional effectiveness assessment	40%	
	2. Water services staff effectiveness (% staff costs of total costs)	20%	35.5%
	3. Grant funding spending effectiveness	20%	
	4. WSA annual report	10%	
	5. % filled posts on organogram	10%	70%
KPI 9: Financial performance	1. Financial integrity	20%	
	2. Average debtor days (water / sanitation)	20%	45 days
	3. Revenue collection efficiency (% sales received)	20%	80%
	4. Average creditor days (bulk water)	10%	
	5. Financial sustainability	25%	
	6. Financial effectiveness	5%	
KPI 10: Strategic asset management	1. Asset management effectiveness	25%	
	2. % O&M expenditure of total asset value	25%	1.8%
	3. Rehabilitation and replacement expenditure (% O&M of total WS income)	0%	Not defined
	4. Replacement saving	10%	
	5. Asset register monitoring	40%	
KPI 11: Water-use efficiency (WDM)	1. % Non-revenue water	100%	25%

Notes: * Not being measured at present; relevant frameworks for measurement are still being finalised by DWA
 Grey shading denotes benchmarking indicators

For the annual comparative exercise the collected data is graphed according to the agreed benchmark indicators and categorised as follows:

- Category A: Metros (6 WSAs; 40% of the population).
- Category B1: Secondary cities (21 WSAs; 14% of the population).
- Category B2: Large towns (20 WSAs; 4% of the population).
- Category B3: Small towns and rural areas (85 WSAs; 13% of the population).
- Category C: District Municipalities (29 WSAs; 29% of the population).

In the initial pilot Phase 1 review for the 2007/2008 financial year, only one third of all WSAs were assessed, and no regulatory action was initiated. In the first formal year of data collection (2008/2009) this improved to 77% of all WSAs submitting data, although there were some difficulties with data verification and the decision was taken to withhold regulatory action. The latest assessment process (2009/2010) saw a 7% drop in participation, but an overall improvement in data integrity owing to the increased requirements for supporting documentation to enable adequate data verification (DWA, 2011b). The current review listed the following as areas of highest compliance in most WSAs throughout the country: Access to Free Basic Water (KPI 3); Access to water supply (KPI 1); Institutional effectiveness (KPI 8); Customer service standards (KPI 7); and Access to sanitation (KPI 2). National indicators identified as areas of critical concern include: Water use efficiency (KPI 11), Financial performance (KPI 9), and Strategic asset management (KPI 10). Regulatory actions were initiated against all WSAs that did not submit data. A summary of the benchmark indicators is shown in Table 2.13, with percentages shaded in grey indicating figures that do not meet the regulatory target – overall the metros are the best performers, while district municipalities fare the worst.

Table 2.13: Benchmark indicator performance summary for the 2009/2010 comparative RPMS analysis (DWA, 2011c)

Benchmark indicator	Metros (A)	Secondary cities (B1)	Large towns (B2)	Small towns (B3)	Districts (C)
Service interruptions – target < 14%	4.5%	4.5%	8.0%	21.4%	36.7%
Posts filled – target > 70%	65.3%	56.4%	65.1%	71.5%	58.8%
Staff costs – target < 35.5%	12.4%	23.6%	22.9%	26.6%	33.8%
Average debtor days – target < 45 days	76	56	98	81	93
Sales received – target > 80%	90.3%	56.9%	73.4%	59.1%	53.8%
O&M spend (assets) – target > 1.8%	3.3%	6.7%	6.0%	4.7%	12.6%
O&M spend (income) – no target	21.0%	22.9%	24.2%	17.8%	32.2%
Non-Revenue Water – target < 25%	35.7%	53.1%	32.7%	39.7%	45.7%

Note: Grey shading denotes indicators not meeting regulatory targets

The data collection process for the RPMS is streamlined and occurs on an annual basis, with data stored in the Water Services National Information System (NIS). If data is not available for a specific municipality in the RPMS process, then non-compliance is assumed. Scores for each weighted component are calculated and added to give an overall KPI score out of 5. Each KPI score is then compared to a ‘compliance’ score which is based on national standards and norms by way of a dashboard analysis between the achieved KPI score and the required score. The measurement aspect of the system allows a performance trend to be developed through the systematic measurement and storage of historical data on each of the KPIs at national, regional and WSA level. It also provides WSAs with a facility to develop corrective action plans to address non-compliance. The RPMS is web-based and can be accessed by public users, WSAs and DWA water sector partners, albeit at different levels of access. Interestingly, authorisations with respect to WSAs have highlighted significant capacity gaps in the water service industry, and this and other external factors have resulted in some tension in local government around making RPMS results publicly available (Moshidi & Tompkins, 2009).

There have been significant developments and improvements with respect to the RPMS since its inception, but there have also been challenges in achieving the goal of effective performance measurement owing to a lack of reliable data at many WSAs. A change in focus for the RPMS is currently being considered by DWA to include a more risk-based approach to compliance – and target resources into areas with the highest risk to the economy, environment and the consumer (DWA, 2012). If this new system is implemented, WSAs will still be required to report annually against the existing KPIs, but there will also be a detailed annual assessment of a specific portion of the business, based on a risk assessment framework. It is not yet clear whether this risk assessment framework will link with the Municipal Strategic Self Assessment (MuSSA) process mentioned in Section 2.8.6.3 which aims at identifying and prioritising vulnerable areas and risks of water services infrastructure, design and O&M.

2.8.6.6 Water and sanitation policy implementation - identifying fault lines

Research conducted by the Centre for Applied Legal Studies, the Centre on Housing Rights and Convictions and the Norwegian Centre for Human Rights identified key fault lines in water and sanitation policy and implementation drawn from interviews with 15 municipalities across SA (Tissington *et al.*, 2008). Whilst SA has one of the most progressive legislative and policy frameworks for water services in the world, when it comes to implementation at a local level, the reality is quite different. The devolvement of responsibility for water services by the national government to local government (in 2000) and the resultant decrease in financial and technical support to municipalities has meant that it is cost recovery, and not social / developmental benefit that determines water service delivery. The nine fault lines identified reflect obstacles to water service provision, as follows:

- i) Eliminating backlogs and improving levels of service.
- ii) Free basic services.
- iii) Indigent policy as the FBS targeting mechanism.

- iv) Tariffs.
- v) Credit control enforcement – water disconnections and restriction devices.
- vi) Financial and technical assistance to municipalities.
- vii) Water quality.
- viii) Water demand management.
- ix) Public participation.

Whilst the report did not delve into specifics of institutional and administrative aspects, it did acknowledge that this requires further research and that the institutional form may well affect service delivery. This was highlighted in a discussion about the National Water Services Regulation Strategy (DWA, 2008a) which shifts DWA's role from water services provider to that of regulator of the water and sanitation services sector. As discussed in Section 2.8.6.5, WSAs have to report across a number of KPIs so that DWA can make performance assessments in the areas of social regulation, drinking water quality, environmental health, water resources and economic regulation. The report noted that within this framework, for many of the fault lines identified in this study, several government departments are listed as lead regulators including the Department of Provincial and Local Government (DPLG), Health (DoH) and National Treasury, along with DWA. Currently, in the absence of a framework which acknowledges the connectivity of water with other critical services, water services are fundamentally de-linked. This may be related to the constitutional setup where healthcare and housing are functional areas of provincial and national competence while water supply and sanitation are local government matters (Tissington *et al.*, 2008).

A review of sanitation policy and practice, commissioned by the Water Research Commission of SA (WRC), found that while the national sanitation policy framework provides an enabling environment for municipalities to deliver sustainable sanitation services, the problem lies in the interpretation of the policy, with too little consideration of issues such as hygiene awareness, behavioural changes, operations and maintenance (O&M) aspects, community involvement, solid waste disposal and greywater management (Mjoli, 2009).

An independent review of the institutional approaches in SA that affect the quality of service delivery was also undertaken between 2006 and 2010 through the Water Dialogues process; a series of national multi-stakeholder dialogues and research processes focusing on examining whether and how the private sector can contribute to the delivery of affordable and sustainable water supply and sanitation services, especially to poor communities. The research provided evidence of the need to address a high level of municipal dysfunction, particularly with respect to service delivery systems and maintenance (Galvin, 2009).

2.8.7 South African Cities Network (SACN) – sustainability reporting

The South African Cities Network (SACN), in partnership with the SA-Denmark Urban Environment Management Programme (UEMP), and with the support of the Danish Government, is responsible for recording, assembling and disseminating current learning, analysis and experience in the field of sustainable urban development in South Africa (SACN, 2008). It does this by way of its State of the Cities reporting process, which is undertaken every two to five years – recent reports were published in 2004, 2006 and 2011. Its member cities comprise the nine largest urban centres in SA: Buffalo City, Cape Town, Ekurhuleni, eThekweni, Johannesburg, Mangaung, Msunduzi, Nelson Mandela Metropole and Tshwane. The UEMP is a targeted programme which prioritises poverty alleviation through people-centred development with appropriate environmental management. These interventions build on the goal of the UEMP to implement South Africa’s development policies and to promote a sustainable development path which contributes to poverty reduction, economic growth and the achievements of the Millennium Development Goals. In particular, urban development is aimed at achieving the national vision of a productive, democratic and non-racial society based on a vision of sustainable human settlements (Boraine *et al.*, 2006).

One of the programme areas in the cities network is the City Development Strategy, specifically geared towards policy development. The policy development cycle is informed by the various focus areas within this programme, including that of Urban Indicators and Studies. *“Indicators are critical to effective planning and management in increasingly complex urban contexts, organising information sets into simple, easy to grasp and easy to compare ‘measures’ of what is happening.”* (SACN, 2012). It is for this reason that an Urban Indicators working group was initiated in 2002 to establish broad agreement on the role and selection of urban indicators, and to focus attention on measuring city performance. This has been informed to some extent by the World Bank-initiated Global City Indicators Facility (GCIF) which is aimed at worldwide performance monitoring and learning across cities, and of which four of the SACN cities (Cape Town, Durban, Johannesburg and Nelson Mandela Metropole) are members. Initiatives such as the City Water Managers Forum which has been established with the nine member cities of the SACN also aim to facilitate debate on key topical issues facing the water sector, as well as providing a mechanism for communication and promoting best practice management of water in the major urban areas of South Africa.

The 2011 State of the Cities Report (SACN, 2011) focuses on the resilience of cities in SA, and in particular on their capacity to withstand and recover from external shocks, and adapt to changing circumstances. It notes that, while economic and social conditions in SA cities are in many respects better than they were a decade ago, increased urbanisation and population growth has resulted in limited progress with access to housing and essential services, as well as increasing pressures on the environment. The report stresses that municipal authorities should go beyond the routine delivery of basic services to ensure urban resilience, as follows:

- Refreshing the developmental vision of metropolitan government – towards a multi-level developmental state where power is harnessed from all spheres and sectors.

- Stabilising metropolitan government and restoring trust – including effective leadership and a willingness to work with communities towards constructive activity.
- Reshaping and reconfiguring cities – by way of strategic planning and investment. This will require an improved evidence base and understanding of urban trends; national government needs to commit to improving the availability of municipal-level data (on all aspects of sustainability), and every city should have some kind of ‘observatory’ function to assemble information, monitor important trends, conduct research and evaluate policy.

Relating to the last bullet point, it has also been suggested that a network of local Urban Observatories and a National Observatory – with programmes for the ongoing collection and analysis of city-level data – should be established as a joint venture with other key stakeholders such as research institutions, civil society and the private sector (Smit *et al.*, 2008).

2.9 Summary and conclusions

The literature review has highlighted the various critical challenges in the urban water sector, both in South Africa and worldwide. It has shown that in order for these challenges to be addressed, and for urban water services to be sustainable in the long term, accountable governments (at both national and local level) are required. For this, robust measures of success and failure in the sector are needed, which can then inform the actions required to ensure service delivery, social advancement and economic growth into the future. The section on the South African context in particular highlights the areas where these measures of success and failure need to be made. The role of sectorally-based sustainability assessment methods – such as that which has been developed as part of this research – is critical in terms of the ability of these methods to provide information on the key issues of a city’s water system and highlight objectives for future improvement.

There are many ways to measure sustainable development, each of which provide different insights for policy makers, academics and the general public. Aggregate measures based on a clear concept of sustainability as an agreed goal, and defined by criteria which separate sustainable outcomes from unsustainable ones are potentially most useful for a multifaceted concept such as this. It should be borne in mind however that sustainability assessment is just one tool. It will not deliver sustainability by itself and must be linked in with other complementary initiatives, such as the provision of targets and action towards implementing policy.

The achievement of sustainability in the context of developing countries demands that social upliftment principles specifically geared towards health and poverty alleviation be prioritised. The economic benefits and environmental gains from well-functioning water services are just as important – improved health can translate to improved productivity, and this in turn can lead to increased incomes and economic growth, whilst the efficient provision of water and adequate management of wastes contributes to the preservation of water resources

and ecosystems. Economic considerations are key determinants of the levels of service to be provided, based on the ability of consumers to pay for these services, and the need for cost recovery. The South African government has addressed this by way of the Free Basic Services policies, which ensure that those who cannot afford are supplied with a minimum level of service (water supply and sanitation), through cross-subsidisation from those who can – and who are charged for consuming more than the stipulated minimum. Achieving the necessary balance between ensuring the general well-being of society and maintaining a level of economic stability demands a high level of capacity from governments to develop appropriate policies and guide development; and of institutions to put this into practice in an efficient and resource-wise manner (De Carvalho, 2007); this remains one of SA's biggest challenges.

This research aims to contribute to this challenge by providing a tool (the SIUWM) which can highlight how good – or bad – the situation is with regard to sustainability in the SA urban water sector. It is hoped that this will become a useful advocacy instrument to provoke appropriate action and enable the tracking of system improvements over time. It is important to stress however that, although efficient water supply and service provision is essential for growth and progress in South Africa, it is not sufficient to ensure development in this area. This must be complemented by work in other sectors and at different levels of society. It demands certain complementary inputs such as active community participation, appropriate technologies and design, improved capacities and most importantly, an overall willingness for change.

3. Research process

The aim of this research was to develop a measure of the potential for sustainability in a South African urban water context. In brief, this has been achieved through the development of a framework for identifying indicators based on a vision of what sustainable urban water management means in South Africa. The resultant composite index, the Sustainability Index for Urban Water Management (SIUWM) has been applied to a number of case study cities in SA and used to highlight some of the crisis areas in urban water management. It does this by linking the results from various existing performance measurement and regulatory systems with a broader sustainability assessment process to provide a more detailed analysis which can be used to establish goals and inform strategic processes to leverage support for improved water services. This chapter outlines the general process that was followed in this regard, while Chapter 4 provides specific details on the applied methodology in respect of the vision for sustainable urban water management, and the development of the Sustainability Index itself.

3.1 Background to SIUWM research effort

Worldwide, the attention of the research community is increasingly being focused on new, integrated approaches to urban water management variously called, amongst others, Integrated Urban Water Management (IUWM), Low-Impact Development (LID) or Water Sensitive Urban Design (WSUD). The recently-completed “Sustainable Water management Improves Tomorrow’s Cities Health” (SWITCH) project in the European Union’s 6th Framework (FP6) is an example of a major project in the field of IUWM. A second call for research as part of the SWITCH project was announced in early 2006, which prompted the University of Cape Town (UCT) to submit an extended partnership proposal together with UNESCO-IHE with the objective of developing and promoting appropriate management options for sustainable water systems to ensure efficient and reliable water services. This was to be achieved through the development of sustainability and risk indices for the assessment of urban water management in the larger cities of Africa. Whilst awaiting the outcome of the proposal submission process, two final-year students in the Department of Civil Engineering at UCT were tasked with investigating the notion of risk and sustainability assessment in urban water management as their final BSc(Eng) projects. The theses resulting from this effort provided the initial framework for the further development of the SIUWM:

- i) BSc(Eng) – Risk assessment in Integrated Urban Water Management (Snoek, 2006).
- ii) BSc(Eng) – Development of a “sustainability index” for integrated urban water management (Stoekigt, 2006).

The proposal to obtain research funding through the FP6 top-up call was unsuccessful; informal collaboration with UNESCO-IHE was maintained however, and a decision was taken to apply for local South African funding to continue with the research. The author, as a member of the Urban Water Management (UWM) group in the Department of Civil Engineering at UCT,

subsequently submitted a research proposal entitled “The development of a robust measure of the long-term sustainability of urban water systems, focusing on the larger cities of South Africa” to the National Research Foundation (NRF) for funding between 2007 and 2010. The application was approved by the NRF in late 2006, providing partial funding for the various students associated with the research during the following four year period. This project formed part of a broader research thrust carried out by the UWM group which includes on-going research into sustainable urban water management focusing particularly on those issues facing developing countries, and comprises a multi-disciplinary team of researchers including *inter alia* civil engineers, environmental scientists and social anthropologists.

3.2 Method

In order to determine what sustainability and the measurement thereof means in the context of UWM in South Africa, the use of a tool such as a composite sustainability index was explored. Following on from the initial work by Stoeckigt (2006) and Snoek (2006) on the development of preliminary sustainability and risk indices, a Masters-level student was tasked with designing a process model to enable the development of the preliminary version of the sustainability index, namely the SI 2007 (De Carvalho, 2007). In this research a structured framework was adopted in order to define the system and identify / verify the indicators for the sustainability index. The iterative procedure, based on the life cycle assessment (LCA) approach of Lundin & Morrison (2002) in their work on the development of environmental sustainability indicators for urban water systems, was used to develop the preliminary conceptual model. This five-level model was coupled with the step-wise methodology proposed by Nardo *et al.* (2008) for the development of composite indicators as it provides a comprehensive approach for the construction of an index such as this (Figure 3.1).

The composition of the SI 2007 itself was based on the structure of the Environmental Sustainability Index (ESI) which was developed by the Yale Centre for Environmental Law and Policy (Yale, 2005). The scale of implementation between the ESI and SI 2007 differs considerably (the ESI targets national-level policy and SI 2007 aims to improve management of water at sector level), requiring a different approach to indicator development and selection. However, there is a commonality of purpose in the two indices with respect to informing on progress towards sustainability, aligning with existing policy and highlighting gaps in legislation. The SI 2007 was thus designed using the same five broad components of the ESI:

- i) Social / cultural – social fairness and equitable resource distribution.
- ii) Economic – economically sound principles, economic growth and cost returns.
- iii) Environmental – environmental protection and preservation of ecological systems.
- iv) Political – support and international stewardship.
- v) Institutional / technological – capacity and progress.

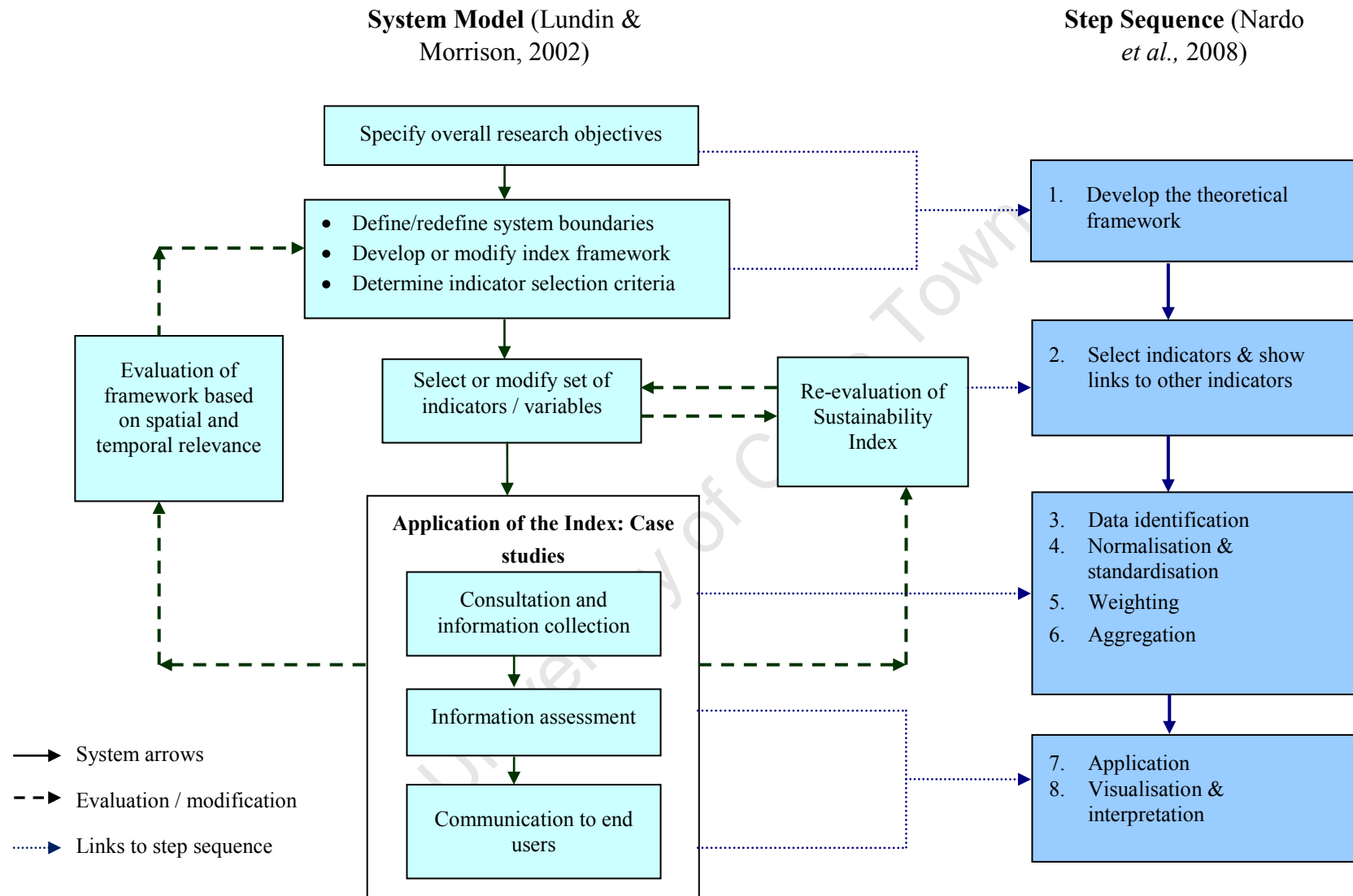


Figure 3.1: Step-wise approach to SIUWM development (adapted from Lundin & Morrison, 2002 and Nardo *et al.*, 2008)

A review of the relevant literature as well as a thorough analysis of the various aspects that make up the urban water cycle in a South African context resulted in the initial selection of 64 variables. The variables were aggregated into 20 indicators – both quantitative and qualitative – and five different components to compute a single index score (Figure 3.2). See Table B.1 in Appendix B for a list of the selected variables and indicators making up the SI 2007.

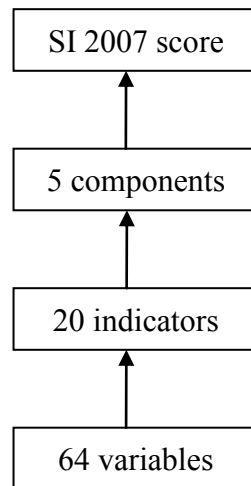


Figure 3.2: Composite index approach based on the structure of the ESI

The next phase of the research involved applying the SI 2007 to several different urban areas in southern Africa in an attempt to test its applicability and validity, and refine the structure of the final index, the SIUWM. Several Honours and Masters level students were recruited to carry out these case study analyses, with the research being directed by the author, who also acted as co-supervisor to the BSc(Eng) students. The following theses resulted from the case study applications that were carried out during the period 2007 to 2009:

- i) MSc(Eng) – “Sustainability Index for Integrated Urban Water Management (IUWM) in southern African Cities. Case study applications: Greater Hermanus region and Maputo City” (De Carvalho, 2007).
- ii) BSc(Eng) – “An evaluation of a Sustainability Index for Integrated Urban Water Management. Case study: Franschhoek, South Africa” (Hotchkiss, 2008).
- iii) BSc(Eng) – “Sustainability Index for Integrated Urban Water Management (IUWM) in southern African Cities. Case study application: Town of Stellenbosch” (Makgalemele, 2008).
- iv) BSc(Eng) – “Determination of the Sustainability Index of Dar es Salaam” (Mrema, 2009).
- v) BSc(Eng) – “The determination of the Sustainability of Water Management in a Typical African City. Case study: Ekurhuleni Metropolitan Municipality” (Siboiboi, 2009).

- vi) BSc(Eng) – “The determination of the Sustainability of Water Management in a typical African city. Case study: Windhoek, Namibia” (Urban, 2009).
- vii) MPhil – “The evaluation and improvement of a Sustainability Index for Integrated Urban Water Management in South African Cities. Case study applications: East London and Port Elizabeth” (Mureverwi, 2009).

As will be discussed in more detail in Chapter 4, the various recommendations and conclusions arising from the case study applications were used to partially inform the final selection of indicators and overall structure for the current SIUWM. The research underwent a shift in focus at this point as the decision was taken to use the index to pull together existing regulatory and benchmarking initiatives in SA so as to provide a more integrated sustainability analysis. A visioning framework was developed, a sustainability vision was prepared for the urban water sector, and comparisons were undertaken with sustainability assessment efforts and other indicator initiatives being undertaken in South Africa and elsewhere. An analysis and audit of potential data sources for the computation of the index followed, as well as the finalisation of the aggregation procedures for the final composite score. Throughout the process, there was ongoing consultation and engagement with the relevant local authority officials and other stakeholders.

Once the SIUWM was finalised, it was applied to the nine member cities of the South African Cities Network (SACN) in an attempt to assess urban water sustainability in these areas, and to further test the validity of the index. The SIUWM highlights inherent strengths and weaknesses in the management of water services in the city and consequently in the performance across each dimension of sustainability, drawing attention to specific challenges through interrogation of the individual indicator and variable results. In summary, the research comprised the following general steps:

- Extensive literature review, with a particular focus on the concept of sustainability within the context of integrated urban water management in South Africa.
- Development / adaptation of the theoretical framework and model for the sustainability assessment process.
- Development of the sustainability index for urban water management (SIUWM) – including the selection of suitable indicators – based on the preliminary SI 2007.
- Identification of candidate towns / cities and establishment of contacts in the relevant local authorities, government departments, universities and other institutions involved in the knowledge and provision of water supply, sanitation and drainage services.
- Engagement with stakeholders regarding the development of a sustainability vision, choice of indicators and their relevant weightings for the index, evaluation of methods for determining weights etc.

- Identification of the water service systems in place in the case study cities, including physical, institutional and management aspects.
- Selection and acquisition of data on the systems, particularly in terms of the social, economic, environmental, political and institutional aspects, and evaluation of their performance.
- Computation of sustainability index results for the cities in order to test the applicability and validity of the SIUWM.
- Re-evaluation of the components, indicators and variables of the SIUWM and modification where necessary.
- Assessment of the usefulness of the SIUWM tool as a measurement of sustainability in urban water management.
- Engagement with stakeholders in the urban water sector to determine how best to disseminate the information so that it can be useful as a decision-support tool.

The research method was an iterative process that evolved over the period 2007 to 2011, with variations of the index being tested in several urban centres in South Africa, Mozambique, Namibia and Tanzania before the final SIUWM was developed. During this time several water services performance monitoring initiatives by national and local government agencies in SA were also being finalised; and the links with them and the SIUWM were explored. Ultimately, as will be described in more detail in Chapter 4, the SIUWM is an attempt to link these monitoring initiatives in order to gauge overall sustainability in water services in SA.

4. Development of the Sustainability Index for Urban Water Management (SIUWM)

The literature review attempted to provide an improved understanding of the complex concepts of sustainability and discussed some of the tools and frameworks that have been developed for monitoring sustainability, particularly with respect to the management of urban water services. Various existing indices were investigated with a view to identifying an appropriate methodology and a core set of indicators / variables to provide input into the SIUWM. As detailed in Chapter 3 (see Figure 3.1), the conceptual model on which the development of the SIUWM was initially based, was adapted by De Carvalho (2007) from the five-level systems analysis model for the selection of environmental sustainability indicators by Lundin & Morrison (2002), coupled with the step-wise methodology proposed by Nardo *et al.* (2008) for the use of indicators and aggregation into a composite index. This included *inter alia* the following methodological steps, which will be discussed in detail in the sections that follow:

- i) Developing the theoretical framework (Section 4.1).
- ii) Selecting indicators and showing links to others (Section 4.2).
- iii) Identifying data inputs and normalising / standardising data where necessary (Section 4.3).
- iv) Applying weights and aggregating indicators (Section 4.4).
- v) Computing the index (Section 4.5).
- vi) Interpreting / disseminating the results (Section 4.6).

4.1 Theoretical framework for sustainability assessment

Integrated and multi-dimensional systems approaches have been emphasised thus far (see Section 2.4) as the vehicles which can enable appropriate coordination and action by relevant decision-makers towards the goal of sustainable urban water management. Sustainability assessment is one such approach that can lead to a more principled way of designing policies and strategies for the long term. It involves the development of analytical tools and methods that attempt to measure, evaluate, monitor and forecast the impacts of all aspects of urban water management, including various non-technical aspects such as social, cultural and environmental factors (Karamouz *et al.*, 2010). Various tools are available for tracking progress against sustainability targets, with sustainability indicators often being used to measure the state of the environment by considering variables and monitoring relative changes against given criteria.

Urban water management programmes aimed at generating approaches and tools which will allow cities to improve knowledge and understanding of sustainability – as well as analysing the urban water situation in order to draw up more effective management strategies –

are becoming routine. Governments are increasingly being called upon to put in place systems to assess and monitor the impacts of water-related initiatives; i.e. “*measure and analyse for informed decisions*” (WWAP, 2009) – both for advocacy and awareness purposes as well as for fine-tuning strategies and policies. The use of performance indicators and benchmarking techniques has thus become common practice in the water industry worldwide with the main aim of verifying the quality of public services in terms of efficiency, effectiveness and economy, and to help decision-makers to identify critical issues and appropriate measures to improve system performance.

The complexity of urban water systems can at times render performance assessments impractical or unfeasible, particularly where cooperation across disciplines is lacking. In order to address this issue, this research explored the theme of multidisciplinary embodied in the principles of systems theory, advocating integration and cooperation across disciplines for better exposure of some of the links within and between urban systems, its beneficiaries and supporting ecosystems (De Carvalho, 2007). IUWM is considered to be the correct vehicle for applying the concept of multidisciplinary in this context.

Sustainability assessment requires the identification of suitable reporting tools as well as the identification of methodologies for assessment. These can be simple assessment criteria, performance indicators and/or conceptual models. Conceptual models can often be complex and tend to involve a number of parameters for which measurement is resource intensive. On the other hand, assessment criteria are largely subject to qualitative assessments and fail to provide the numerical dimension needed. Indicators provide a compromise between these two approaches; on the one hand they allow for both qualitative and quantitative assessments, and on the other hand they can address the complexities of reality which are sought by model representations (De Carvalho, 2007). Sustainability indicators and composite indices are increasingly recognised as useful tools for policy making and for conveying information about performance; however before developing the indicator methodology, a clear definition of the policy goals towards sustainability is required (Singh *et al.*, 2009).

An important starting point in the construction of composite indices is a clear definition of the phenomenon to be measured and its sub-components (Butler, 2003; Nardo *et al.*, 2008). Thus the development of the theoretical framework started with an exploration of the concept of sustainability and a clear definition of goals and expectations in order to develop a solid foundation for the index. Once this had been done, it was possible to start identifying the underlying issues which had to be represented and measured. The process of indicator selection was of itself a complex process, and involved a series of steps which will be described in Section 4.2. Above all, this process was centred on the creation of a vision of sustainability in the context of urban water management in South African cities, as will be discussed in detail in Section 4.2.6.

4.1.1 Sustainability concepts

Whilst the term ‘sustainability’ has characterised much of the thinking in recent times, it still has no single meaning and there is no agreement on how it is recognised and measured in an objective sense. In essence, it can be regarded as a “*broad evaluative framework...which needs to be made operational in each specific context, depending on separate visions of sustainability*” (Lundie *et al.*, 2005).

Sustainability concepts are often described in terms of the Triple Bottom Line, essentially a balance between environmental, social and economic considerations, although in some cases this concept has been expanded to include institutional considerations (Figure 4.1). The drawback of this depiction however, is that it is based on the recognition of the supposedly separate existence of these systems. It implies that sustainability is only the union of the three aspects and that the area outside this zone of integration is assumed to be an area of contradiction (De Carvalho, 2007). The integrated systems model shown in Figure 4.2 on the other hand portrays the economic and social / technical systems as subsets of a larger ecosystem, and all are integrated through an effective governance system that holds them together within a regulatory framework (SACN, 2011). Sustainability implies the continuous and mutually compatible integration of these systems over time.

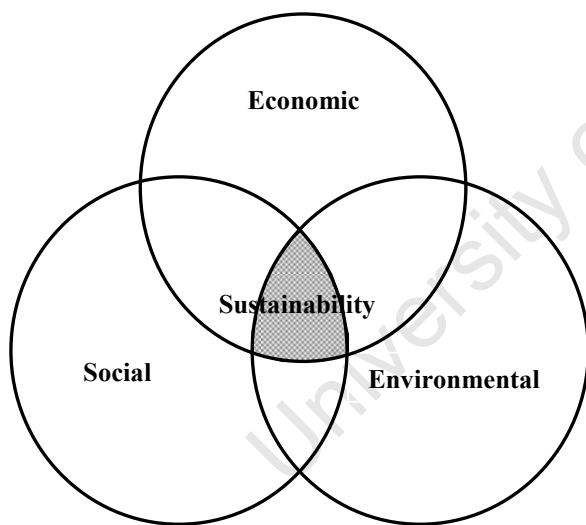


Figure 4.1: Triple bottom line (independent system model)

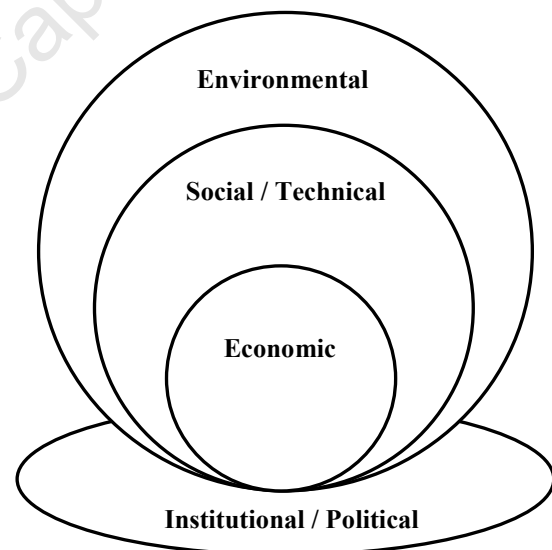


Figure 4.2: Integrated systems model for sustainability (SACN, 2011)

As will be discussed in further detail in Section 4.2.6, the SIUWM indicator selection process has been founded on this integrated systems model; i.e. with the premise that the urban water system forms a subsystem of the interlinked social / economic / institutional systems, and they are all related to and dependent on the natural environment. This re-framing based on systems theory creates possibilities for describing and assessing sustainable systems – in this instance,

urban water systems – as it takes as a point of departure the basic prerequisites for sustainability in this regard (Sundberg *et al.*, 2004).

It is thus clear that in order to be effective in endeavours to achieve sustainability, a commitment to integrate a range of socio-economic, administrative and resource management processes is required. In her development of the preliminary index, SI 2007, De Carvalho (2007) acknowledged these processes through the ‘Prism of sustainability’ framework provided by Valentin & Spangenberg (2000) – refer to Section 2.3 (Figure 2.4) for more detail in this regard. As with the integrated systems model of sustainability, the ‘Prism of Sustainability’ is composed of four dimensions, namely: social, economic, environmental and institutional. The institutional dimension in this case represents both political and administrative aspects; however De Carvalho (2007) suggested that these two aspects could contribute significantly to the success or failure of integrated management independently of one another, and merit a categorical separation. De Carvalho (2007) saw this as being particularly relevant in a developing nation context such as the one in which the SI 2007 was applied; specifically in Maputo, Mozambique. Corruption, poor representation and low levels of democracy are commonly cited problems in almost any public (and private) sector in the cities of Africa. At the same time, understaffing, under-resourcing, and shortages of skills continue to be strong contributors to poor water management in the public sector. While intrinsically linked, the two aspects appear to present unique sets of problems which could be tackled accordingly, hence De Carvalho’s call for a separate dimension of sustainability. The first version of the sustainability index, the SI 2007, was thus designed using five components of sustainability: social, economic, environmental, institutional and political. During the index testing process that followed, however, the decision to treat the institutional and political dimensions separately was questioned and, as will be discussed in the sections that follow, the framework for the design of the final index was based on the structure and the four components of the integrated systems model shown in Figure 4.2. It is important to note that, particularly in developing countries where poverty and inequality aspects have profound influences, sustainability evaluation frameworks should be flexible enough to allow for inclusion of these and other aspects related to the specific context (Sanya, 2012).

Ultimately sustainable development is dependent on the maintenance of three main aspects; social development, economic growth and environmental protection / management – whilst also addressing political and institutional considerations. Of these, environmental protection is often the least acknowledged and, for urban water management in particular, only limited attention is paid to environmental aspects. Whilst it is important to consider environmental impacts this however should not occur at the expense of development, particularly in the southern African context. This is made clear in the definition of environmental sustainability made by Goodland & Daly (1996), which refers to the maintenance of ‘capital’ in four different categories: man-made (infrastructure, roads, houses etc.), natural (the environment and what it provides), human (investments in people, education, health etc.) and social (institutional, cultural etc.). If developing countries are to have any hope of protecting their natural capital, it is imperative that economic and human development is

accelerated, as long as it is within the limits of the biophysical environment both as a provider of inputs as well as a receiver of wastes (outputs). In line with this thinking, the concept of sustainability as it relates to water services in South Africa, is described by the Department of Water Affairs (DWA) as a “*vision of a community’s future, where the vision is community-oriented and focused on long-term goals and takes into account linkages between the social, economic, institutional and environmental aspects of the community*” (DWA, 2008b). It is with this in mind that the SIUWM has been developed in an attempt to identify current performance and to suggest how practices can be modified toward the ideals of sustainability.

4.2 Selection of indicators for SIUWM

4.2.1 Goals and direction for research

To reiterate, the overall aim of this research was to provide a comprehensive understanding of sustainability in the context of urban water management in a developing country context in order to determine what the ‘leverage points’ are in moving towards sustainability. Put in the form of a question, this could be: “Are the various dimensions of sustainability being considered and integrated in urban water systems in South Africa at both management and strategy levels”? The development of a composite sustainability index was proposed as the way in which to address this issue, whilst acknowledging that there are various methodological issues with the use of indices which, unless addressed, could render attempts at assessing sustainability in urban water in this way irrelevant. As will be noted in Chapter 5, common issues encountered in the computation of composite indices comprise: variable / indicator selection (including problems with decision-makers choosing to leave out certain indicators) and the potential impacts of using a different indicator set; missing data treatment; aggregation and weighting methodologies; as well as performance testing (OECD, 2003).

4.2.2 Sustainability assessment – “measuring the immeasurable”?

A sustainable system can simply be defined as one that can be maintained *ad infinitum*. The ability to recognise such a system and measure its potential for sustainability is more complex, however. As discussed in Chapter 2, sustainability is a qualitative concept and not a precise condition or absolute quantity that can be scientifically defined or measured (Hjorth, 1996). It can be viewed as a concept dependent on the various perceptions of the stakeholders residing within the problem context (Bell & Morse, 2008). In this regard, sustainability assessment becomes a form of direction analysis for determining whether there is a move towards or away from the ultimate goal of sustainability. In a similar vein, Scerri & James (2010) note that achieving sustainability begins with the task of reflecting upon the nature of human activity. The challenge with this is to develop a flexible framework that speaks to existing relevant measures of sustainability, translates between them, and then broadens the terms of relevance and the nature of engagement. A defined vision of sustainability in a particular context is required so that the epistemological links to indicator selection are clear and to ensure that the

indicators and their data sets have the monitoring of sustainability as their main purpose (Davidson, 2010). Similarly, the identification and use of benchmarks and targets is required in order to assess progress towards sustainability. The following sections will focus on the process that was followed in an effort to engage with the sustainability challenges and the various viewpoints of the stakeholders involved in the South African water sector, so as to formulate a set of indicators for the sustainability analysis.

4.2.3 Indicator identification and selection process

“The development of an adequate indicator set is, in fact, extraordinarily difficult”
(James & Scerri, 2009)

The development of a framework of indicators encompassing environmental, social, economic and institutional dimensions is a necessary step in the sustainability assessment process. The selection of the most appropriate indicators is crucial in this regard, and Bell & Morse (2003) have highlighted a number of key questions related to this framework development and its application:

- What indicators should one select?
- Who selects them?
- Why are they selected?
- What are they meant to help achieve?
- What about the balance between the various dimensions of sustainability?
- How are the indicators to be measured?
- How are the indicators to be interpreted, and by whom?
- How are the results to be communicated, to whom, and for what purpose?
- How are the indicators to be used?

The process of selecting and developing indicators is thus a complex one involving a series of steps, from an initial conceptual stage defining key issues to be monitored, to the selection of preferred indicators and testing for relevance. This approach of defining the underlying precepts of research and the desired outcomes ties in closely with the Bellagio Principles for development and assessment of sustainability indicators (Hardi & Zdan, 1997), as discussed in Section 2.5.

Hellström *et al.* (2000) stress that the multi-dimensionality expressed by the various definitions of sustainable development emphasises that thinking in terms of economic costs and benefits is no longer sufficient – social, cultural and environmental aspects have to be incorporated into the decision-making process, especially with regard to long-term effects.

They noted that it is beneficial to use sets of indicators to make the concept of sustainability more operational and practical; however large numbers of indicators create multidimensional problems of high complexity, and smaller sets of priority indicators were therefore selected for their study (grouped into five sustainability components – health and hygiene; social-cultural; environmental; economic; and functional / technical). Their priority set of 20 indicators represented what was to be investigated initially in an analysis of an urban water system, with the option of a full analysis with the larger indicator set (39 indicators) if necessary. Palme (2007) categorised criteria and indicators for sustainability assessment according to the different dimensions of sustainability adopted in various water-related research projects. From this, an initial set of urban water indicators could be identified. Neba *et al.* (2007) suggest that both selection criteria and sustainability indicators differ between developing and developed countries largely as a result of the different needs and prevailing socio-economic conditions in different regions. Local conditions in the area to be assessed therefore inform the choice of indicators, based on the main purpose of the system in question.

The focus of the current research has thus been a careful appraisal of key indicators, those specific to the South African context and with a direct link to urban water management. In a developing country context, the main objective of urban water services is to provide a reliable water supply aimed at safeguarding the health of the population whilst protecting the environment; sustainability indicators must therefore take this into account. It has been shown that much of the disease burden in developing countries could be prevented by improving water supply, sanitation, hygiene and the management of water resources (Mathee & Naicker, 2011). Core sustainability indicators for urban water and sanitation systems in developing countries should therefore include those related to: health; household water consumption; energy required for water and sanitation services; non-revenue water (NRW); urban water supply and sanitation (UWSS) coverage; water supply and sanitation (WSS) provider efficiency; water and sanitation (WATSAN) tariffs; participation / transparency; access to basic services; greenhouse gas (GHG) emissions; source protection; and risk of major failure.

According to the 2007 Federal Universal Basic Sanitation law in Brazil (*Lei 11445/07 para o saneamento básico*), a basic sanitation system is defined as not only focusing on the management and disposal of sanitary waste, but as a combination of: clean water supply, sanitary sewers, urban solid waste management, and stormwater management. This was driven by the desire to reduce poverty and the promotion of social equity and universal access to sanitation services, as well as the realisation that water services are all interlinked and need to be considered as one (Beveridge & Diamond, 2010). The city of Belo Horizonte has used this definition of basic sanitation, together with an added indicator concerning vector control, to compile a weighted Index of a Healthy Environment (ISA – *Índice de Salubridade Ambiental*). The index takes into account the percentage of the population with access to water supply, sanitation and solid waste services, instances of flooding, and numbers of mosquito larvae found in traps. This index is then used as the basis for the prioritisation of funding by sub-catchment, together with three other indicators as follows:

- i) Population density.
- ii) Percentage of population in informal settlements.
- iii) Rate of diarrhoeal infection in under 5's.

As has been noted, indicators can play a very useful role in determining what is achievable with respect to sustainability, but only in terms of their use as an advocacy tool, and not as precise measures (Bell & Morse, 2008). It is not possible to develop a universal and unchanging set of sustainability indicators; because the indicators can themselves change the way people think about sustainability, the challenge is to keep pace with people's perceptions. As discussed previously in Section 2.6.3, Bell & Morse (2008) continually emphasise reflective practice as an essential element of this work, and suggest a learning cycle approach towards the selection of indicators in this regard. The indicator selection process for the SI 2007, as developed by De Carvalho (2007), was undertaken in four phases:

- i) Development of selection criteria based on those used for the selection of environmental indicators for use in strategic environmental assessment by Donnelly *et al.* (2007). A precondition was established to ensure that all indicators were compliant with a minimum set of criteria.
- ii) Comparison of indicators with those provided by the World Water Assessment Programme (WWAP) for South Africa.
- iii) Comparative analysis with relevant local (for South Africa and Mozambique) monitoring initiatives.
- iv) Preliminary consultation with water services authority (WSA) staff members during the data collection process.

This step-by-step method of selecting indicators was then expanded to include the notions of reflective practice as promoted by Bell & Morse (2008). An overview of the indicator selection process for this research is highlighted in Figure 4.3 which summarises the convergence / learning cycle approach that was adopted to account for the various different sources of information required for the final selection of indicators. In this approach the identification of possible indicators – including the review of existing indices to identify suitable indicators and variables – was considered along with the information gathered during the participatory process with staff from the WSAs, as well as an assessment of data availability and credibility. This informed the learning cycle for the final identification of indicators (adapted from Bell & Morse, 2008), with predicted outcomes at the various stages of the cycle described as follows:

- *Acting* – sustainability indicators are unpacked and set out in some detail.
- *Reflecting* – stakeholders formulate their sustainability indicators.
- *Connecting* – valid sustainability indicators are formulated across stakeholder groups.

- *Deciding* – indicators are reduced to those which are feasible.

One of the principal intentions of an approach such as this, which incorporates reflective practice and social learning (refer to section 2.6.1.4) into the SIUWM framework, is an attempt to drive improved decision-making capacity so as to apply adaptive management and IUWM concepts at local authority level.

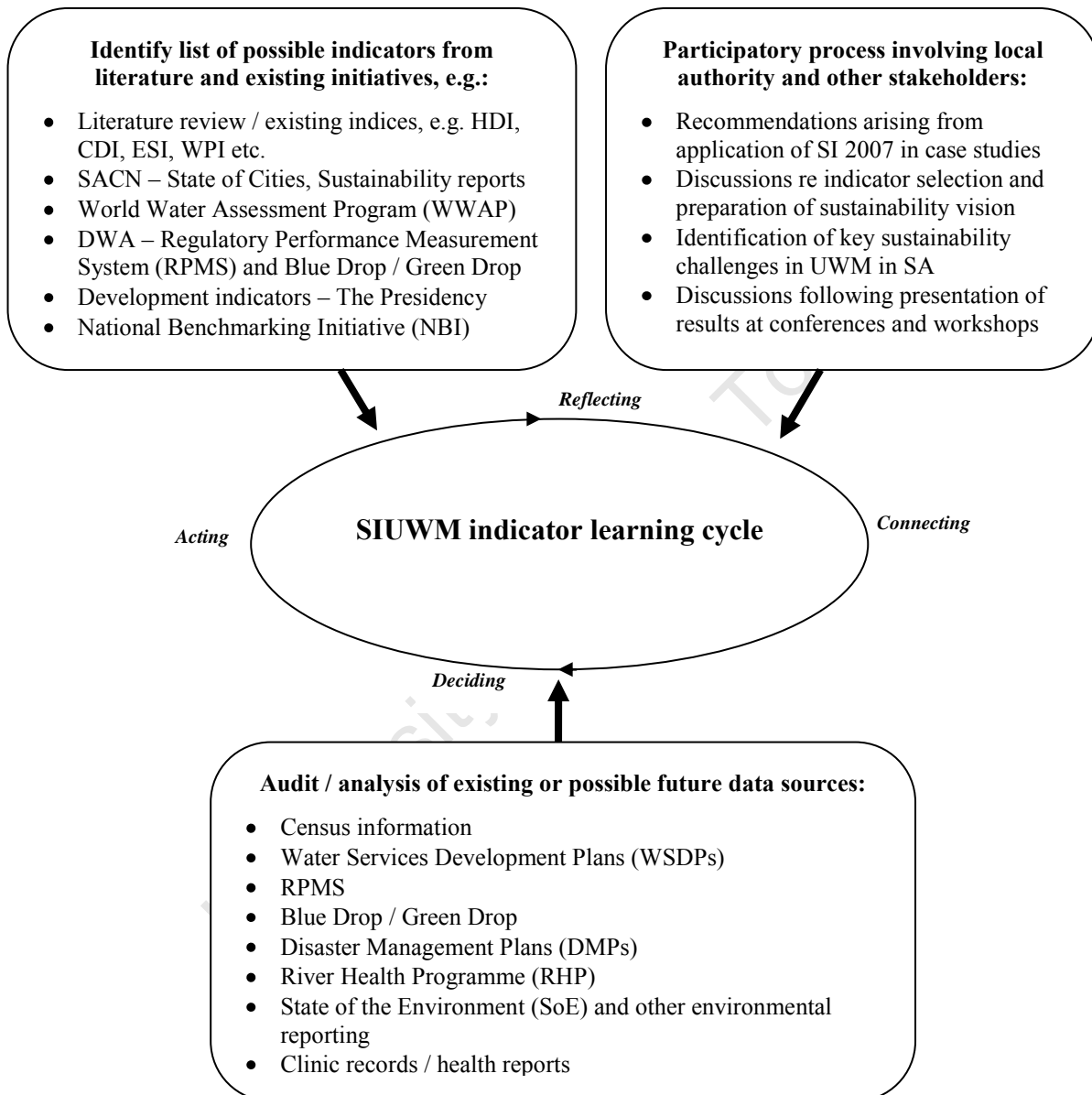


Figure 4.3: Learning cycle approach to determining indicator set for SIUWM

The initial set of indicators selected by De Carvalho (2007) for the SI 2007 are shown in Table 4.1 in order to provide the context for the ensuing discussion on applying the learning cycle approach to the determination of indicators for the SIUWM.

Table 4.1(a): List of components, indicators and variables for SI 2007

Component (5)	Indicator (20)	Variable (64)
1. Social security and cultural acceptability (Social fairness and equitable resource distribution)	1. Access to water supply	1.1 Total collection time
		1.2 Gender bias
		1.3 Conflict over water sources
		1.4 % with access to protected water
	2. Access and use of sanitation facilities	2.1 No. people per sanitation facility
		2.2 Safety of use and safety to access facilities
		2.3 Cultural and social acceptability (type, odour issues, visual and physical contact with excreta)
	3. Levels of Service (LOS)	3.1 Water supply
		3.2 Sanitation
		3.3 Drainage
		3.4 Waste collection
	4. Vulnerability to disasters	4.1 Susceptibility to natural disasters
		4.1.1 Dolines and sinkholes
		4.1.2 Earthquakes
		4.1.3 Droughts
		4.1.4 Tornados
		4.1.5 Cyclones & floods
		4.1.6 Tsunamis or shock waves
		4.1.7 Fires (impact of inadequate water supply)
	4.2 Risk Management and disaster mitigation	
	5. Health (morbidity and mortality)	5.1 Under 5 mortality rate
		5.2 Malaria-related mortality rate
		5.3 Reported cases intestinal / infectious diseases per 1000
		5.4 HIV/AIDS prevalence
	6. Education and awareness	6.1 Level of dissemination (various forms of advertising accessible to all income groups)
		6.2 Level of stakeholder consultation and public participation
2. Economic (Economically sound: economic growth and cost-returns)	7. Capacity (to pay or access services)	7.1 % people with secondary education
		7.2 Unemployment rate
		7.3 Income levels
		7.4 No. of days per year taken off work due to water related diseases (loss of income due to sickness)
		7.5 Minimum / Basic water tariff
	8. Cost Recovery	8.1 % users paying for water
		8.2 % of unaccounted for water (UFW)
		8.3 % of free basic water (FBW)
	9. Investment levels	9.1 % budget increase for water supply
		9.2 % budget increase for sanitation
		9.3 % of budget increase for O&M
		9.4 Sources of investment

Table 4.1(b): List of components, indicators and variables for SI 2007

Component (5)	Indicator (20)	Variable (64)
3. Environmental performance (Environmental protection and preservation of ecological systems)	10. Fresh water resources	10.1 Per capita water availability (l/capita/day)
		10.2 Reliability or variability
		10.3 Water quality at source
	11. Sustainability / Feasibility of water sources	11.1 Sustainability of source
		11.1.1 Local Groundwater
		11.1.2 Rainwater
		11.1.3 Local surface water
		11.1.4 Imported groundwater
		11.1.5 Stormwater
		11.1.6 Greywater
		11.1.7 Imported surface water
		11.1.8 Brackish water
		11.1.9 Treated effluent (wastewater)
	11.1.10 Salt water	
	12. Use (resource distribution per sector)	12.1 Domestic
		12.2 Industrial
		12.3 Agricultural and livestock
12.4 Maintenance of ecosystems		
13. Wastewater management	13.1 Effluent quantity	
	13.2 Effluent quality	
14. Stormwater management	14.1 Effluent quantity	
	14.2 Effluent quality	
15. Compatibility with surrounding environment	15.1 Close to solid waste dump or landfill site	
16. Compatibility of sanitation systems with the surrounding environment	16.1 Located on flood prone area	
	16.2 Steepness	
	16.3 Depth to groundwater table	
	16.4 Soil permeability	
	16.5 Ground stability	
17. Environmental stresses	17.1 % of polluted water sources	
	17.2 % of total area identified as severely water stressed	
4. Political support	18. Governance	18.1 Democracy and representation
		18.2 Measure of corruption
		18.3 Defined roles and responsibilities
	19. Compliance with policy	19.1 Government policies
19.2 MDGs		
5. Institutional capacity and technological progress	20. Institutional and technical capacity	20.1 Adoption of IWRM approach
		20.2 No. of water management institutions
		20.3 Adoption of alternative water supply technologies
		20.4 Adoption of 'sustainable' sanitation
		20.5 Corresponding education levels for O&M
		20.6 Monitoring capability (including issues of data quality)
		20.7 Reliability of service provision
		20.8 Failure in service delivery due to dependence on other sectors (electricity, transport etc.)

4.2.4 Links to existing SA indicator initiatives

A set of indicators should correlate with the level of effort that a city / municipality / water services authority is able to invest in medium to long term in the monitoring and data collection programme (Van der Steen, 2011). Part of the process of identifying a list of possible indicators for the sustainability index was thus a review of selected existing local and national government level benchmarking and/or sustainability assessment initiatives in the South African urban water sector. This had a two-fold purpose: 1) to assess the suitability of existing indicators and 2) to identify possible sources of suitable data for computation of the index. The initial set of SI 2007 indicators as chosen by De Carvalho (2007) was therefore compared to the following initiatives (most of which are described in Section 2.8.6) in order to highlight overlaps between indicator sets and determine possibilities for data gathering:

- i) Department of Water Affairs – Regulatory Performance Measurement System (RPMS) for water services authorities.
- ii) Department of Water Affairs – Blue Drop and Green Drop certification programmes.
- iii) South African Local Government Association (SALGA) and the Water Research Commission of South Africa (WRC) – National benchmarking initiative for water services (NBI).
- iv) SALGA and the Institute for Municipal Engineering of Southern Africa (IMESA) – Electronic water quality monitoring system (eWQMS).
- v) Department of Water Affairs – Municipal strategic self-assessment (MuSSA) and the Water services infrastructure vulnerability and risk assessment tools.
- vi) South African Cities Network (SACN) – State of the Cities reports, City Water Manager’s Forum reports, and feedback from members of the Indicator working group.
- vii) The Presidency – Development Indicators.

Whilst this list shows that a considerable amount of performance assessment is already taking place in the South African urban water sector, the exercise was helpful in highlighting which of these initiatives are being carried out on a regular basis, and what they are being used for; e.g. regulatory purposes, policy review, local-level monitoring and benchmarking. Most importantly, it provided detailed information on what was being measured and highlighted where there were gaps with respect to sustainability reporting. There is substantial overlap between the indicators used in the various processes (described more fully in Chapter 2), although the data sources often differ. The decision was taken to concentrate on the various indicators that are being used for the three Department of Water Affairs’ regulatory initiatives (RPMS / Blue Drop / Green Drop) to compare with those selected for the SIUWM, and in the hope of being able to use their output data in the final index calculation. This was based on the fact that these initiatives have comprehensive, publicly-available data sets that are updated on a regular basis (at least annually). Sections 2.8.6.4 and 2.8.6.5 provide specific detail on the

components and indicators that make up the Blue Drop / Green Drop and RPMS indicator sets respectively, and Appendix C gives more information on how they are used in the scoring system for the SIUWM.

4.2.5 Recommendations arising from trial index applications

A series of case study applications of the trial index and its variations followed after the SI 2007 was developed (De Carvalho, 2007; Hotchkiss, 2008; Makgalemele, 2008; Mrema, 2009; Siboiboi, 2009; Urban, 2009; Mureverwi, 2009), all of which provided recommendations for indicator selection and for furthering the research. These recommendations are given in full in Appendix B, but the main issues that contributed to the development of the final index are summarised in Table 4.2, and will be discussed further in the text that follows.

Table 4.2: Summary of recommendations from case study applications of the SIUWM

Recommendation	Researcher
1. Engage with relevant stakeholders around indicator choice	De Carvalho (2007) Makgalemele (2008) Mureverwi (2009)
2. Vary indicator selection and undertake wider testing of SIUWM	De Carvalho (2007)
3. Address the temporal dimension by tracking progress over time	De Carvalho (2007)
4. Test the issue of scale by applying index at local, city and national level	De Carvalho (2007)
5. Audit availability and quality of existing performance measurement data for input to the SIUWM	De Carvalho (2007) Hotchkiss (2008)
6. Investigate alternative calculation methods	De Carvalho (2007)
7. Combine the Political and Institutional components of the index	Hotchkiss (2008) Mureverwi (2009)
8. Develop weight selection methodology using stakeholder input and statistical analysis	De Carvalho (2007) Mureverwi (2009)
9. Check for duplication of measurement of variables	Hotchkiss (2008)
10. Re-consider categorisation of sustainability score	Hotchkiss (2008)
11. Reduce the number of indicators and/or variables in the index	Urban (2008)
12. Compare with characteristics of (existing) well-known indices	Urban (2008)
13. Ensure developmental focus maintained, i.e. UWM for poverty alleviation	Makgalemele (2008)
14. Design outputs for ease of comprehension (also for non-technical people)	Makgalemele (2008)
15. Extend / adapt index for use in rural areas	Siboiboi (2009)

As shown in Table 4.1, the original SI 2007 comprised five components, 20 indicators and 64 variables (De Carvalho, 2007). The case study applications revealed several inconsistencies with the SI 2007 indicator set, including information overlaps and gaps, inappropriate

indicators, difficulties with data collection etc. Several recommendations were thus made with respect to reducing the overall number of indicators and variables as well as being more strategic about those to be included (Appendix B1). The changes with respect to the inclusion / exclusion of specific indicators from the SI 2007 list were considered together with the evaluation of existing SA benchmarking and measurement initiatives in order to assemble an interim list of indicator choices for the SIUWM (Table 4.3). Yellow shading denotes indicators to be excluded from the original SI 2007 list, and suggestions for inclusion are shaded in red.

Table 4.3(a): Interim SIUWM indicators variables and links to RPMS KPIs

Component	Indicator	Variable	Related RPMS KPI
Social	Access to water supply	Total collection time	
		% gender bias	
		% conflict over water sources	
		% with access to protected water	
	Access and use of sanitation facilities	No. people per sanitation facility	
		Safety of use and access to facilities	
		Cultural and social acceptability	
	Levels of Service	Water supply	
		Sanitation	
		Drainage	
		Solid waste	
		Housing backlogs	
	Vulnerability to disasters	Susceptibility to natural disasters	
		Risk management, disaster mitigation	
	Health (morbidity and mortality)	% Under 5 mortality rate	
		% Malaria-related mortality rate	
		Cases infectious diseases per 1000	
% HIV/AIDS prevalence			
Education and awareness	Level of dissemination		
	Level of stakeholder consultation	KPI 7.2	
	% people with secondary education		
Economic	Capacity (to pay or access services)	% unemployment	
		Majority income bracket	
		Levels of inequality (Gini coefficient)	
		Average debtor days WATSAN	KPI 9.2
		Ave number days off work per person	
		Minimum basic water tariff	
	Cost Recovery	% users paying for water	KPI 9.6
		% unaccounted for water (UFW)	KPI 11.1
		Income generated vs. income received	KPI 9.3
		Cost of water supply to LA (R/kℓ)	KPI 9.5
	Investment levels	% budget increase for water supply	KPI 1.3
		% budget increase for sanitation	KPI 2.3
		% of budget increase for O&M	KPI 10.2
		Sources of investment	KPI 8.3
Asset management		KPI 10.1	
Asset register monitoring		KPI 10.5	

Table 4.3(b): Interim SIUWM indicators variables and links to RPMS KPIs

Component	Indicator	Variable	Related RPMS KPI	
Environmental	Fresh water Resources	Per capita water availability (l/c.d)		
		% reliability or variability		
		Water quality at source		
		Demand – annual population growth rate		
		Potable water quality / Blue Drop	KPI 5.1	
	Sustainability / Feasibility of water sources	% contribution to supply per water sources		
		Resource quality (River Health Index)		
		Quality of groundwater resource		
		Energy consumption by local water sector		
		Climate change strategic planning		
	Use (resource distribution per sector)	Domestic demand (l/c/d)		
		% Industrial use		
		Agricultural and livestock demand (l/c/d)		
		% Maintenance of ecosystems use		
	Wastewater management	Effluent quantity (l/c/d)		
		Effluent quality		
		Green Drop score	KPI 6.1	
	Stormwater management	Stormwater policy - WSUD implementation		
		Effluent quantity		
	Water / environment	Sanitation systems and surrounding environment	Effluent quantity	
			Effluent quality	
		Environmental stresses	Proximity to landfill site	
			Located on flood prone area	
Steepness				
Depth to groundwater table				
Soil permeability				
Ground stability				
% of polluted water sources				
% total area severely water stressed				
Political	Governance	Democracy and representation		
		Effectiveness of planning/ EIA processes		
		Measure of corruption		
		Defined roles and responsibilities	KPI 8.2	
	Compliance with policy	Government policies		
		WSDP, relevant policies and by-laws	KPI 8.1	
		MDGs		
		Access to water (MDG targets)	KPI 1.1 / 1.2	
		Access to sanitation (MDG targets)	KPI 2.1 / 2.2	
		Access to free basic water (FBW)	KPI 3.1	
Access to free basic sanitation (FBS)	KPI 4.1			
Institutional	Institutional and technical capacity	Level of IWRM implementation		
		No. of water management institutions		
		Integration between UWM departments		
		% water supply by alt technologies		
		% sustainable sanitation practiced		
		Appropriate training for O&M		
		Municipal staffing / capability	KPI 8.5	
		Monitoring capability - score out of 10	KPI 8.4	
		% reliability of service provision		
Incidents service delivery failures p.a.	KPI 7.1			

Table 4.3 also gives an indication of the links between the SIUWM indicators and the various components that make up the key performance indicators for the DWA Regulatory Performance Measurement System for water services (RPMS). It is worth noting that while certain indicators correlate well, there are several areas considered to be crucial in sustainability assessment (mainly social and environmental aspects, e.g. health, development issues; poverty; lack of housing, river health, stormwater etc.) which are not covered in the RPMS. These aspects were also identified in the sustainability visioning process (detailed in Section 4.2.6) thus highlighting the importance of including them in the final list of indicators.

4.2.6 Vision of sustainability in a South African urban water context

As mentioned previously, an important part of the process of selecting indicators to assess urban water systems is agreement on a shared vision of sustainability, and specifically on what kind of water system is required to meet the challenges of *inter alia* population growth, increased pollution and climate change. Bell & Morse (2008) note that the idea of measuring sustainability in absolute, traditional, and reductionist terms – as attempted through the use of sustainability indicators – runs the risk of oversimplifying complexity and reducing relevant views to the dominant mindset of the developer, owing to the fact that sustainability itself is not a single element. The key premise is that “...*the approach to measurement is always based on a vision of sustainability, which in turn can be changed depending upon the measurement mindset*” (Bell & Morse, 2008).

In a similar way to the Learning Alliance process being used as part of the SWITCH project (see Section 2.6.2) for strategic planning purposes (Howe & Van der Steen, 2008), the visioning exercise for this research was used to establish sustainability objectives for the various cities, and thereafter identify various indicators against which progress could be measured. In this regard, the visioning process helped to:

- Encourage constructive discussion and promote active involvement and forward thinking of stakeholders.
- Provide targets or benchmarks against which success or failure can be measured.
- Compile a statement of intent with respect to sustainable urban water management.

The Africa Water Vision for 2025 was used as a starting point for considering a sustainability vision for the urban water sector. This was developed by UN-Water in an attempt to support the equitable and sustainable use of water for socioeconomic development in Africa in the face of threats such as extreme climate variability, growing water scarcity, environmental degradation, inappropriate governance, and unsustainable financing of investments in water supply and sanitation (UN-Water, 2004). It is thus a shared vision for “*an Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment*”, including, *inter alia*:

- i) Sustainable access to safe and adequate water supply and sanitation for all.

- ii) Sufficient water for food and energy security.
- iii) Adequate water (quantity and quality) for sustaining ecosystems and biodiversity.
- iv) Adequate numbers of highly skilled and motivated water professionals.
- v) An enabling environment for effective and integrated management of water (by way of institutional reform and the development of national policies).
- vi) A financially sustainable system for data collection, assessment and dissemination.
- vii) Effective and sustainable strategies for addressing water resources issues, e.g. from climate change.
- viii) The promotion of equity, efficiency and sustainability through appropriate financing and pricing of water.

The Africa Water Vision 2025 thus provides overall objectives for sustainable water resources at a national level, as does the recently published vision for Water Resources and Services for 2030 by the National Planning Commission in the SA Presidency (RSA, 2011b). This document also focuses on the alignment of the country's social and economic development with available water resources, and the protection of the natural environment through the prevention of excessive abstraction and pollution. These aspects need to be contextualised for urban water management systems, however, so that it is possible to establish what sustainability means to UWM decision-makers. Employees of water services utilities, local authorities and other stakeholders most knowledgeable about local conditions are best suited to not only determine a vision for sustainability, but also to compiling the necessary data to assess performance towards achieving this vision. As noted by Pahl-Wostl *et al.* (2011), in terms of a water management paradigm, "...the respective epistemic community of actors possesses a shared mental model with respect to the nature of the system to be managed, the management goals and the way the goals may be achieved".

A sustainability vision for South African water services was drafted as part of this research through the use of participatory interview processes with stakeholders at several of the larger municipalities in South Africa. Comparisons with other sustainability assessment efforts, such as that done by the South African Cities Network (e.g. SACN, 2011) for the State of the Cities reporting, and various other water services indicator initiatives were also undertaken. Information on themes and programmes such as service delivery, cost recovery, and skills – as supplied through municipal documents like the Water Services Development Plans (WSDPs) and Integrated Development Plans (IDPs) – was also extremely useful for defining the vision. Table 4.4 summarises the results of discussions with municipal stakeholders regarding a vision of sustainability in the water sector, and also highlights specific obstacles and/or challenges to achieving this. See Appendix A for a list of the types of questions posed as well as transcripts of the discussions with local authority officials about the notion of sustainability in urban water management in SA.

Table 4.4: Summary of discussions with municipal officials towards establishing a vision of sustainability in the SA water sector

City	Sustainability vision	Obstacles / Challenges
Johannesburg	<ul style="list-style-type: none"> • Total water balance management • Linking water conservation strategies to pollution / flooding • Integrated management systems 	<ul style="list-style-type: none"> • Stormwater management • Water quality monitoring / poor river health • Governance model • Service delivery backlogs • Skills / capacity • Capacity at WWTWs • Lack of integration between departments
Tshwane	<ul style="list-style-type: none"> • Establishment of an operational, ring-fenced WATSAN business unit • Ensure no development within floodplain • Eradication of informal settlements and access to services for all • Ability to respond to impacts of climate change 	<ul style="list-style-type: none"> • Stormwater planning (not seen as a basic service) • Water losses • Institutional structures, including town planning processes, environmental requirements and procurement processes • Funding for O & M and Stormwater • Skills / capacity • Political deadlines • Separation of service delivery functions (lack of integration) • Stormwater pollution impacts on rivers, groundwater pollution (from services backlogs)
Cape Town	<ul style="list-style-type: none"> • Good governance / planning • Supportive and enabling legislation and budgetary frameworks • Ownership and a willingness / ability to pay for services • Environmental stability, incl. beyond the City limits • Infrastructure integrity • Inter-governmental economic arrangements and regional planning • Guiding documentation on corporate strategy / supportive policies • Water resource optimisation and climate change strategies 	<ul style="list-style-type: none"> • Education and literacy levels / communication with residents and stakeholders • Inadequacy of financial resources for capital projects as well as O & M; cost recovery • Government structures, political dynamics • Lack of integration of different departments (particularly stormwater) • Size of the City, growth / demand for resources and services • Stormwater policy implementation (esp. WSUD) • Poor river and sea water quality; pollution impacts from service backlogs and sewage overflows • Skills shortages / lack of capacity • Informal settlements, backyard dwellings • Security of water supply / NRW
eThekweni	<ul style="list-style-type: none"> • Total water balance management – including recycling options • Partnerships between three spheres of government (“Raising Citizen’s Voice”) • Conducive and creative working conditions for municipal officials • Collaboration between municipality and research institutions • Integrated planning and provision of services 	<ul style="list-style-type: none"> • Non-Revenue Water / water losses from illegal connections etc. • Lack of integration and communication: intra and inter-departmentally • EIA processes • Staff skills shortages / time spent on non-technical matters / capacity / continuity • Poor development decisions - policy dictates planning • Low payment levels (debt relief programmes) • Planning horizons too short term; need more defined forward planning • River quality; pollution impacts of service backlogs • Stormwater management • Water resources yield being exceeded • Alignment of budgets / procurement processes • Informal settlements upgrading

The list of questions shown in Appendix A1 highlights the fact that the interviews with municipal officials were an attempt to ascertain their qualitative views on how cities could provide water supply, sanitation and drainage services whilst conserving resources and minimising pollution of the natural environment. In this regard, one of the first questions posed to officials was “What are the defining features of a sustainable urban water system, and what currently are the biggest obstacles / challenges to achieving this?” The issues they raised were summarised and transposed onto the interdependent systems model system diagram (discussed in Section 4.1.1), to depict a vision of sustainability in the SA water sector (Figure 4.4).

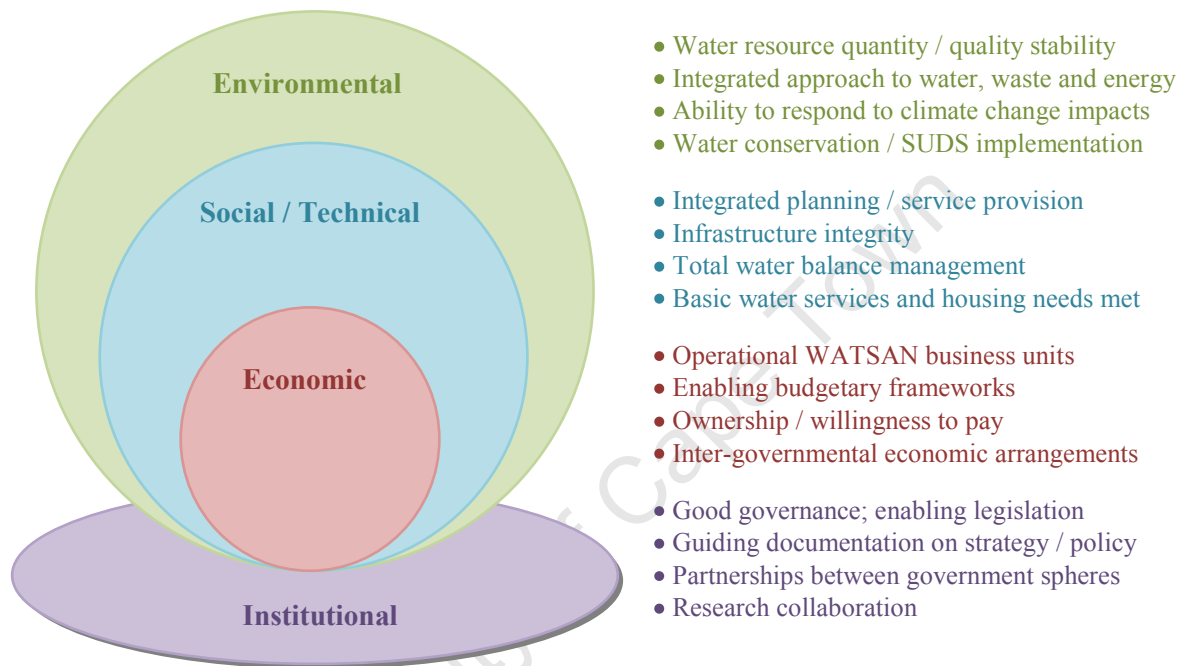


Figure 4.4: Vision of sustainability in urban water management in South African cities

When the various obstacles to sustainability were compared across municipalities and considered together with the outputs from the Africa Water Vision process, the general nature of sustainability issues in the water sector became clear (Table 4.5); i.e. it began to highlight major areas of ‘unsustainability’. Thus, in the case of urban water management in South Africa, the systems framework was linked to the fundamental outcomes of sustainable UWM in order to highlight important indicators. This also required regrouping of key indicators that ‘speak’ to the analytical framework, i.e. determine the key aspects that drive integrated urban water management.

Table 4.5: Challenges to and a vision of sustainability in the water sector – comparative viewpoints

Comments	Johannesburg	Tshwane	Cape Town	eThekweni	Africa Water Vision
Challenges	Stormwater management / climate change planning	Stormwater / climate change planning	Stormwater policy / climate change planning	Stormwater management / climate change planning	Climate change
	Water quality monitoring / river health	Pollution impacts on rivers / groundwater	River / sea quality	River / sea quality	Sustaining ecosystems / biodiversity
	Governance model; institutional capacity	Institutional structures; planning, procurement	Governance structures, technical capacity; politics	Governance model - EIA / planning / procurement	Institutional environments
	Skills / capacity	Skills / capacity	Skills / capacity	Skills / capacity / staffing	Skills / capacity
	Lack of integration	Lack of integration	Lack of integration	Lack of integration	-
	Service delivery	Service backlogs	Service backlogs	Service backlogs	Access to services
	Capacity at WWTWs	-	Demand for resources	Water resources yield	Water security
	-	Political deadlines	-	Poor development decisions	Political will for WRM
	-	Funding	Inadequate financial resources; cost recovery	Budgeting, payment levels	Financing and pricing
	-	Water losses	Security of supply / NRW	NRW / water losses	-
	-	-	Informal settlements	Informal settlements	-
-	-	Education / communication	-	-	
Vision	Total water management	Operational, ring-fenced WATSAN business unit	Good governance; infrastructure integrity	Total water management	Strengthened governance structures
	Water conservation; climate change strategies	Ability to respond to climate change impacts	Environmental stability, climate change strategies	Collaboration - municipality and research institutions	Improved water 'wisdom' -
	Integrated management systems	-	Inter-governmental economics / planning.	Integrated planning and partnerships	Enhanced financial base for desired water future
	-	No development within floodplain	Guiding documentation on corporate strategy / policy	Conducive working conditions	-
	-	No informal settlements; access to services	Ownership, ability to pay for services	-	Urgent water needs met

A framework for achieving this ‘shared’ vision of sustainability could then be developed to depict the challenges in urban water management and thus determine what the leverage points are in moving towards urban water sustainability. This framework, as adapted from Jerneck *et al.* (2011), was based on the four broad components of the sustainability vision in order to be able to inform and identify indicators for the sustainability index and comprises the following (Figure 4.5):

- 4 sustainability challenges:** Environmental; Socio-technical; Economic; Institutional / Political.
- 3 core themes:** Understanding of causes and effects and choice of indicators; Establishment of sustainability goals and targets; Recommendations on policy and performance measurement.
- 1 cross-cutting approach:** Critical research.

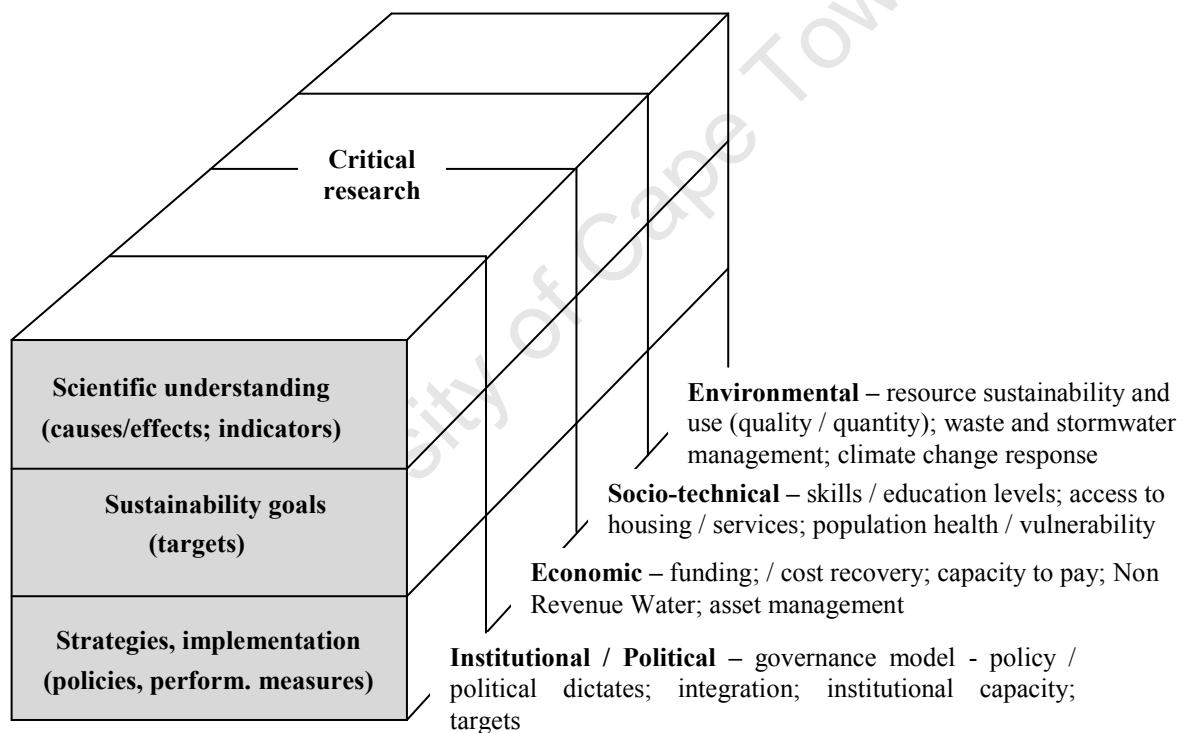


Figure 4.5: Framework to describe sustainability challenges in urban water management and identify sustainability indicators (adapted from Jerneck *et al.*, 2011)

The sustainability challenges that were highlighted during the discussions with city officials provided the basis for the core set of indicators for use in the SIUWM, and contributed to an increased understanding of the various drivers and impacts in the urban water services context in SA. By placing indicators within a causality-issue matrix (as shown in the DPSIR linkage

diagram for urban water management in SA in Section 2.6.1.2), the cause-effect relationships and interconnections between the variables become clearer. This is important as different types of indicators are found in the cause-effect chain, and aggregation should only take place with independent indicators at the same step in the chain (UN-DESA, 2005; Giné Garriga & Perez Foguet, 2010). A cause-effect analysis is thus a critical step in the selection of indicators to ensure this independence.

The framework highlights the fact that sustainability assessment is not just about selecting indicators. The remaining two themes – sustainability goals and targets, and policy and performance measurement – show that the visioning process which is used to establish objectives, and the regulatory and benchmarking initiatives which inform the monitoring process as well as policy development, are both essential elements for an integrated sustainability analysis such as this.

4.2.7 Audit / analysis of existing or possible future data sources

Part of the process of selecting indicators was an ongoing audit of potential data sources for the index calculation. Whilst it was acknowledged that at least some of the information required was only going to be available through interviewing relevant local authority officials, it was hoped that the bulk of the data would be freely accessible and widely published; i.e. in the public domain.

As discussed previously, for indicators to be legitimate in terms of assessing sustainability, it is crucial that their data sets have sustainability monitoring as their primary purpose (Davidson, 2010). This is particularly relevant in monitoring systems used to inform policy development – Spangenberg *et al.* (2002) suggest that reliance on data collected for other purposes limits the ability of policy makers to take proactive action to address potential threats to sustainability. For this reason, the following sources of data were investigated for their suitability as they are all relevant to sustainability in urban water systems in SA: Census, Water Services Development Plans (WSDPs), RPMS, Blue Drop / Green Drop, Disaster Management Plans (DMPs), River Health Programme (RHP) reports, State of the Environment (SoE) and other environmental reporting, and Clinic records / health reports.

4.2.8 Final indicators for the SIUWM

All of the above steps were used to cross-check the variables against one another so as to ensure a comprehensive list of indicators that would be able to assess sustainability with as few overlaps as possible. Table 4.6 lists this final list of indicators for the SIUWM and Figure 4.6 shows the index framework, highlighting the relationship between components, indicators and variables in the SIUWM.

Detailed information on the background to and reasons for the selection of specific variables and the ranking / scoring process that was adopted for the computation of the index can be found in Appendix C.

Table 4.6: Final list of indicators and variables for SIUWM

Component (4)	Indicator (16)	Variable (35)
Social	1. Levels of Service	1.1 LOS Water supply
		1.2 LOS Sanitation
		1.3 LOS Solid waste collection
		1.4 LOS Drainage
	2. Health	2.1 Under 5 mortality rate
		2.2 HIV/AIDS prevalence
	3. Vulnerability	3.1 % population living in informal dwellings
		3.2 Risk management / disaster mitigation
	4. Skills and awareness levels	4.1 Customer service standards
		4.2 Secondary education levels
Economic	5. Capacity to pay or access services	5.1 Unemployment rate
		5.2 Levels of inequality (Gini coefficient)
	6. Cost recovery / funding	6.1 WSA financial performance
		6.2 Water use efficiency / NRW
	7. Asset management	7.1 Strategic asset management
Environmental	8. Resource sustainability / feasibility (quantity)	8.1 Per capita water availability
		8.2 Sustainability of source
		8.3 Demand for water resources (average population growth rate)
	9. Sustainability of water resources (quality)	9.1 Potable water quality (Blue Drop)
		9.2 Water resource quality (River health)
		9.3 Groundwater quality
	10. Climate change response	10.1 Energy consumption by water sector
		10.2 Climate change strategic planning
	11. Use (resource distribution per sector)	11.1 Domestic water demand
		11.2 Industrial water demand
		11.3 Ecosystems water demand
12. Wastewater management	12.1 Wastewater quality (Green Drop)	
13. Stormwater management	13.1 WSUD / SuDS policy and implementation	
Institutional	14. Governance model	14.1 Defined roles and responsibilities
		14.2 Departmental integration
	15. Progress with meeting targets (MDGs etc.)	15.1 Access to water supply
		15.2 Access to sanitation
		15.3 Access to Free Basic Water (FBW)
	16. Institutional capacity / policies	16.1 WDM policy / IUWM approach
16.2 Institutional effectiveness		

As will be described in further detail in Chapter 5 which deals with issues concerning the application of the index, significant difficulties were encountered in initiating discussions on, and obtaining data for, the two variables that were selected for the Climate change response indicator ('Energy consumption by water sector' and 'Climate change strategic planning').

Energy utilisation at water and wastewater treatment plants in South Africa is not routinely tracked at present, and the variable levels of energy consumption across the water services supply chain makes it difficult to model energy utilisation at a local level (as noted in Section 2.8.3; see also Winter, 2011). Whilst the inclusion of climate change impacts is deemed crucial for an analysis of sustainability in the urban water sector, the decision was ultimately taken to exclude these two variables from the index calculation at this stage, with the option of including them later as more information becomes available in this regard.

All current (2010 / 2011 year of assessment) RPMS KPIs were included in the case study analysis except for KPI 4 (Access to Free Basic Sanitation) as this is not yet being enforced by the Department of Water Affairs, and not all municipalities have the programme in place. This could also be added at a later stage to Indicator 15 – Progress with meeting targets.

The above sections have highlighted the process that was followed in order to determine a set of indicators for a sustainability analysis that is linked to a vision of urban water services now and into the future. As noted previously, this process remains a work in progress as it is likely that the vision will be refined over time and this could prompt the selection of additional and/or different indicators for the analysis. To keep the process connected to current assessment initiatives, it should be linked to both the annual RPMS assessment as well as other systems attempting to improve the management of urban water services in South Africa. One of these is the Municipal Strategic Self-Assessment (MuSSA) initiative, described in Section 2.8.6.3, which requires local authorities to highlight problem areas and consider improvements where possible (Wensley, 2011). This form of ongoing self-evaluation by Water Services Authorities could be used to inform the visioning process for sustainability assessment.

The construction of composite indicators involves making choices and this introduces various issues of uncertainty including: selection of variables and data, imprecision of and missing data, imputation methods, normalization, weighting and aggregation, and performance testing (Khatri *et al.*, 2011; Singh *et al.*, 2009; Yale, 2005). As has been discussed, while absolute measures of sustainability are not achievable, many aspects can be measured on a relative basis over time, with results that provide a context for policy evaluations. The following sections will attempt to address these issues.

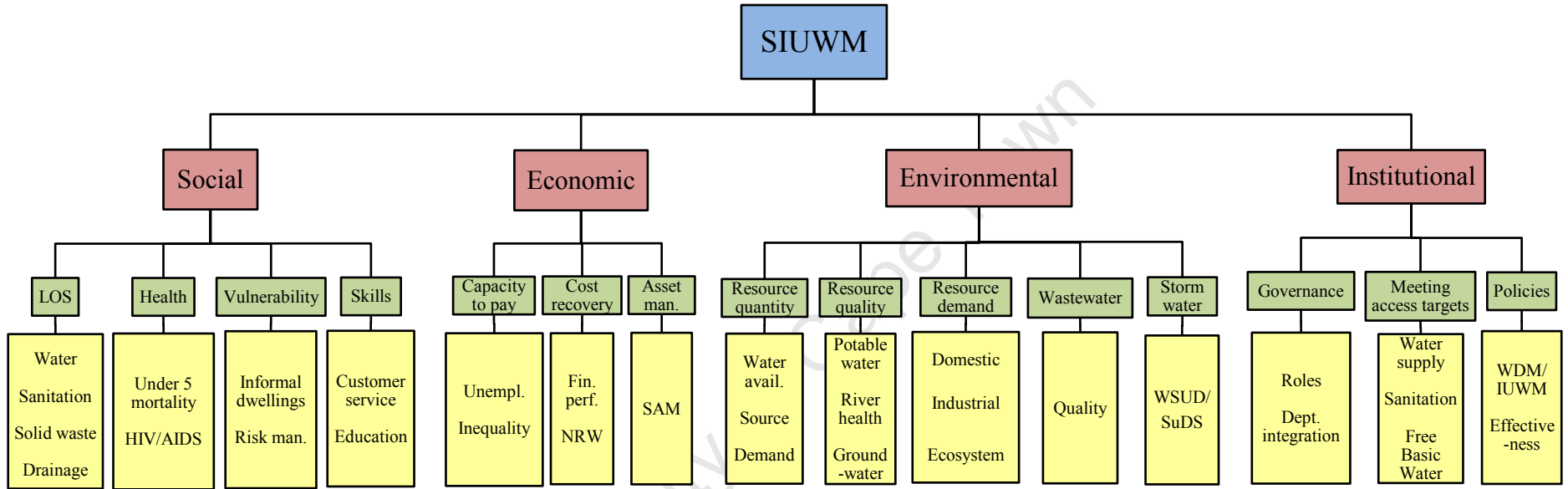


Figure 4.6: Relationship between SIUWM components, indicators and variables

4.3 Data selection and standardisation

The collection of valid data for a sustainability assessment exercise such as this is a major issue for concern. The main problems encountered during this research effort will be discussed separately in Chapter 5, together with a critique of the composite index approach that was employed, so will not be covered in this section. Suffice to say that the decision was taken to make use of as much readily available, published data as possible; and to try and link this to existing performance measurement initiatives in the SA urban water sector.

South Africa has the advantage of a fairly sophisticated system for collecting and disseminating (mostly) national data through Statistics SA, complemented by other public and private organisations that produce and analyse data. Some data are not available at adequate levels of disaggregation however, and updating is often infrequent. From a water services perspective the Department of Water Affairs maintains a web-based Water Services National Information System (WSNIS) and this is a good source of comprehensive data on water services provision throughout the country, even though there are some doubts as to the accuracy of some of the information quoted. As noted previously though, there are several existing monitoring initiatives in SA which publish regularly-updated and relatively easily-accessible data which can be used in the assessment process. Appendix D provides a list of all of the data sources that were identified for the SIUWM variables.

4.3.1 Normalisation and standardisation

The SIUWM aggregates multiple and diverse variables, and it is often the case that these variables are measured and represented in irreconcilable units. It is therefore necessary that the data be standardised according to a set and comparable frame of reference. This is required in order to remove the scale effects of different units of measurement without changing the relative distances between observations. There are a number of techniques which achieve this and, in the testing phase of the SI 2007, various methods were explored (as per Nardo *et al.*, 2008), with the Categorical Scale technique ultimately employed for the standardisation process (De Carvalho, 2007):

- *Categorical scale:* In a categorical scale approach, scores are assigned to individual indicators or the lowest level of measurement, in this case the variables. These categorical scores can be either quantitative, e.g. a score from 0-100, or qualitative, e.g. assessing on the basis of good, adequate, or poor. This gives an idea of absolute performances but, depending on the scale chosen, can obscure significant differences across variables and within indicators. Variations might not be significant in terms of the overall score but become problematic if these produce a change in the final rankings.
- *Ranking:* This method enables a relative measure of the performance of city or study area based on a pre-established best-case. While it is not possible to assess performance in absolute terms, the benchmarking exercise enables cross-area comparisons, both

provoking responses and stimulating change. This approach becomes relevant when similarly performing countries are grouped around clusters and their similarities and dissimilarities are highlighted.

- *Distance to reference:* The distance to reference approach establishes the performance of a city in reference to a pre-determined fixed target. It is a measurement in reference to a proposed ideal outcome, and as a result may enable an incremental movement towards that fixed end-point.
- *Comparison to mean:* The method involves the determination of the mean value, to which all other values are then compared. The mean value receives a 0 score and indicators above and below the mean receive 1 and -1 accordingly. While favourable for its simplicity, this approach fails to recognise the degree to which areas are under or over-performing, i.e. while Case A might be performing seven times better than Case B, both will be scored equally.

Ultimately there are limitations to the use of any of the above techniques. It was resolved that the indicator conversion should employ a categorical scale normalisation approach, where all indicators were to be scored on a 0 – 5 scale. The majority of the categorical scales were selected on the basis of pre-established reference points, standards or rules, i.e. wastewater quality criteria, guidelines provided by the World Health Organisation, and others. However, where literature, expert opinion or personal knowledge were not sufficiently clear, subjective scales were selected – attempting to balance the distribution between endpoints. The higher the score for a variable, the better it performs towards sustainability in urban water systems. Appendix C provides a detailed discussion on the standardisation of each variable.

4.4 Weighting and aggregation of component scores

The way in which composite indices are constructed has a profound impact on the consistency of the sustainability assessment process. In particular, the selection of weights and the method of aggregation of component scores contribute to the overall quality of the analysis. The choice of weights can reflect the importance given to the variables comprising the index or the substitution rates between them. In other instances, weights are used to adjust for unequal variances of the variables, and hence their unequal levels of certainty. The specification of the weights is thus an integral part of index development (Yale, 2005). Ideally composite indices should remain relatively simple in terms of their construction and interpretation, and the aggregation process must be completely transparent. They also require validating in order to improve the quality of the final index.

4.4.1 Weighting

One of the major complexities when aggregating information into indices, is how to establish a weighting system that integrates data without losing its meaning or becoming too subjective.

This complexity increases when evaluating sustainable development due to the different aspects (UN-DESA, 2005). In composite indices, the choice of weights can reflect the importance given to the variables comprising the index or the substitution rates between them (Yale, 2005). Decisions have to be taken on weighting systems and the methods employed in aggregating component scores into one composite index result. In addition to the implicit weights introduced during scaling, explicit weights may be introduced during aggregation although the first option is generally not to employ explicit weights. After weights have been assigned to each component index and the component scores weighted accordingly, the scores are aggregated into a composite score. There are three main approaches to indicator weight determination, and a number of methods associated with each. The first is an application of equal weights, the second enables weight allocation using statistical methods such as Principal Components Analysis (see Glossary of terms), and the third is dependent on consultation and stakeholder participation (De Carvalho, 2007). These opinion-based methods include bringing together experts and practitioners in the field concerned (Budget Allocation), extensive public consultation processes (Public Opinion), preference-based surveys (Conjoint Analysis), and the ranking of indicators on the basis of quantitative / qualitative assessments (Analytical Hierarchy Processes, AHP).

During the testing process of the initial index, the SI 2007, various weighting systems were applied in order to check for variation in the resulting composite scores. A balanced equal weighting system was applied to all components and variables so as to establish an initial base situation. Thereafter, an unbalanced equal weighting system was used, followed by five additional sets of subjective weightings in line with the dimensions of sustainability represented in the index, to introduce the desired biases towards certain issues. The determination of the subjective weightings was achieved through a combination of statistical analysis and stakeholder consultation – ultimately a ranking approach was adopted in which variables were ranked within their indicator category and then assigned corresponding scores. However, De Carvalho (2007) acknowledged that there were “*many more possibilities which went unexplored*”. The intention of the subjective weighting was to propose various different schemes which could highlight progress along the various dimensions of sustainability, rewarding those areas which perform better with regard to one or more of these dimensions. The aggregation process for the SI 2007 was followed by a sensitivity analysis in order to determine the stability and effect of the different weighting assumptions on the final results. It was found that the use of different weighting sets resulted in slight variances in the scores at both index and sub-aggregate levels, but had little impact on the overall scores (see De Carvalho, 2007).

Variable, indicator and component weighting is always an issue for debate and as such generates significant criticism. This is because spatial and temporal priorities will ultimately inform the importance given to one or another aspect of the indicator, but also because weights are determined by ‘few’ on matters that affect ‘many’ (De Carvalho, 2007). It is therefore not possible to say with certainty that one set is more appropriate than another. Statistically determined weights have the advantage that they apply a neutral and data-reliant weighting.

However, statistical weights do not always reflect the priorities of decision-makers or the budget constraints that limit free choice among a range of policy options (Yale, 2005). When the objective is to design the best possible index, considerations of the most advanced statistical techniques available are important. On the other hand, if transparency and easy understanding by non-experts are equally important, as is presumed in this case, the logical framework of the ESI represents a useful and valid alternative. The suggestion is that where possible, both statistical analysis and stakeholder consultation be employed to determine appropriate weights. This will be discussed in further detail in Section 5.1.2.

Munda & Nardo (2005) claim that a theoretical inconsistency exists between the real meaning of weights and the meaning that is generally attributed to them in the standard practice of constructing composite indices. Common practice relates to greater weight being given to components which are considered to be more significant in the context of the particular composite index (OECD, 2003). Munda & Nardo (2005) argue, however, that this practice of using weights as importance coefficients is not defensible on theoretical grounds based on the fact that weights are connected to the values of trade-offs and dependent on the scales of measurement. They note that the use of non-compensatory aggregation rules is thus more desirable if weights are to be considered.

The argument for the use of equal indicator and variable weights in the Environmental Sustainability Index (ESI) is based on the premise that no objective mechanism exists to determine the relative importance of the different aspects of urban water sustainability; it is thus a neutral and justifiable allocation of importance across all indicators (Yale, 2005). Due to the fact that the SIUWM is loosely based on the ESI, and because the subjective weighting schemes used in the SI 2007 testing process were found to have little appreciable impact on the overall sustainability scores (De Carvalho, 2007), the decision was finally taken to adopt an equally weighted variable and indicator structure. As will be discussed further in later sections, this decision was also based on the aggregation methods adopted, as well as the fact that the data from the RPMS and Blue Drop systems that was used in the analysis, is already weighted average data (combined as a final score per indicator). The SIUWM spreadsheet (refer to enclosed CD for the Excel spreadsheet) has however been designed such that it is possible to change the weighting options at different levels of the analysis in order to observe the effects on the aggregated index if required. As with the ESI, the interactive spreadsheet format also allows the user to alter the values of variables themselves so as to observe the impact on the SIUWM for the purpose of scenario analysis.

4.4.2 Aggregation into a composite score

Composite indices are aggregations of sets of variables / indicators for the purpose of meaningfully condensing large amounts of information. Various aggregation methods exist and the choice of an appropriate method depends on the purpose of the composite indicator as well as the nature of the subject being measured (Yale, 2005). Aggregation tends to be of either an additive (weighted sum, in the form of an average) or functional (weighted geometric mean)

nature; in standard practice a composite index is considered to be a weighted linear aggregation rule applied to a set of variables. In the SI 2007, the overall sustainability index score for a particular city was calculated as the sum of all the weighted components (Equation 4.1). Variables and sub-indicators were aggregated in the same manner as components. The standardised value of each variable X_i , was multiplied by the attributed weight, $w_{x,i}$, to give a value on a scale of 0 – 5. The scores for the indicators and components were determined as the weighted average (arithmetic mean) of the variable and indicator values respectively.

$$SI\ 2007 = \frac{\sum_{i=1}^N w_{x,i} X_i}{\sum_{i=1}^N w_{x,i}} \quad (\text{Equation 4.1})$$

The overall SI 2007 score was then calculated as the arithmetic mean of the five component scores, all expressed as percentages by dividing by 5 and multiplying by 100. To account for all 5 dimensions (components) of sustainability the formula is as shown in Equation 4.2.

$$SI_i = \frac{w_s S + w_e E + w_{ev} EV + w_p P + w_i I}{w_s, w_e, w_{ev}, w_p, w_i} \quad (\text{Equation 4.2})$$

(with SI_i expressed as a percentage. S = Social; E = Economic; EV = Environmental; P = Political; I = Institutional. The symbols: $w_s, w_e, w_{ev}, w_p, w_i$ represent the weights for the 5 components)

Weighted summations, in the form of averages, are not necessarily scale invariant, and the aggregation therefore requires that all variables are on the same scale; i.e. normalisation is necessary to remove the different units of measurement without changing the relative distances between observations. This method of summing up weighted and normalised sub-components is very common, mainly for its simplicity in aggregation and representation of multiple issues. There are however some shortcomings; for example, the quality and relevance of the composite index depends largely on the quality of the underlying indicator framework, the compound sub-indicators and components, their unit of measurement and the overall interpretation of their importance (weights) within the composite index. Furthermore, indicator incommensurability can render the results obtained unrealistic or irrelevant. Finally, there is also the issue of presupposed compensability where it is assumed that independent of the variability of the underlying components, if the final scores for two cases are equal then their performances are equal. There is an assumed equality derived from very particular inequalities (Nardo *et al.*, 2008). This is illustrated in the component results (scores between 0.1 and 5.0, as well as the equivalent percentages) for the hypothetical examples shown in Table 4.7, using the same components developed for the SI 2007 for City A and City B: social, economic, environmental, political and institutional.

The composite index scores using the arithmetic mean calculation are the same; however the two settings represent very different socio-economic, political and environmental scenarios

– as is evident from their different scores – suggesting that caution be taken when interpreting the overall index results. This is particularly relevant for those cases where one component scores much higher (or lower) than all the others. In these instances an alternative method of determining the composite score may be required to incorporate the differences.

Table 4.7: Examples of SI 2007 component scores

Component	Component score (%)	
	City A	City B
Social	1.5 (30%)	2.0 (60%)
Economic	5.0 (100%)	1.5 (50%)
Environmental	1.5 (30%)	2.5 (50%)
Political	1.0 (20%)	2.0 (40%)
Institutional	1.0 (20%)	2.0 (40%)
Index score – arithmetic mean	2.0 (40%)	2.0 (40%)
Index score – geometric mean	1.62 (32%)	1.97 (40%)

Means are mathematical formulations used to characterise the central tendency of a set of numbers (arithmetic mean = average). The geometric mean is the average of the logarithmic values of a data set, converted back to base 10 numbers; i.e. the n^{th} root of the product of n numbers. Using geometric means (vs. arithmetic) tends to dampen the effect of low or high values which might bias the mean if a straight average was calculated (Böhringer & Jochem, 2005). In the example shown in Table 4.7, the index score derived from the geometric mean calculation is a more realistic representation of the aggregation of the range of scores for the components. This is particularly the case for City A where the 100% score for the Economic component has the potential to bias the overall index score. In general, arithmetic means are sum-based, i.e. appropriate for additive processes; whereas geometric means are product-based, for use in multiplicative processes. Linear weighted summation implies that the variables are preferentially independent, i.e. there are no synergistic or antagonistic effects among the variables (Yale, 2005). It can be argued that this is not a realistic assumption for the type of data that is being used in a sustainability analysis of this nature. Given, for example, the proven synergistic relationships between health status and levels of service (amongst other variables), preferential independence cannot realistically be assumed. Weighted geometric mean aggregation is thus a potential alternative, as defined in Equation 4.3. In this instance, the indicator score, I_i is the geometric mean of the relevant variable data set, $\{X_1, X_2, \dots, X_n\}$, where w_j is the j^{th} weight given to variable X_j . For composite indices, component and overall index scores can be determined in a similar manner.

$$I_i = \sqrt[n]{\prod_{j=1}^n w_j X_j} \quad i = 1, \dots, n \quad (\text{Equation 4.3})$$

Ebert & Welsch (2004) demonstrate that in the case of strictly positive, ratio-scale noncomparable variables, aggregation by geometric (rather than arithmetic) mean can provide better, more meaningful indices. Giné Garriga & Pérez Foguet (2010) also found that a weighted multiplicative geometric mean function is the most suitable aggregation method for assessment of the Water Poverty Index (WPI) at local scale. It is worth noting that although the use of the geometric mean has been relatively rare in computing social statistics, starting from 2010 the United Nations Human Development Index switched to this mode of calculation on the grounds that it better reflected the non-substitutable nature of the statistics being compiled and compared: *“The geometric mean reduces the level of substitutability between dimensions [being compared] and at the same time ensures that a 1 percent decline in say life expectancy at birth has the same impact on the HDI as a 1 percent decline in education or income. Thus, as a basis for comparisons of achievements, this method is also more respectful of the intrinsic differences across the dimensions than a simple average”* (UNDP, 2012). Not all of the values used to compute the HDI are normalised however; some of them have the form $(X - X_{min}) / (X_{norm} - X_{min})$, and this can make the choice of the geometric mean less obvious.

Multi-criteria decision analysis (MCDA) aggregation methods are considered to be advanced ways of dealing with the problem of poor performance in one variable being compensated by good performance in another (Yale, 2005). Additionally, indicators can be represented by way of a ‘fuzzy composite’ approach, using fuzzy inference processes (see Section 2.6) – these options were not explored in detail however, owing to data availability issues and the need to maintain transparency and ease of understanding of the sustainability index by non-experts. This could be the focus of any future revisions of the index if necessary.

A weighted geometric mean aggregation method (as shown in Equation 4.3) was adopted for the composite index calculation in the SIUWM, together with an approach which assumes that all variables, indicators and components have equal weight. A geometric mean aggregation can only be used with positive numeric data so that this meant that null values in the calculation had to be replaced with small positive values – i.e. 0 ratings were changed to 0.1. Specific details on the computation of the index will be provided in Section 4.5.

Efforts were made to address the various shortcomings with both weighting systems and aggregation methods by testing assumptions, undertaking comparisons with other initiatives, adopting different weighting schemes and finally by evaluating results at the level of the index as well as at the component and indicator level. As will be discussed in Chapter 5, the notion of reporting a simple composite index figure was also questioned, but ultimately it was decided that a final composite figure does not detract from the component analysis and that the simplicity and desirability for a single number could ultimately generate greater awareness for the underlying issues. This has particular resonance in the technical arena of UWM in a developing country context, where simplified measures of performance which can be tracked over time are needed to highlight sustainability issues in poorly-resourced and skilled local authorities.

4.5 Computing the SIUWM

An Excel workbook was developed consisting of several spreadsheets (refer to the attached CD) as the tool for calculating the index scores. The first spreadsheet is an instruction sheet, which outlines specific detail on completing the sustainability analysis. The next spreadsheet is the data fill-in sheet, where the user can attribute values to the variables provided. In this spreadsheet, the user is required to fill in values for the different variables, either in the form of numbers, or by selecting the correct option. Thus, for variables such as percentage access to levels of service, or percentage contribution per source to water supply, actual figures are reported (Table 4.8). For other variables the fill-in presents a multiple choice type scenario; tick boxes are provided adjacent to the options to be selected, and an 'X' is inserted in the relevant box (Table 4.9).

Table 4.8: Example of fill-in table requiring numbers

1.1 LOS for Water Supply	
%	Level of service
51.9	LOS1
0.0	LOS2
48.1	LOS3
0.0	LOS4
0.0	LOS5

Table 4.9: Extract from fill-in sheet showing tick box format

4.1 Customer services standards (KPI 7)	
	NO DATA
	0.0-1.49
X	1.5-2.49
	2.5-3.99
	4.0-4.49
	4.5-5.0

The third spreadsheet, the calculation sheet, provides a breakdown of the scores and how these were assigned to each variable. Table 4.10 gives an example of how the variable scores are calculated for the indicator 'Levels of Service' (LOS). The different LOS (1 to 5) for each service (water supply, sanitation, solid waste and stormwater) are assigned a rate of 1 to 5 and this is multiplied with the percentage access to that service (expressed as a decimal), and then added together to give an overall score for the variable.

Table 4.10: Example of score attribution to the water supply variable for the indicator 'Levels of Service' (LOS)

Levels of Service	Water supply	Rate	Score
LOS1	0.519	5	2.595
LOS2	0	4	0
LOS3	0.481	3	1.443
LOS4	0	1	0
LOS5	0	0	0
Variable score			4.038

Similarly, the corresponding rates for all other variables provide the final scores. See Appendix C for further details regarding how the indicators and variables were rated, as well as a description of the five levels of service for each category (water supply, sanitation, drainage, and solid waste) that were adopted in this research, including examples of the type of system and the frequency of the service (Table C.1). Appendix F provides instructions on how to use the index.

The fourth spreadsheet (SIUWM Results) completes the calculation and presents the final results of the aggregation process. In this sheet, variable scores are imported from the previous ‘Calculations’ sheet (both sheets are linked), and weights are assigned if required. This then provides the calculation of indicator, component and finally the sustainability index scores. In summary, the aggregation process takes place as follows:

- The variable scores are the standardised scores as per the ‘Calculations’ sheet, on a scale of 0 – 5.
- The indicator and component scores are determined as the geometric mean of the relevant variable and indicator scores respectively.
- The component scores are divided by 5 and multiplied by 100 in order to express them as percentages. The overall SIUWM score is the geometric mean of these component scores.

The final sheet works as a check for possible errors made by the user; similar error checks are also provided in the other sheets to ensure that values are filled in correctly. The interactive spreadsheet allows the user to alter the values of the variables for the urban water system under review if desired, and observe the impact on the final SIUWM figure – for purposes of scenario planning or model sensitivity analysis. For a detailed view of the spreadsheet refer to the full case study application provided on the attached CD (SIUWM tool).

4.5.1 Selection of cities for application of the SIUWM

In order to test the validity of the index an assessment of urban water sustainability was carried out in selected case study cities throughout South Africa. These cities were chosen for assessment based on the fact that they are all members of the South African Cities Network (SACN) as described in Section 2.8.7, and it was therefore assumed that they would have the necessary resources and personnel to enable a thorough discussion on sustainability analysis, as well as being able to provide the required data for the assessment. The cities comprise the nine largest urban centres in the country and are located in the top five (out of nine) provinces, with respect to their impact on SA’s economy. Three of the cities are located in Gauteng Province, which is responsible for 32% of the country’s net economic output or Gross Value Added (GVA), and 22% of the total population (SACN, 2011). Specific detail on each of these cities is provided in Appendix G. The SACN member cities, and the provinces in which they are located, are as follows:

- Buffalo City Local Municipality, Eastern Cape Province (BC).

- City of Cape Town Metropolitan Municipality, Western Cape Province (CT).
- City of Johannesburg Metropolitan Municipality, Gauteng Province (JHB).
- Ekurhuleni Metropolitan Municipality, Gauteng Province (EK).
- eThekweni Metropolitan Municipality, KwaZulu-Natal Province (ET).
- Mangaung Local Municipality, Free State Province (MN).
- Nelson Mandela Bay Metropolitan Municipality, Eastern Cape Province (NMM).
- The Msunduzi Local Municipality, KwaZulu-Natal Province (MS).
- Tshwane Metropolitan Municipality, Gauteng Province (TS).

These cities are already being assessed as part of the State of the Cities reporting process by the SACN, which also has other initiatives in place with respect to their Urban Indicators Working Group, the City Water Managers Forum, as well as connections to the Global City Indicators Facility (as discussed in Section 2.8.7). The decision to use as much data as possible from the RPMS and Blue Drop / Green Drop schemes also means that the SIUWM can easily be applied to any Water Service Authority (WSA) in the country (with the addition of some information sourced directly from the WSA concerned), regardless of its size or category, as the regulatory information is kept updated on an annual basis.

4.6 Interpretation of index and dissemination of scores

The interpretation of the index scores and dissemination of the results is crucial in a sustainability assessment exercise such as this, particularly in terms of advocating how to make sustainability operational in this regard. This will be discussed in further detail in the sections that follow, but in terms of the index development process, one important aspect is to benchmark the SIUWM results against other sustainability assessment initiative results in order to verify targets for sustainability, and provide a means of interpreting the results. This was achieved by comparing the results with related indices at component level (see Section 6.3).

It should be borne in mind that, as with any similar numerical approach to what is essentially a reflective exercise, there is potential for significant subjectivity with the results of the city sustainability assessment. Manipulation of the data is possible in the value ranges for variables; how scores are rated; as well as in the way in which the composite index calculation is done. However, the selection of indicators and variables which make use of widely-published data sets is one way of reducing subjectivity, as is the decision to link it to existing annually-updated regulatory measurement processes. The value of this exercise is thus not in a once-off assessment – which could be criticised for being somewhat arbitrary in nature– but in a regular (yearly) process from which trends (and time series information) can be drawn.

4.7 Summary

This section has outlined the process that was followed to develop the SIUWM and has provided specific details on its calculation. Through the framework that was adopted, it shows how indicators can be used to provide an analysis of whether an urban water system is moving towards or away from a sustainable state. The following chapter will focus on some of the constraints and limitations of the indicator approach and how these were overcome as part of this research, and Chapter 6 will then present the results of the application of the SIUWM to the selected case study cities.

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5. SIUWM – dealing with constraints and limitations

This chapter summarises some of the main difficulties encountered with this research, and also provides a critique of the use of composite indices in the sustainability assessment process. As was made clear in the Literature Review, the development and use of indicators to track progress towards or away from sustainability is already common urban practice. There are various criticisms of the indicator approach however, including: issues of scale and data availability; difficulties with meaningful interpretation; a lack of causal linkages between indicator values and desired outcomes; and a failure to consider resilience (the ability to maintain or improve upon a current state over time) in the system being measured (Milman & Short, 2008). Some of these issues will be elaborated on in the sections that follow.

5.1 Use of composite indices in sustainability assessment

During recent times, much effort has been put into the development of sustainability indicators aimed at making policy processes more transparent and accountable (UN-DESA, 1992), but less attention has been paid to the usefulness or efficiency of these tools, and there is even less evidence of policy reforms that have been initiated based on sustainability indicators (Yli-Viikari, 2009). This can be related to the fact that very often they are poorly constructed and/or misinterpreted. An ideal composite index should measure multi-dimensional concepts which cannot be captured by a single indicator; hence their use in sustainability assessment. The main pros and cons of using composite indices are shown in Table 5.1.

Table 5.1: Pros and cons of composite indices (adapted from Saisana & Tarantola, 2002)

Pros	Cons
<ul style="list-style-type: none"> • Summarise complex or multi-dimensional issues with the aim of supporting decision-makers • Enable easier interpretation of trends than with separate indicators • Facilitate ranking on complex issues / benchmarking • Assess progress over time on complex issues • Reduce the size of a set of indicators and include more information • Place issues of performance and progress at centre of policy arena • Facilitate communication and promote accountability • Enable users to compare complex dimensions 	<ul style="list-style-type: none"> • May send misleading messages if poorly constructed or misinterpreted • May invite simplistic policy conclusions • May be misused if the construction process is not transparent and lacks sound statistical principles • Selection of indicators and weights could be the subject of political dispute • May disguise serious failings in some components and increase difficulty in identifying remedial action • May lead to inappropriate policies if difficult-to-measure dimensions of performance are ignored

As will be shown in the paragraphs that follow, the value of an easy-to-interpret, integrated summary of the complex issues of sustainability cannot be overstated – particularly in the South African context, where this type of multi-dimensional analysis is still in its infancy.

5.1.1 Frameworks

As noted by Nardo *et al.* (2008), the development of a theoretical framework is crucial in providing the basis for the selection and combination of single indicators into a meaningful composite index which is fit-for-purpose. The difficulty with the present research was not so much in identifying the problem, nor was it in developing an approach for calculating the index, as these concepts have been well-documented in the literature and there are standard approaches which can be followed. It was the need for multi-disciplinarity, integration and a systems approach towards assessing sustainability which proved to be particularly challenging. De Carvalho (2007) addressed this by developing a conceptual model upon which the index and the specifics of its design was ultimately founded. This model combined the systems model proposed by Lundin & Morrison (2002) and the step-by-step methodology for constructing composite indices by Nardo *et al.* (2008). This paradigm shift from a single discipline approach also had to take into account the various key aspects of systems thinking, as identified by Ravetz (2000):

- “*Extended time horizons: linkages within and between generations*” (i.e. temporal aspects) – in this research the capacity for sustainability in urban water systems focused on immediate to short term aspects across four dimensions, with a view to being able to provide trends over time. The assessment of longer term changes will only be possible through regular application of the index, using commensurate data.
- “*Extended physical horizons: linkages from local to global*” (i.e. spatial aspects) – it is important that a tool of this nature be scale-relevant. In its present form, the index can be applied at any scale – from suburb, district, and city to national – even though application was limited to cities for the present research. Linkages with global indicators can be shown in comparisons with the SIUWM results.
- “*Extended causal chains: upstream pressures to downstream impacts*” – the identification of causal chains was to some extent achieved through the application of the DPSIR framework to the urban water management system in SA. The SIUWM explores the overall well-being of the system, and therefore indirectly illustrates unsustainable practices and the required capacity to address them.
- “*Extended sectoral boundaries: linkages from environmental to human activities*” and “*Extended value systems: a multiplicity of social, economic, political and cultural perspectives*” – as far as was possible these linkages were addressed by way of the inclusion in the index of all dimensions of sustainability.

The present research took the concept of systems thinking a step further into the development of a theoretical framework for the selection of indicators for the SIUWM, through the process of preparing a vision of sustainability for the water sector. This enabled a more thorough representation of the various dimensions of sustainability.

5.1.2 Indicator selection and weighting

As has already been discussed, sustainability is characterised by concepts such as indeterminacy (which results from the impossibility of accurate measurement), complexity and diversity (Ravetz, 2000), which can make assessment efforts that rely on quantifiable measurements very difficult. In an attempt to address this, De Carvalho (2007) explored the use of several statistical techniques for the selection of indicators and weightings so as to reduce uncertainty and improve the robustness of the index, although none provided any demonstrable improvement. So as to meet the ultimate objective of developing a tool that could be used to assist local authorities with strategic planning, the decision was taken to rather concentrate on more participative, opinion-based approaches with a focus on stakeholder consultation. The adoption of methods such as Analytical Hierarchy Processes (AHP) – which incorporate comments from different sets of city stakeholders – can make decisions regarding the prioritisation of sustainability indicators and their weightings more defensible. However, the level of stakeholder consultation achieved during the current research process was not sufficient to allow for this, as described in Chapter 4. The decision was therefore taken to link the selection of sustainability indicators to a visioning process; as Yli-Viikari (2009) puts it, “*using indicators as management tools is possible if there exists a joint opinion about the preferred way of development*”. Bell & Morse (2008) also provide some explanation regarding the level of subjectivity inherent in such an approach:

- Subjectivity can provide a qualitative measure of the integral nature and wholeness of a given system.
- Subjectivity on the part of stakeholders is unavoidable.
- Subjectively-derived measures of sustainability are useful if the subjectivity is explicitly accepted at the outset and if the method for deriving the measures is available to a range of stakeholders.
- Participatory tools for developing thinking and modelling around sustainability measures are of value to a wide range of stakeholders within development policy.

At the outset of the indicator identification process, it was clear that current sustainability and performance measurement processes in SA offered limited choices with respect to the selection of urban water management indicators owing to the fact that none of these initiatives provide an integrated assessment. In particular, the Sustainable City indicator set for the State of the Cities reporting process by the SACN was found to be extremely large and poorly populated with data in many of its themes; it was thus unable to provide any useful information on the state of urban water systems in the participating cities. The SACN advocates developing a bank of common indicators that can be used to collectively measure comparative progress over the long term, conditional on a systematic investment in indicator setting and data collection and processing capability by all participating cities (SACN, 2002). The Urban Indicators group of the SACN has thus been working on defining a smaller set of suitable indicators for some time

now, starting just before the 2nd SACN Urban Conference held in East London, SA in late 2009, but there has still not (as at December 2011) been final agreement on it, owing to issues of capacity and a lack of commitment on the side of the local authorities / SACN. Repeated attempts to engage with the consultants responsible for convening the working group and to participate in the process were largely unsuccessful, and it was not possible to get further details on the indicators that are in use and their selection framework.

Other difficulties were encountered with contacting and connecting the various role players in the visioning process for this research (although the individual officials who did provide inputs, did so willingly). For instance, at the re-launching workshop of the National Benchmarking Initiative (NBI) held in October 2011 to finalise indicator selection and the benchmarking system, it became clear that National and Local Government in SA are at loggerheads with one another on the issue of benchmarking vs. regulatory performance assessment. The regulatory systems (RPMS and Blue Drop / Green Drop) are seen as mandatory external assessment processes, whereas the NBI system involves municipalities wanting to improve their own operational business performance. Local government officials were of the opinion that the implementation of regulatory performance measurement, whilst useful from a central government point of view, ‘ambushed’ their existing benchmarking initiatives. They were therefore not open to any suggestions of either shared indicators or data sets. This is unfortunate, as a core set of standardised key performance indicators, based on a common framework and with defensible input data for both systems, could provide the basis for a solid sustainability analysis of the water sector over a period of time.

There were also challenges with the selection of indicators for ‘difficult’ subject matter, such as the provision and sustainability of stormwater services, and climate change impacts. Repeated attempts were made to engage municipal officials in this regard, but aside from general comments from individuals about aspects such as “*no development in the floodplain*”, or “*limit the impacts of climate change*”, it seemed they were largely unable to voice any opinions on suitable indicators – and similarly, it was very difficult to identify data to support the indicators once they had been selected. Particularly in respect of climate change responses, it appears that a commitment to climate change mitigation and reduction targets is not yet fully entrenched in the SA water sector, although some work has recently been carried out in terms of optimising energy use and reducing GHG emissions, specifically at wastewater treatment facilities (Roman, 2011). As will be discussed in Section 5.2, data on both energy consumption and climate change strategic planning was extremely difficult to obtain and ultimately these indicators were omitted from the current sustainability index calculation.

5.1.3 Single figure composite index results

“... it is hard to imagine that debate on the use of composite indicators will ever be settled ... official statisticians may tend to resent composite indicators, whereby a lot of work in data collection and editing is ‘wasted’ or ‘hidden’ behind a single number of dubious significance. On the other hand, the temptation of stakeholders and practitioners to summarise complex and sometime elusive processes into a single figure to benchmark country performance for policy consumption seems likewise irresistible.” (Saisana *et al.*, 2005 in Nardo *et al.*, 2008)

Many authors contend that reducing a ‘measurement’ of sustainability to a single figure as in the case of a composite index result is undesirable as it means that detail is lost and opens up the possibility of vital indicators being ignored (Bell & Morse, 2008; Komnencic *et al.*, 2009; Lai *et al.*, 2008; Farsari & Prastacos, 2002). However, some of the same authors (e.g. Bell & Morse, 2008) also assert that the notion of one numeric value for sustainability – such as in the ESI – is attractive in that simplifying system complexity into single values allows for easy comparison. Tabular and diagrammatic formats such as radar diagrams can compensate for any loss of detail by introducing ‘richness’ into the results. Most importantly though, a level of simplicity is required, and the notion that local stakeholders should own and develop their own view of sustainability via the index is crucial. *“The key will be to remember the audience and to listen to what they have to say about the purpose and practicalities of developing measurements that chart the progress of their community over time”* (Bell & Morse, 2008).

In the end, there are two main schools of thought regarding the development and application of composite indicators – the ‘aggregators’ and the ‘non-aggregators’ (Nardo *et al.*, 2008). The first believe that this summarised presentation of results provided by composite indicators is not only relevant and realistic but also meaningful and that the very comparative, and at times competitive-driven, nature of indicator application which stresses the ‘bottom line’, irrefutably attracts the much-sought attention of policy makers (De Carvalho, 2007). The ‘non-aggregators’ on the other hand believe that, while indicators are undeniably useful, the final aggregation into a composite should be omitted for the very sound criticism that the selection and aggregation (particularly with respect to what they consider to be the arbitrary nature of weighting) of indicators is and will continue to be extremely subjective and ultimately dissatisfactory to some.

Whilst both of these viewpoints have merit, the simplicity and strength of composite indices in conveying a message and motivating for change is extremely attractive, particularly in the SA urban water management context where many of the issues highlighted have thus far been either poorly addressed or unrecognised. It is with this in mind that the decision was taken to make use of a composite index approach as part of this research. The notion of composite indices being able to assess progress over time on complex issues is also attractive in a developing nation context such as in South Africa, where an analysis of sustainability trends could contribute to a more effective state. As will be shown in Chapter 6, the aggregated results from the SIUWM may be displayed in such a way that the components of the index can be

disaggregated, as in for example, a radar diagram and/or other graphical and tabular displays so as to allow for the interpretation of single indicator and variable results.

The information these indices provide must be disseminated with caution however; the results provide but a rough assessment of reality, and should therefore be seen as a starting point for initiating discussion. In order to make an assessment process such as this manageable and cost-effective, the indicator set has to be limited in size and will inevitably only be able to provide part of the available information on the urban water system (Van der Steen, 2011). As noted by Bagheri & Hjorth (2007b), indicator sets in this regard act as filters for stakeholders to select which data they wish to take into account and which they choose to neglect.

5.2 Data issues

Attempts at assessing and monitoring sustainable urban water management require a clear definition of research and operational objectives and a concerted multidisciplinary data measurement approach; i.e. good quality metrology (Bertrand-Krajewski *et al.*, 2000). Issues of data availability, accuracy and reliability are critical for the development of a tool such as the SIUWM, as a lack of data or missing values in a time series of data could result in varying indicator scores and a level of uncertainty. Evaluating urban water management sustainability requires empirical data (e.g. data regarding access to water supply and sanitation services), qualitative evaluations of non-measurable characteristics, and in-depth knowledge about the urban area to provide demographic and contextual information (Milman & Short, 2008). The start of this research project coincided with the establishment of the Cape Urban Observatory (CUO) – an applied urban research initiative of the African Centre for Cities (ACC) at the University of Cape Town. The intention of the CUO was to provide a public, web-based storage platform for timely and geo-spatial information and analysis on themes relevant to Integrated Development Planning in the metropolitan area of Cape Town (Hamman & Smit, 2009). It was to include the development of thematic content and the participatory identification of relevant indicators, all of which would have provided extremely useful information for the SIUWM effort. Unfortunately, ongoing problems in the setting up of the CUO – particularly related to the sharing and standardising of data – meant that the facility (as at December 2011) is not yet, and seems unlikely to ever be, fully operational.

On the assumption that the single biggest constraint to the calculation of the SIUWM is data, the decision was taken to focus on widely available, regularly-updated and reliable public data, or ‘hard’ data. Qualitative information (‘soft’ data; i.e. indirect evidence or informed opinion) was obtained during interview processes with municipal officials and where necessary secondary resources (e.g. documents available on municipal web-sites, WSA reports, DWA documents etc.) were used to corroborate answers on specific system details. A variety of data sources were thus used where possible to check that the information reported for a specific indicator was consistent. With regard to uncertainty, therefore, this research has endeavoured to use sources which are both reputable and frequently referenced. It is acknowledged that by using existing composite results developed for other purposes (e.g. the RPMS data) as input to

the SIUWM, there may be concerns about the specific relevance of the data and its usefulness in reporting on the overall state of the theme under consideration, i.e. urban water management in SA. At the same time, it should be noted that a lack of readily-available data impedes the quality of information that can be provided by the monitoring system, which in turn limits the monitoring system's capacity to report accurately (Davidson, 2010). Thus, in this context, and based on the sustainability framework that was developed, the use of data from systems such as the RPMS was felt to be justifiable.

5.2.1 Data selection and gathering exercise

As with benchmarking, and as a matter of governance policy, publicly-owned utilities should have no objection to publishing data on their basic technical and economic operations. Whilst this was true in most cases, the following issues acted as constraints to the data gathering process:

- Poor cooperation and reluctance to share information – in some instances, the relevant authorities were not willing to provide information; either because of their workload (and issues of 'data fatigue'), or because they did not understand the sustainability assessment concept and felt that this was a duplication of existing monitoring initiatives. This was further justification for correlating the SIUWM with the performance measurement and regulatory systems already in place.
- No information and/or data – the use of existing monitoring data did not completely do away with the necessity to collect data directly from the local authorities involved, and there were some instances where this information was not forthcoming at all, even after trying all avenues of communication, e.g. interviews, telephone, email. In these cases, certain steps had to be taken to substitute or impute data, or to omit the variable completely (as will be discussed in the following section), with consequent impacts on the credibility of the results.
- Unreliable or inaccurate data – it was not possible to fully match the timing of all of the data used in the various city assessments. Poor quality data limits the usefulness of an assessment process such as this (Van den Berg & Danilenko, 2011) and efforts should be made to ensure reliable data from reputable sources. Alegre *et al.* (2006) claim that the quality of data should be assessed in terms of the reliability of the source (which accounts for the extent to which the data source yields consistent results over a period of time) and its accuracy (accounts for measurement errors in the acquisition of input information). What is particularly important for future assessments is that there is a focus on developing commensurate time-series data so that trends in performance and the impacts of sustainability challenges can be determined. Effective development of time-series data requires that the data remains comparable over time through the rigorous use of a standardised data set and indicators, as well as frequent data updating (Van den Berg & Danilenko, 2011).

It should be noted that all of the students who were involved in the testing phase of the initial SIUWM encountered similar issues with the collection and standardisation of data – and particularly when trying to get data from the same time period. This has been overcome to some extent through the decision to use RPMS and Blue Drop / Green Drop data which is updated annually and is thoroughly checked for consistency and accuracy. The one drawback with the RPMS system is that if the data cannot be verified it is displayed as a ‘nil’ (or FAIL) return, which does not necessarily reflect the true situation on the ground, and has a negative impact on the final score for the relevant indicator in the SIUWM. This was particularly problematic in the start-up phase of the RPMS. However, in its three years of operation, the data accuracy function of the system has consistently improved, so it is expected that issues such as these will improve over time. It was for this reason that the testing of the SIUWM using data from the nine SACN cities made use of the latest available RPMS results (i.e. 2010 / 2011 data) in the hope that many of the ‘teething’ problems with respect to data accuracy had been resolved.

5.2.2 Missing and/or incomplete data

The question of how to treat missing or incomplete data observations is among the most persistent and complicated problems in assessment processes. The degree of uncertainty introduced from a lack of data affects the ability to draw accurate conclusions, which increases with the level of data aggregation (Yale, 2005). Insufficient data availability can thus have direct implications on effective decision-making.

Due to the nature of this index, and the relatively limited number of mostly simply-formulated variables, the likelihood of missing data having a significant impact on the overall score is fairly low, although impacts could be felt at variable and indicator level. Also, some of the data required for the index calculation is subjective, and complicated imputation methods are not likely to add further rigour to the process; of more value are the discussions with local authority officials towards envisioning a more sustainable future. Following on from the process started by De Carvalho (2007), numerous statistical and other data simulation methodologies were considered for imputing data, some more complex than others, but ultimately direct substitution and informed guesses were mostly used to fill in missing data where required. There is thus an inevitable level of uncertainty in the SIUWM results.

Table D.1 (Appendix D) lists the data sources that were used for the variables that make up the SIUWM; of these 35 variables, only 10 use RPMS or Blue Drop / Green Drop data. This is due to the fact that the regulatory systems mainly focus on the efficient functioning of the urban water system and not on sustainability *per se*. Missing from the regulatory data set are issues of: health, development, poverty, lack of housing, river health, and stormwater – i.e. the social and environmental dimensions of sustainability.

Of the remaining 25 variables making up the index, 11 use widely-published information sources and reports; and 14 require direct input from Water Service Authority officials to provide the information required. Depending on the monitoring and information storage

capabilities of the WSA concerned, data for some of these 14 variables could be accessed via municipal libraries and/or websites; the rest required interviews with the relevant officials or access to privileged reports not available in the public domain. As mentioned previously, it was extremely difficult to get data for some variables, and in some cases even interviews with officials were not forthcoming. Where it was possible to infer data, such as for levels of service for drainage; and per capita water availability, this was done (as shown in Table E.1, Appendix E). In others, where repeated attempts to obtain information were unsuccessful, other measures had to be adopted. In the case of the two variables for the indicator ‘Climate change response’, i.e. ‘Amount of energy consumed’ and ‘Climate change strategic planning’, the decision was eventually taken to omit them from the calculation until such stage as this data is more routinely collected by the authorities.

Ultimately, as will be shown in the next chapter discussing the results of the SIUWM analysis on the nine case study cities, it is clear that the poor availability and reliability of data relates strongly to poor municipal performance; i.e. it is an indicator in itself.

5.2.3 Incommensurability of data

In order to be able to aggregate variables and overcome the issue of incommensurability, all variables were converted to a common 0.1 to 5 score, irrespective of their unit of measurement. This is in itself subjective – where specific standards or targets were not available to assign end-points, both the end-points and intermediate ranges for each indicator were subject to the researcher’s interpretation, and sometimes a personal value base. A more refined scale may have made it possible to identify smaller variations in variable scores, but this was not explored, mainly because the RPMS scoring system is also based on a similar scale and was therefore compatible with the SIUWM.

5.2.4 Issues of scale

Scaling is an important attribute in indicator development and implementation – owing to the fact that information needs may differ at local, regional and global level, indicators developed for a certain spatial scale may not be useful at another scale (Vrba & Lipponen, 2007). Sustainability indicators have therefore been critiqued for not being applied to an appropriate spatial scale and therefore not discriminating between the different impacts for the various components (Milman & Short, 2008). The importance of community-based indicators, which set water-related targets relevant to a local scale, should be noted – these indicators empower local water users thereby linking the indicators directly to outcomes.

The testing phase for the preliminary index SI 2007 included some smaller municipalities whereas the final SIUWM was only applied to the nine member cities of the SACN. The SIUWM was ultimately developed to consider urban water management at municipal level in South Africa through the assessment of the Water Services Authority (in most cases the municipality itself) responsible for this function. It is therefore applicable across the full range of municipal scales, from local to metropolitan. Whilst it is acknowledged that a more refined

analysis of sustainability in general may have been achieved if the SIUWM had been applied at a lower scale – e.g. at district, or even settlement-level – this was not the purpose of the present study which focused on whole towns / cities as the most appropriate unit of analysis of the urban management system. Also, the required information for the sustainability assessment is often not available at this lower level and certain data is incomparable, for example water supply and health – water supply boundaries conform to the formal district boundaries established, but health data is devised on the basis of health care facilities available and therefore different boundaries are used. Future studies could address the concept of meaningful scales within a city and the notion of whether there are there controlling factors (through a focus on specific indicators) that mean that UWM is better in one area than another.

It would have been useful to apply the index across the different categories of municipalities, from small towns to metros (as described in Section 2.8.6.5), in an attempt to determine the differences between large and small WSAs in terms of their potential for sustainability in urban water management. A full assessment such as this was not possible within the confines of the present research, but some initial thoughts were gleaned from the SI 2007 case studies and recommendations for further research in this regard have been made (Chapter 8). For example, it appears as though smaller municipalities are likely to do better in terms of integration and stakeholder involvement, but will fare less well on a technical level; specifically in terms of meeting the requirements for the provision of water and wastewater services (i.e. the Blue Drop / Green Drop programmes). Many smaller municipalities lack the financial and technical capacity to manage water services adequately, but due to their smaller size are able to address the entire water services value chain in a more integrated manner.

5.2.5 Ground-truthing

Employees of utilities and other stakeholders most knowledgeable about local conditions are best suited to not only determining a vision for sustainability, but also to compiling the necessary data to assess performance towards achieving this vision. Whilst much of the input data for the SIUWM was sourced from publicly-available information, interviews with local authority officials (either in person or by way of other communication channels) were required to fill in data gaps, as well as to establish their views on the visioning process. Aligned to these discussions and visits to the respective cities was the notion of ground-truthing; i.e. using first-hand observations to confirm findings and prepare a mental image of current conditions ‘on the ground’. Owing to the general difficulties encountered with engaging local authority officials, the ground-truthing exercise was only undertaken in seven out of the nine case study cities (visits did not take place in either Mangaung or Msunduzi), and was restricted to what could be undertaken in the limited time made available by the official concerned. Also, it was not possible to observe all aspects of the urban water management system in any one city. Nonetheless, these visits were helpful in providing a basis for interpretation of the SIUWM results, and were used together with other published information on the state of these cities to prepare some conclusions.

5.2.6 Comparison with other sustainability assessment initiatives

In order to test the robustness of the index and to attempt to validate the scores from the city assessment, a comparison was carried out with the results from other related sustainability assessment initiatives (as discussed in Section 6.3). This exercise was useful at an over-arching scale only, based on the fact that comparative scores were only easily obtainable at country level, and none of the initiatives used for comparison purposes were specifically geared towards urban water management.

The City Development Index (CDI) and the Enhanced Water Poverty Index (eWPI) have been identified as two assessment indices against which the SIUWM could possibly be compared, although in both cases a more focused data collection process would be required in order to be able to complete the calculations. This is included as one of the recommendations for the research, but the following is worth noting at this point:

- CDI comparative results are only likely to be useful at settlement scale, based on the way in which the scores are determined (see Section 2.5.1.2); this would therefore require the SIUWM assessment to be conducted at the same scale.
- Similar to the objectives of the SIUWM, the eWPI is aimed at allowing resource managers to determine and target priority needs in the water sector, whilst assessing development progress. However it differs from the SIUWM in that it is used principally to reflect the challenges related to the provision of water in rural areas in low-income countries. Another difference appears to be in the perceived ability of the SIUWM to provide information on interlinkages in urban water management systems.

5.3 Concluding remarks

As can be seen from the preceding sections, there are some key practical challenges to sustainability assessment in urban water management, not least of which is the definition of what sustainability itself means in this regard, as well as the identification of a set of indicators which can adequately describe it. Hamdouch & Zuideau (2010) contend that this calls for a move to innovative methodologies, as follows:

- i) The use of multi-criteria approaches in order to take into account the different aspects of sustainability; i.e. social equity, environmental protection and economic efficiency.
- ii) The importance of including mechanisms of governance in the decision-making and assessment process, i.e. mobilising and including stakeholders.
- iii) Taking account of risks and uncertainties (i.e. issues of resilience) in evaluation tools.

The sustainability assessment process, by way of the SIUWM, is an attempt at systematically including these methodologies. It is acknowledged that there are several shortcomings with the index at present, specifically in terms of the way in which data is collected by local authorities

for the different measurement processes and the fact that a different set of indicators could result in different sustainability outcomes. It is also acknowledged that there are methodological issues regarding the bounds of validity in the SIUWM, specifically arising from data measurement uncertainties, and that these issues should be addressed in future. However, whilst this type of approach is still in its infancy in SA, monitoring systems and their use in establishing new policies and practices towards sustainability are becoming commonplace in the urban water management business, and many of the data and indicator selection issues are slowly being addressed. This will be discussed in more detail in Chapter 7.

University of Cape Town

6. Results of city sustainability assessment

As highlighted in the literature review, water supply and sanitation in South Africa are characterised by both achievements and challenges. Whilst substantial progress has been made in addressing historical inequalities in access to water services, there are still significant backlogs, and perhaps more importantly, real difficulties in sustaining service provision over the long term. This arises from; *inter alia*, uncertainties about the government's ability to maintain funding levels in the sector as well as fragmented and problematic institutional capabilities in a developing nation context. Increasing environmental and population health impacts in the form of water resource availability and quality issues are a direct result of these difficulties.

In many urban areas, water services infrastructure is reaching replacement age, but funding constraints, a lack of lifecycle asset planning, poor design, weak technical skills and poor operating and maintenance practices are hampering the required maintenance and replacement programmes (RSA, 2011a). The consequences of this include: higher long-term costs, increased NRW (currently estimated to be costing the country over R2 billion per year), pollution and health problems resulting from dysfunctional water and sanitation infrastructure, and increased social tensions and protests (RSA, 2011a). The South African Institute of Civil Engineering (SAICE, 2011) in its recent assessment of the state of infrastructure across South Africa found the following with respect to water services:

- There has been significant progress in the provision of water services since 1994, but the focus has been on quantity, not quality – there are now serious problems with water quality (especially outside the metro areas), and water wastage is high.
- Many of the country's 850 wastewater treatment plants need urgent maintenance or replacement.

It has become clear that the deterioration in water management is largely due to a failure of government at all levels, with current water policies privileging short-term gains over long-term sustainability. In 2008, the SA Department of Water Affairs (DWA) launched its Water for Growth and Development (WfGD) framework which gave the following recommendations for addressing the 'crisis' (DWA, 2008c):

- i) Strengthen institutional capacity and political leadership – many of the issues are a consequence of the overambitious policy goals formulated in the 1990s.
- ii) Mainstream water in development planning; improve capacity-building at water management institutions.
- iii) Address service backlogs (2014 target) and maintain existing infrastructure.
- iv) Promote and maintain water quality – acid mine drainage to be urgently addressed.

- v) Prices to reflect costs and scarcity so as to nurture attitudinal and behavioural changes towards the value of water.
- vi) Diversify water mix – significant increases in return flows and desalination.
- vii) Promote water conservation and water demand management.

These are significant challenges; a recent (April 2012) news report noted that SA needs to invest a massive R573 billion in water infrastructure, services and demand management over the next decade if it has any hope of meeting the current demands, but has budgeted for less than half this amount (News24, 2012).

The SIUWM scores from the 2010 assessment highlight the inherent strengths and weaknesses in the management of urban water in the city at that time, and consequently in the performance across each dimension of sustainability. The following sections discuss the results from the urban water sustainability assessment of the nine case study cities (locations shown in Figure 6.1) and draw attention to specific challenges and areas of ‘unsustainability’ within these areas.

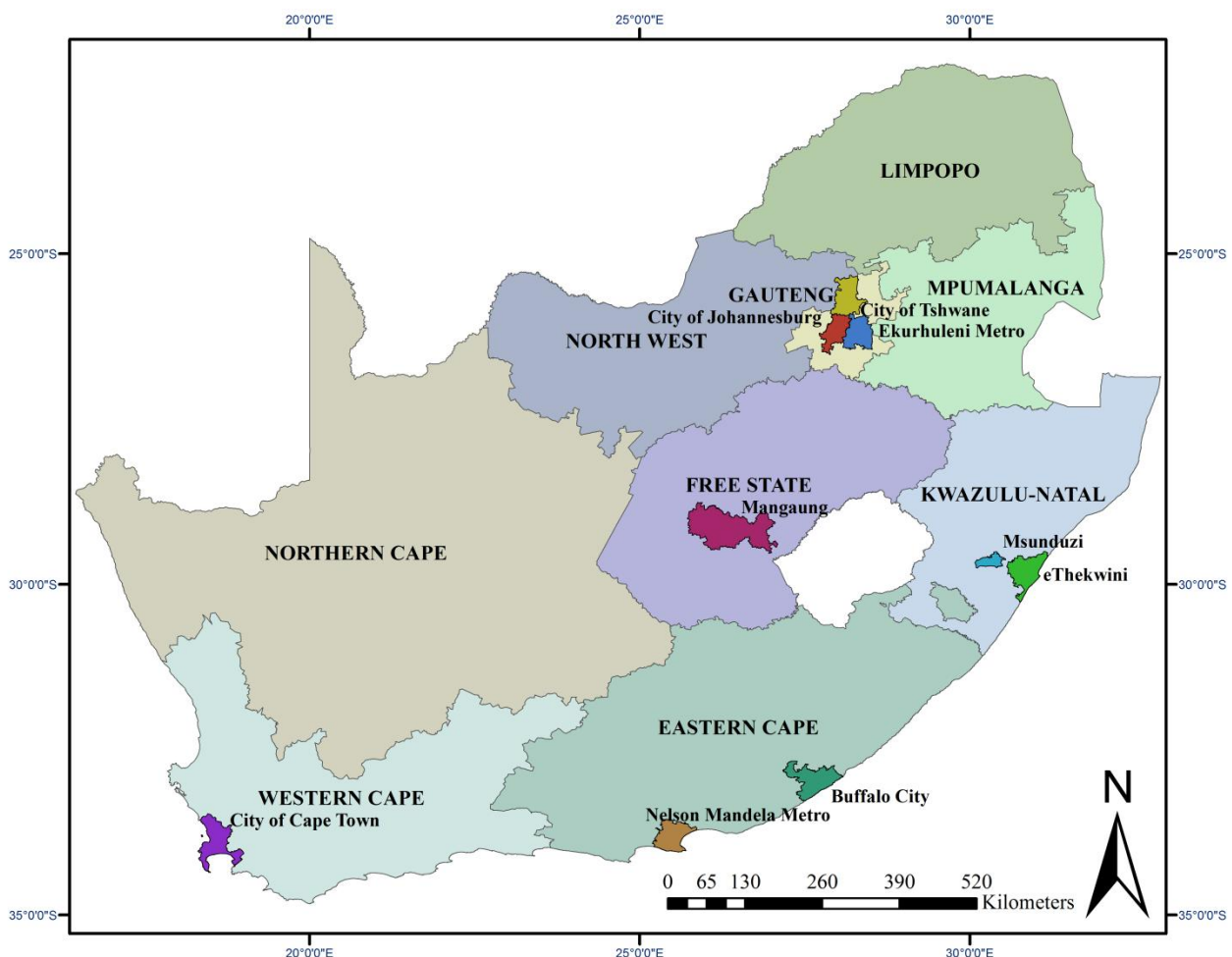


Figure 6.1: Map of South Africa showing locations of case study cities

6.1 Comparative city scores

The indicators which make up the SIUWM were chosen based on their ability to indicate the state of the urban water system being evaluated. As noted by Van der Steen (2011), the state of the urban water system can be understood as a combination of the condition of the infrastructure, the ecological quality of the natural systems, the well-being of the population, and the performance of the water services authorities themselves. The single figure result of the composite index calculation does not itself provide a measure of sustainability. In order to be meaningful, the SIUWM results for an individual city need to be compared either with other similar-sized, resourced and structured urban centres – for example, the SACN cities – or else with themselves over a period of time, so as to assess a trend towards a more (or less) sustainable state in the urban water sector. The ‘unpacking’ of further detail in this regard, by way of the interrogation of indicator and variable results, provides specific information on causal factors and areas of concern.

Based on the fact that there were concerns about the accuracy of the data sets from the first two years of RPMS assessments (see Section 5.2.1), only the 2010 / 2011 RPMS results were used in the calculation of the index scores for the nine member cities of the SACN. It was therefore not possible to determine sustainability trends for particular cities, although this will hopefully become possible as the annual RPMS review process continues.

Appendix E provides a summary table (Table E.1) of the complete data set that was used for the assessment. In order to ensure commensurability with the RPMS results and to provide a 2010 ‘snapshot’ for the cities, attempts were made to obtain 2010 information for as many of the variables as possible. In certain cases where this was unavailable, the decision was taken to use the most reliable data, published as close to 2010 as possible, e.g. 2007 Community survey data from StatsSA. There were instances where it was not possible to obtain the required data through published information, or by way of interviews and/or correspondence with the relevant authority. Aside from the absence of information on the climate change variables (which were then omitted from the 2010 SIUWM calculation), data on drainage / stormwater aspects was also difficult to obtain. As mentioned in Chapter 5, various steps were taken to fill information gaps where necessary.

The complete set of SIUWM results for the nine cities are shown in Appendix G, as well as on the CD included with this thesis, which has copies of the index calculation for each of the case studies.

6.1.1 Overall SIUWM scores

Figure 6.2 shows the range of overall SIUWM scores from the assessment of the case study cities – Buffalo City (BC), Cape Town (CT), Ekurhuleni (EK), eThekweni (ET), Johannesburg (JHB), Mangaung (MN), Msunduzi (MS), Nelson Mandela Metro (NMM) and Tshwane (TS). As expected for the nine urban centres who are all members of a development network such as the SACN, and who all experience comparable issues in the context of a developing country like South Africa, the composite index results are all fairly similar. Cape Town scores highest

using 2010 data, with a score of 65%, and Buffalo City is lowest at 51%; the average score for all nine cities is 56%. These are mediocre figures if sustainability in urban water management is the aim; but are also not unexpected given the continual struggle by cities in SA to provide and maintain decent levels of services to all their residents.

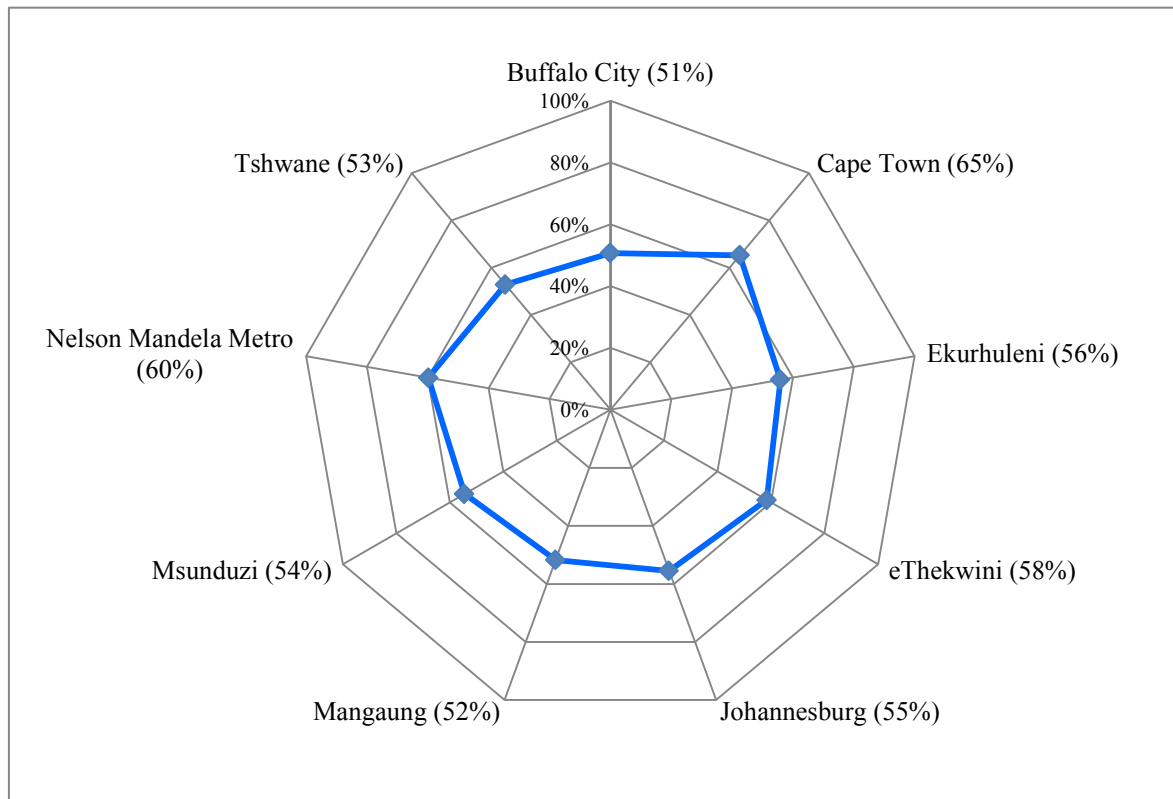


Figure 6.2: SIUWM scores for SACN cities

Whilst these overall scores give an initial ‘snapshot’ appraisal of the potential for sustainability based on the vision that was established, and could be used to benchmark cities against one another, they do not provide any indication of contributing factors and areas where there is room for improvement. They also do not account for the ‘push-pull’ factors where often an improvement in one indicator may occur only at the expense of another. This only becomes possible on further interrogation of the component, indicator and variable scores, as well as on a reflection of changes in scores over time. Conversely however, individual indicators can be very misleading without some sort of integrated analysis, and the value of a composite index is that the combination of several indicator scores can highlight the negative effects of specific problem indicators. So, for example, if high ‘Levels of Service’ as reported by StatsSA are combined with poor results for ‘Health’ or ‘Vulnerability’, a clearer picture of the overall state of urban water services emerges.

As already noted, some caution should be exercised in using this set of results to effect comparisons between urban areas, based on the fact that the timing of the data used in the various case studies was not fully commensurate.

6.1.2 Component scores

Table 6.1 provides comparative results for the four different component scores for each participating city. The component scores for the nine cities reveal that the Economic component fares the worst, with an average score of just 43%; indeed, in most cities it appears that economic variables are the main contributors to their poor performance.

Table 6.1: SIUWM component scores for SACN cities

City	Component scores (%)				Overall SIUWM score (%)
	Social	Economic	Environmental	Institutional	
Buffalo City	57	35	58	57	51
Cape Town	69	62	64	66	65
Ekurhuleni	58	43	55	67	56
eThekweni	60	42	55	77	58
Johannesburg	63	42	64	54	55
Mangaung	58	41	40	68	52
Msunduzi	65	38	52	63	54
Nelson Mandela Metro	61	46	61	72	60
Tshwane	53	44	59	56	53
Average scores	60	43	57	64	56

The other three components (Social, Environmental and Institutional) all have similar average scores, although the Institutional component has the widest range of scores, and there is some variation in the component scores at individual city level.

6.1.3 Indicator scores

Scrutiny of the average (Figure 6.3) indicator scores for the nine SACN cities reveals general problems in the indicators ‘Health’, ‘Capacity to pay’, ‘Cost recovery’ and ‘Resource quality’, with a number of the cities also experiencing problems in ‘Health’ and ‘Meeting targets’. The scores of six of the 15 indicators are below the overall average SIUWM score for the nine case study cities, indicating specific issues.

Interestingly, the average scores for the indicator ‘LOS’ are extremely high, even though in most cities the indicator for ‘Meeting targets’ was problematic. The LOS figures were obtained from national Census information (StatsSA, 2010) and it appears that they do not

reflect the true situation regarding levels of service in cities, particularly with respect to access to sanitation in informal settlements.

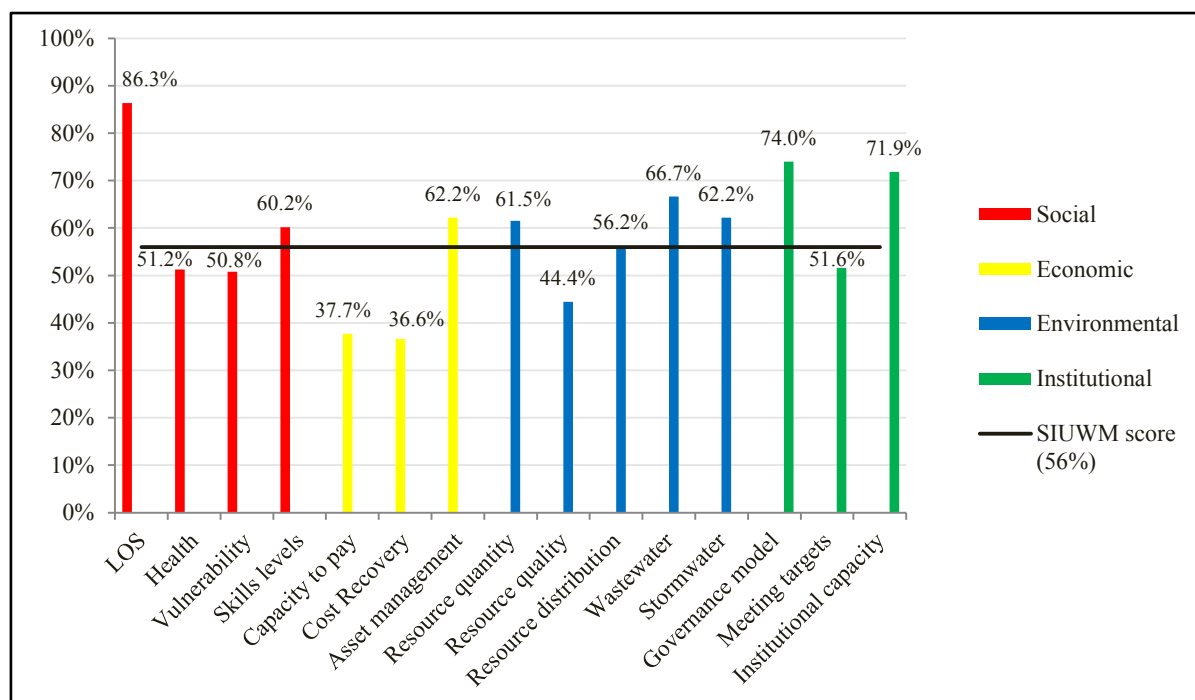


Figure 6.3: Average indicator scores for the nine SACN cities

These issues are highlighted in more detail in Table 6.2 which shows the individual indicator scores for the nine case study cities. Scores below the average overall SIUWM score of 56% are shaded in grey. As will become obvious in the graphs to follow which display the variable scores for each indicator, there are several contributing factors for poor performance, many of which impact on others. In some instances, the indicator scores appear to be acceptable, but a closer look at the contributing variable results shows that a good score in the one variable may be balancing out a very poor score in another. In this way therefore, it is possible to use the results of the SIUWM analysis to highlight linkages between indicators so that some of the less obvious water issues being experienced by cities can be identified. In other words, it allows the identification of areas of weakness where additional action could be taken to increase system resilience (as per Milman & Short, 2008).

The details of specific issues being experienced by the various cities are described more fully in Appendix G, but some examples of these indicator linkages can be inferred from the selected graphs as follows:

- i) **Figure 6.6: Vulnerability** – as long as there are still significant numbers of people living in informal settlements with limited access to functioning services, they will remain vulnerable, even if the relevant local authority has efficient risk management services.

- ii) **Figure 6.7: Skills and awareness levels** – whilst the overall scores for this indicator are reasonable, this is as a result of excellent performance in the RPMS variable ‘Customer service’, which gives an indication of the functioning of customer relations management systems as well as a WSA’s record in terms of service interruptions. On the other hand, the scores for the indicator ‘Secondary education’ are poor. The current state of affairs in SA’s education system is reflected in the very low numbers of people (less than 30% in all cities) who have completed high school. Education levels will need to be lifted in order to improve citizenship and for residents to be able to understand their responsibilities as stakeholders in their cities.
- iii) **Figure 6.8: Capacity to pay** – linked to peoples’ ability to comprehend water services issues (i.e. through education levels) is their willingness to take ‘ownership’ of these services to ensure their effective use of resources, and an ability and willingness to pay for the services. This indicator is measured by way of two variables: ‘Unemployment levels’ and ‘Gini coefficient’. As long as the levels of inequality in SA cities remain as high as they are, there is little hope of the majority of city residents having the capacity to pay for and access water services.
- iv) **Figure 6.9: Cost recovery** – while general financial performance at local authority level, as measured by the RPMS variable on WSA financial performance, does not appear to be particularly problematic, it appears that Non Revenue Water (NRW) is a major challenge for most WSAs. Of the nine cities assessed, only Cape Town was able to report NRW levels lower than 30%.
- v) **Figure 6.11: Resource quantity** – in this case, the scores reveal that the decreasing availability of freshwater resources in most urban areas is having a negative impact on the potential for sustainability.
- vi) **Figure 6.12: Resource quality** – while potable water quality and availability in most cities is excellent, the potential for the use of groundwater is often unknown (resulting in very low scores for that variable). Also, river quality in urban areas is often extremely poor, mostly as a result of point-source and diffuse pollution from unserved areas.
- vii) **Figure 6.16: Meeting targets** – this indicator measures compliance with various policies and with the MDG targets for water supply and sanitation. As part of this assessment, backlog rates are considered, as well as project spending on water supply and sanitation services. Water supply targets are being met, as well as those regarding the provision of Free Basic Water, but the indicator scores are being brought down by the low scores for many cities in respect of sanitation targets. The overall city scores for the indicator ‘Meeting targets’ (average of 51.6%) seem to provide a reasonable approximation of the potential for sustainability in most of the cities (with the possible exception of Buffalo City), again highlighting the importance of aligning with targets and holding governments to account.

Table 6.2: SACN city indicator scores

Indicator	City indicator scores (%)									
	BC	CT	EK	ET	JHB	MN	MS	NMM	TS	Ave
Social component										
Levels of Service (LOS)	83.7	93.1	90.8	81.2	88.7	86.0	82.5	88.6	82.1	86.3
Health	49.0	69.3	49.0	49.0	49.0	49.0	49.0	49.0	49.0	51.2
Vulnerability	40.0	56.6	40.0	56.6	56.6	49.0	69.3	49.0	40.0	50.8
Skills and awareness levels	63.2	63.2	63.2	56.6	63.2	56.6	63.2	63.2	49.0	60.2
Economic component										
Capacity to pay	34.6	56.6	34.6	34.6	34.6	40.0	34.6	34.6	34.6	37.7
Cost Recovery / funding	20.0	69.3	28.3	34.6	34.6	28.3	40.0	34.6	40.0	36.6
Asset management	60.0	60.0	80.0	60.0	60.0	60.0	40.0	80.0	60.0	62.2
Environmental component										
Resource quantity	64.0	65.3	64.6	45.6	66.0	57.9	50.4	73.0	66.5	61.5
Resource quality	57.7	49.3	43.1	34.2	43.1	31.7	40.0	57.7	43.1	44.4
Resource distribution	57.7	52.4	52.4	52.4	57.7	66.0	52.4	62.1	52.4	56.2
Wastewater management	80.0	80.0	60.0	80.0	80.0	20.0	60.0	80.0	60.0	66.7
Stormwater management	40.0	80.0	60.0	80.0	80.0	40.0	60.0	40.0	80.0	62.2
Institutional component										
Governance model	80.0	77.5	77.5	77.5	56.6	69.3	69.3	89.4	69.3	74.0
Meeting targets	34.2	41.6	49.3	66.0	45.8	66.0	60.0	60.0	41.6	51.6
Institutional capacity	69.3	89.4	80.0	89.4	60.0	69.3	60.0	69.3	60.0	71.9

Note: Buffalo City (BC), Cape Town (CT), Ekurhuleni (EK), eThekweni (ET), Johannesburg (JHB), Mangaung (MN), Msunduzi (MS), Nelson Mandela Metro (NMM) and Tshwane (TS)

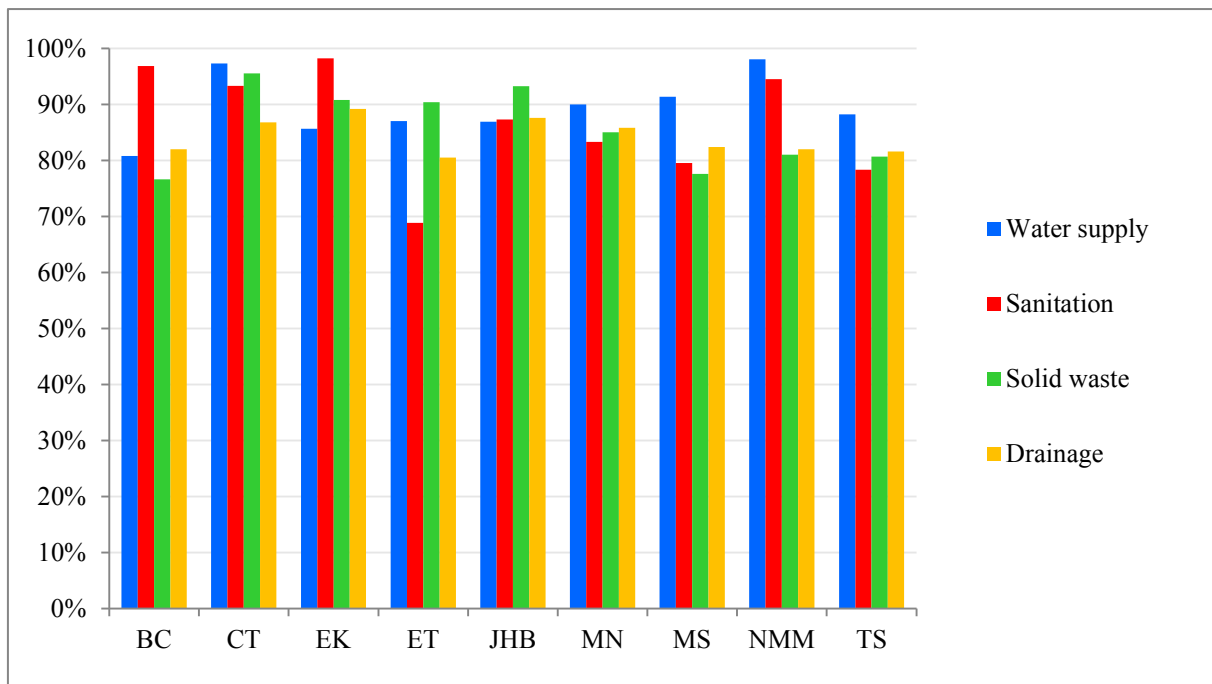


Figure 6.4: LOS variable scores

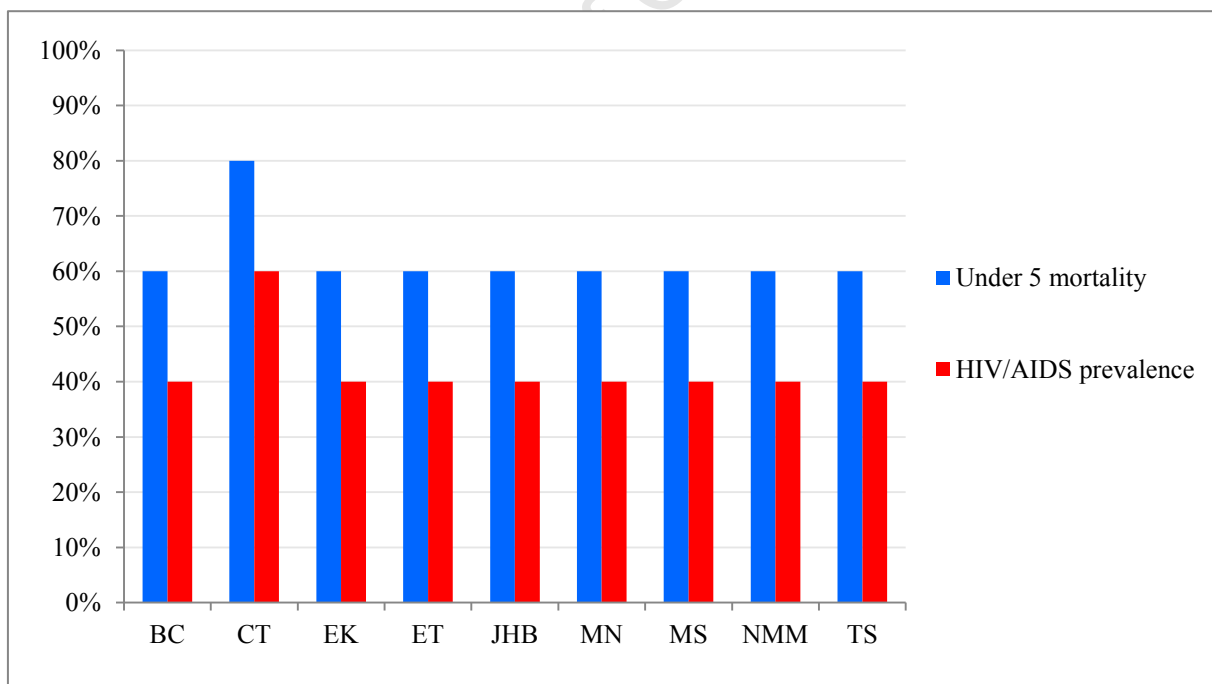


Figure 6.5: Health variable scores

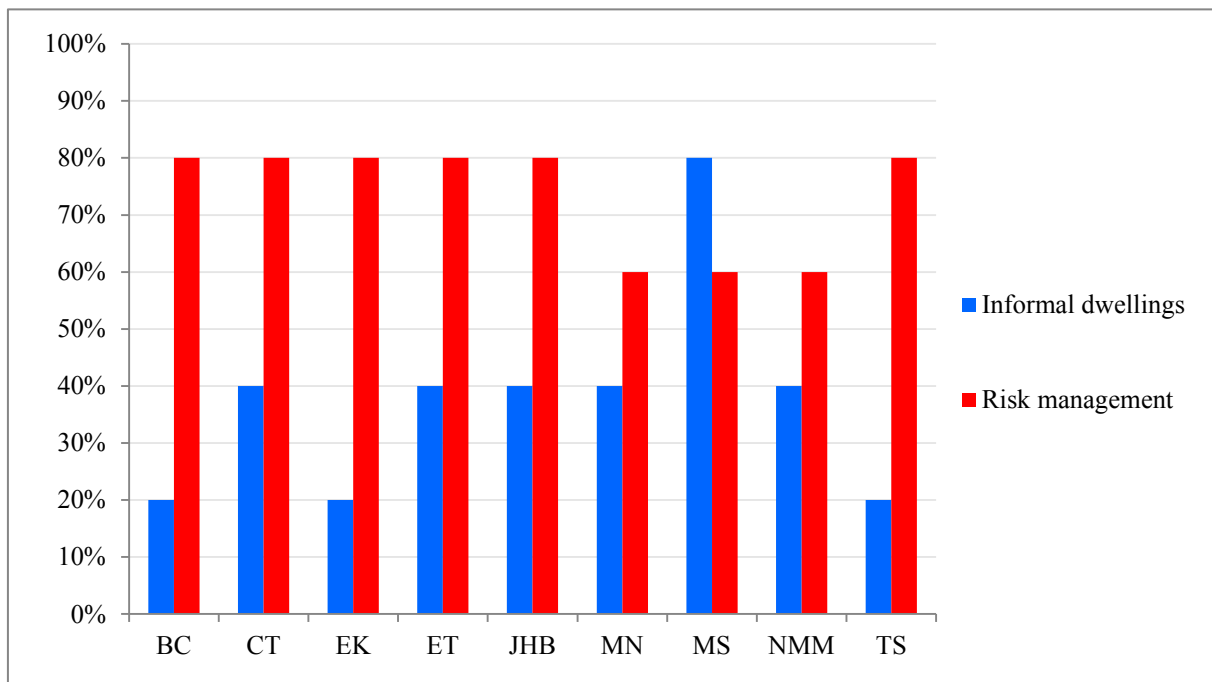


Figure 6.6: Vulnerability variable scores

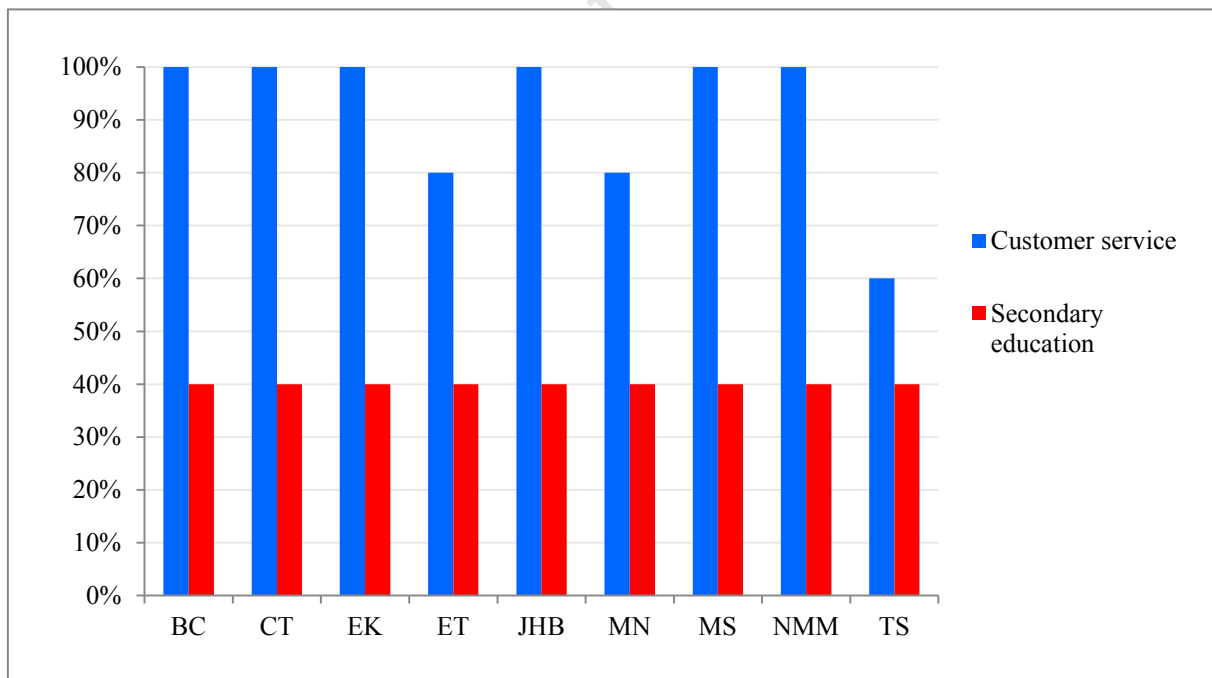


Figure 6.7: Skills and awareness levels variable scores

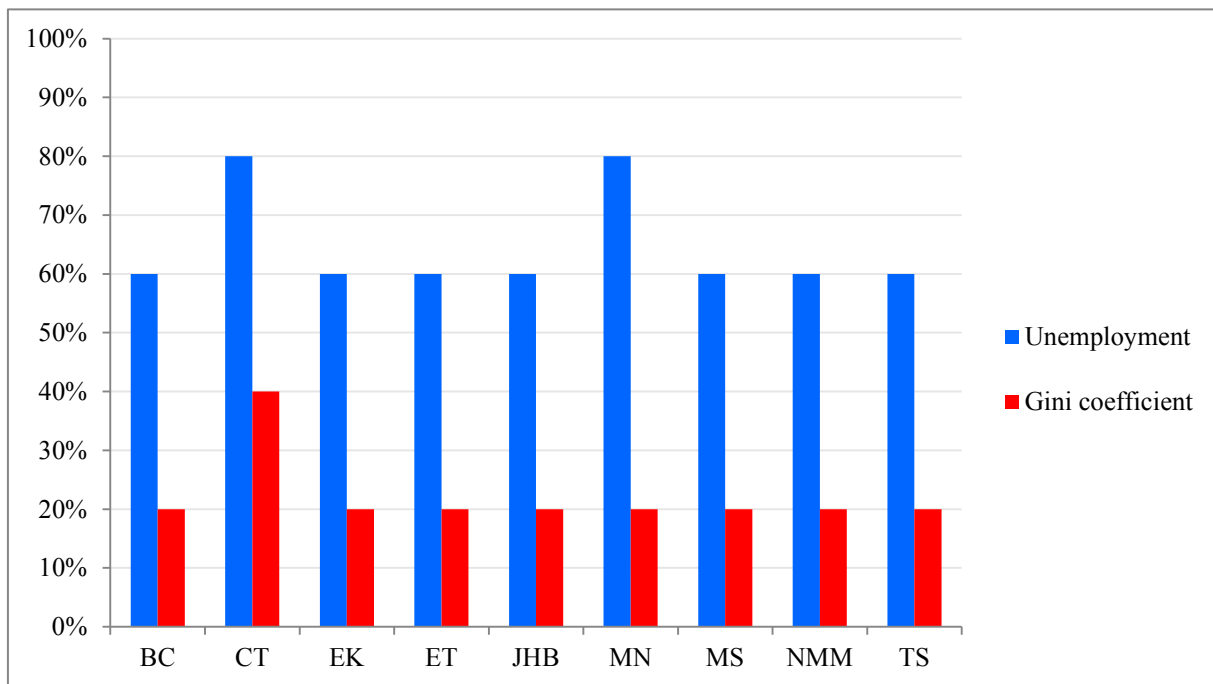


Figure 6.8: Capacity to pay variable scores

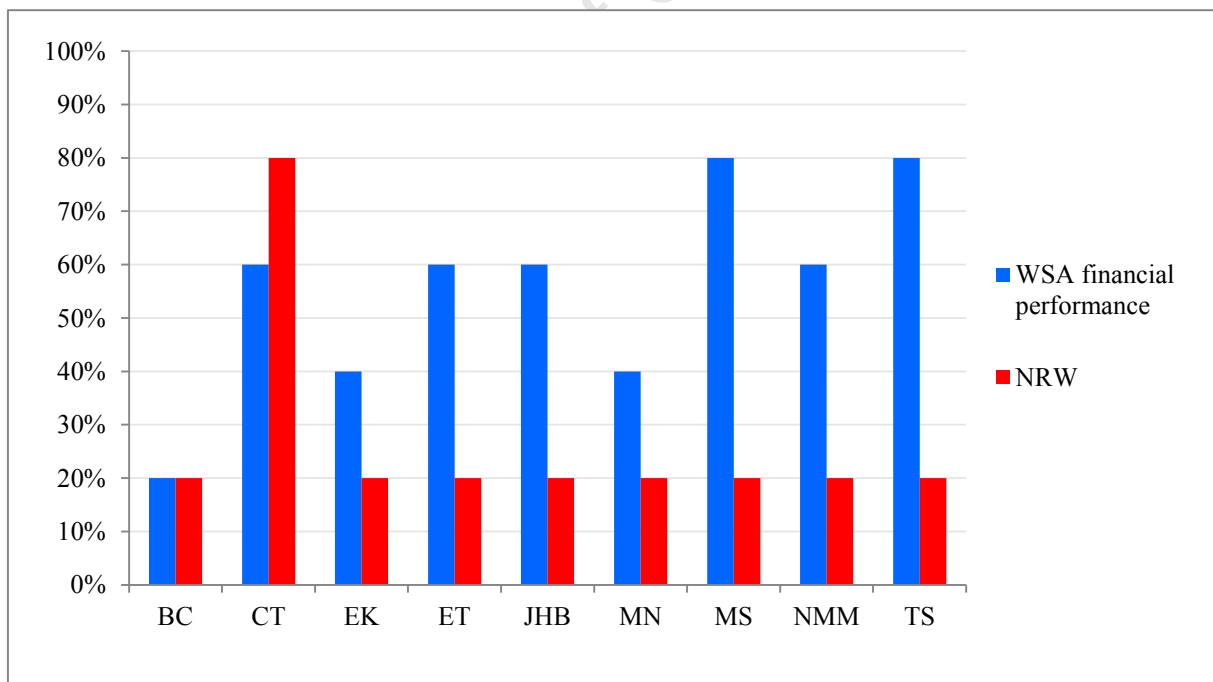


Figure 6.9: Cost recovery variable scores

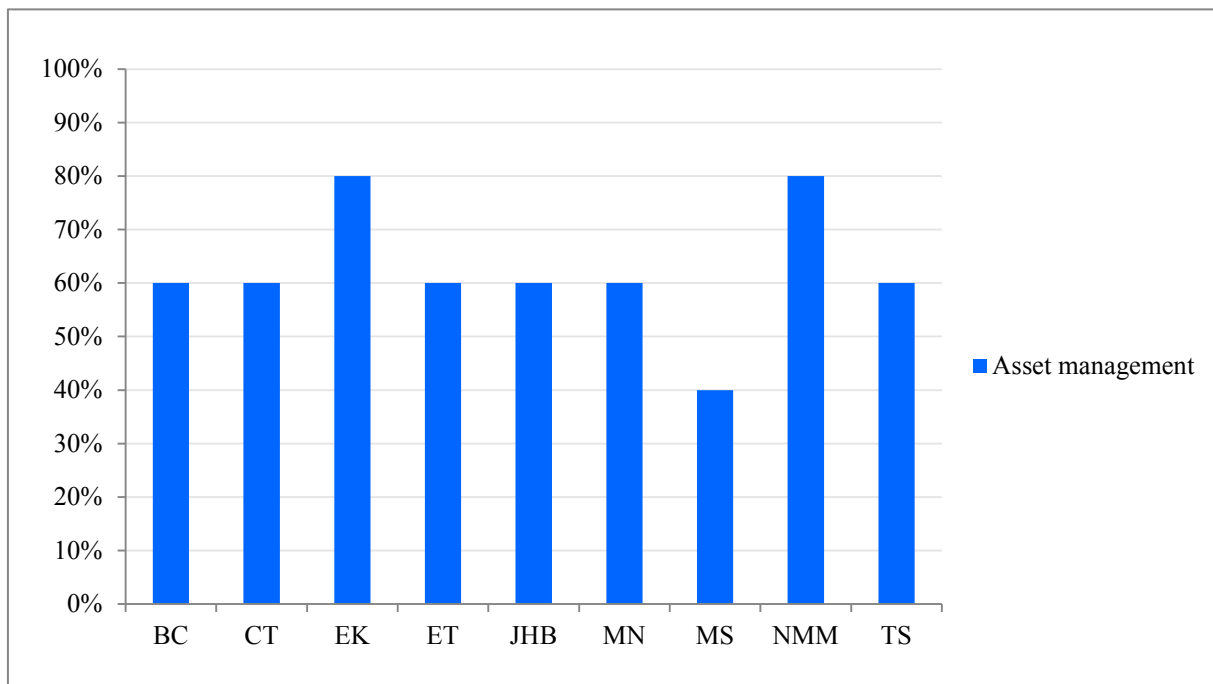


Figure 6.10: Asset management variable scores

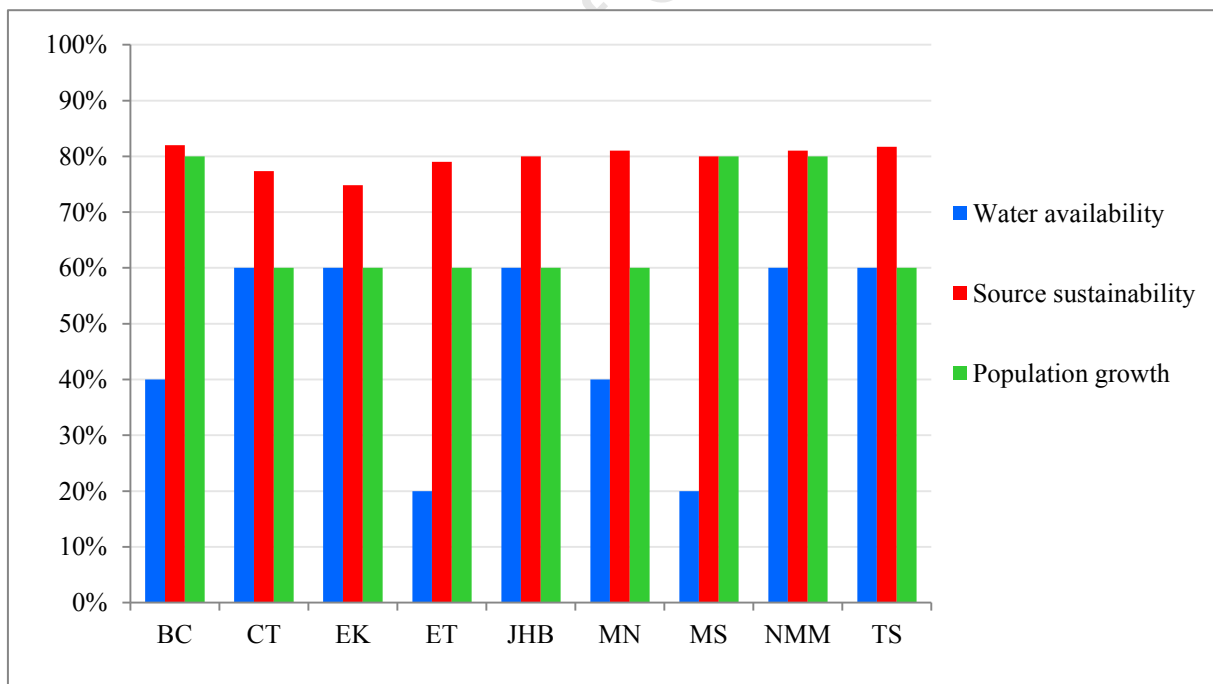


Figure 6.11: Resource quantity variable scores

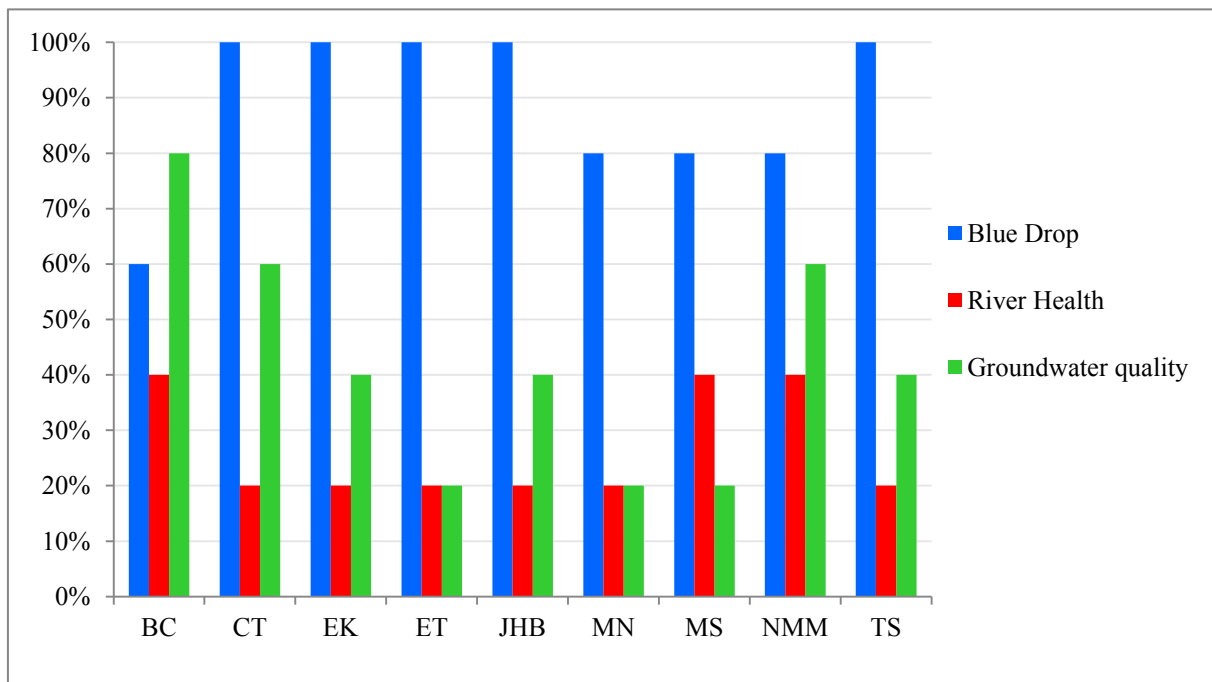


Figure 6.12: Resource quality variable scores

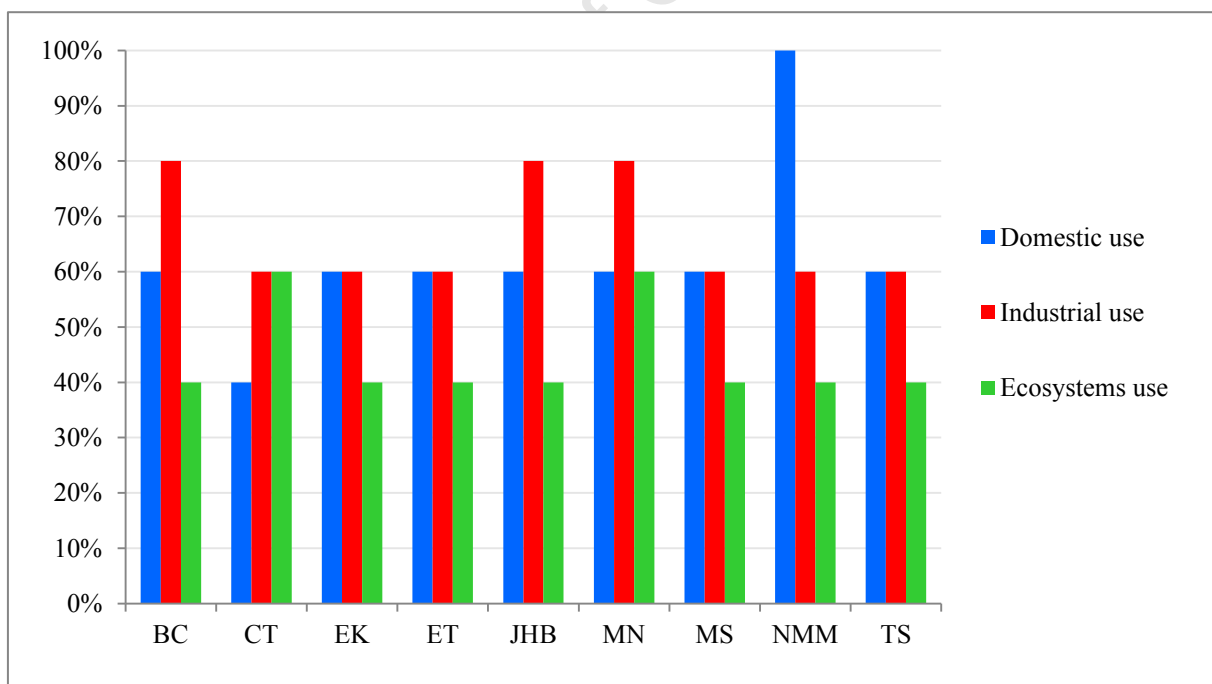


Figure 6.13: Resource distribution variable scores

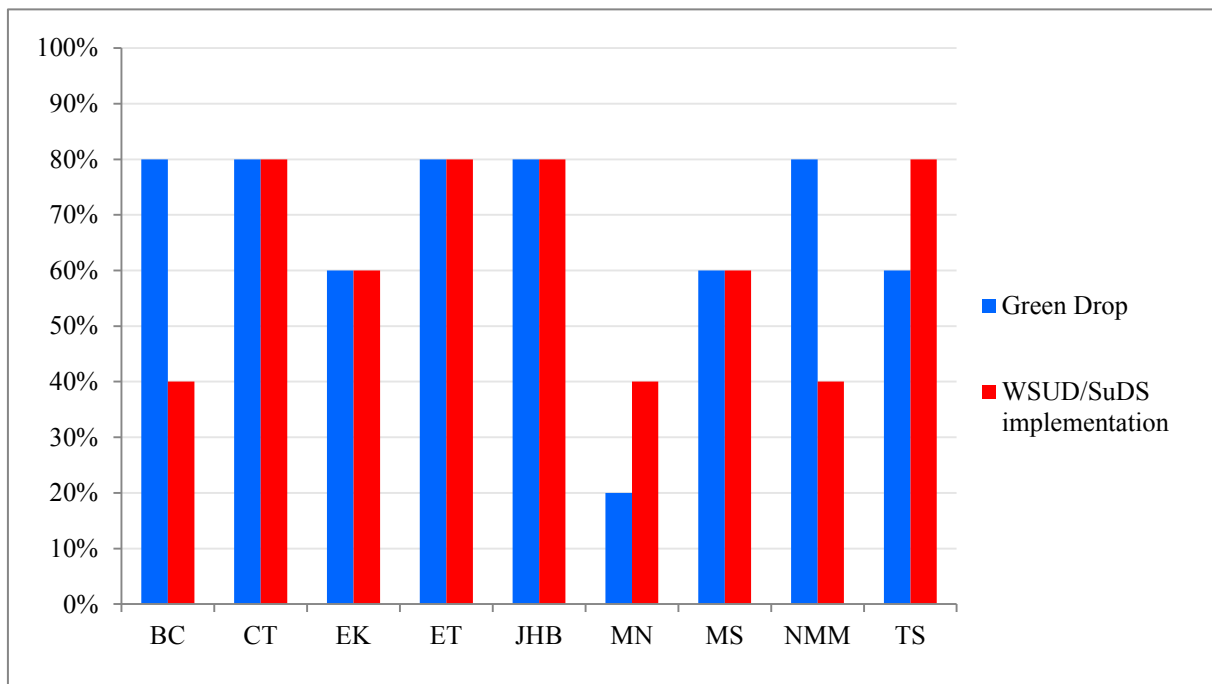


Figure 6.14: Wastewater / stormwater variable scores

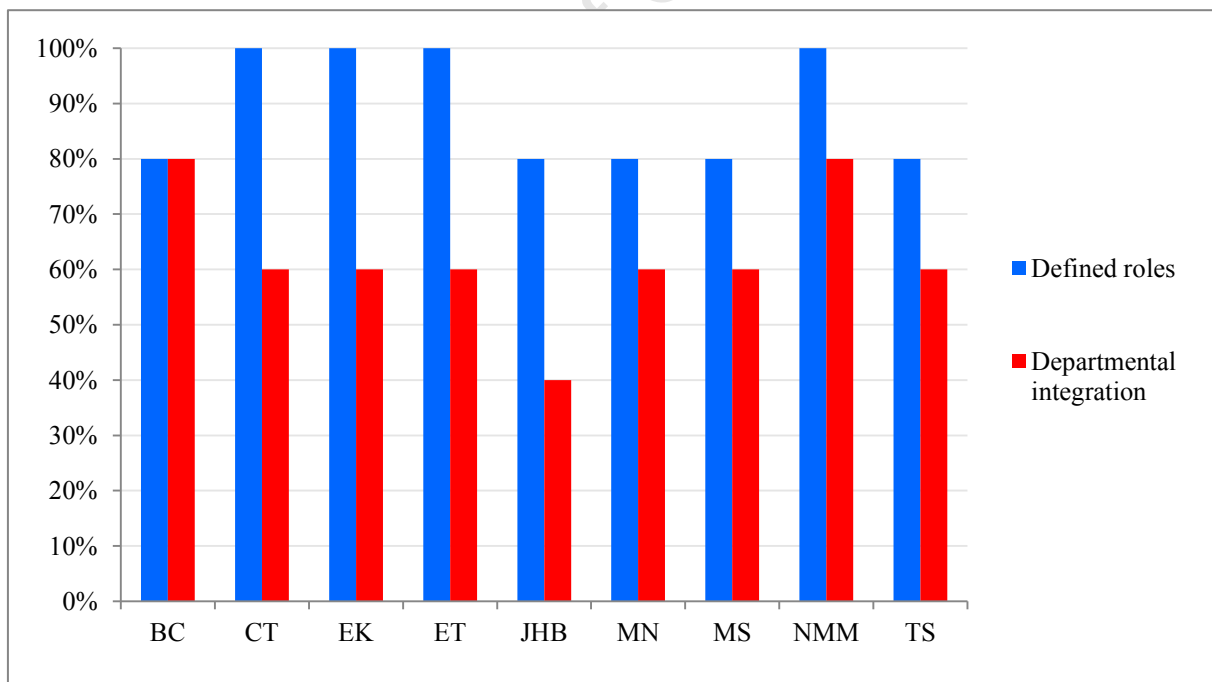


Figure 6.15: Governance model variable scores

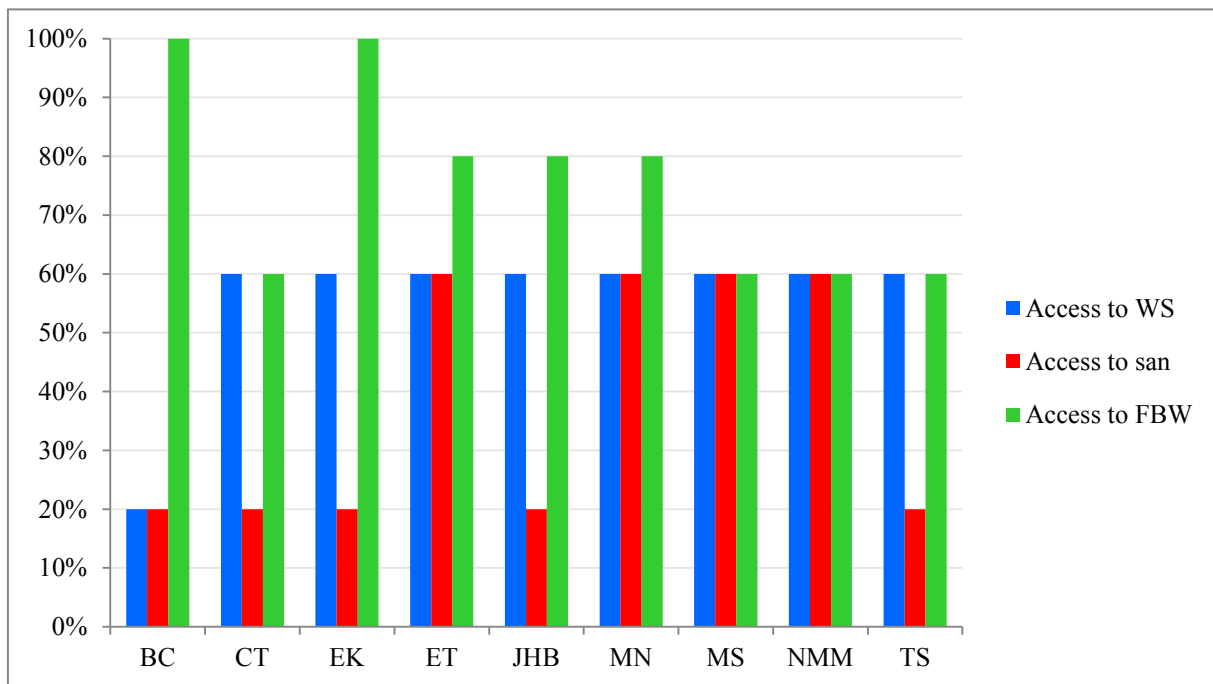


Figure 6.16: Meeting targets variable scores

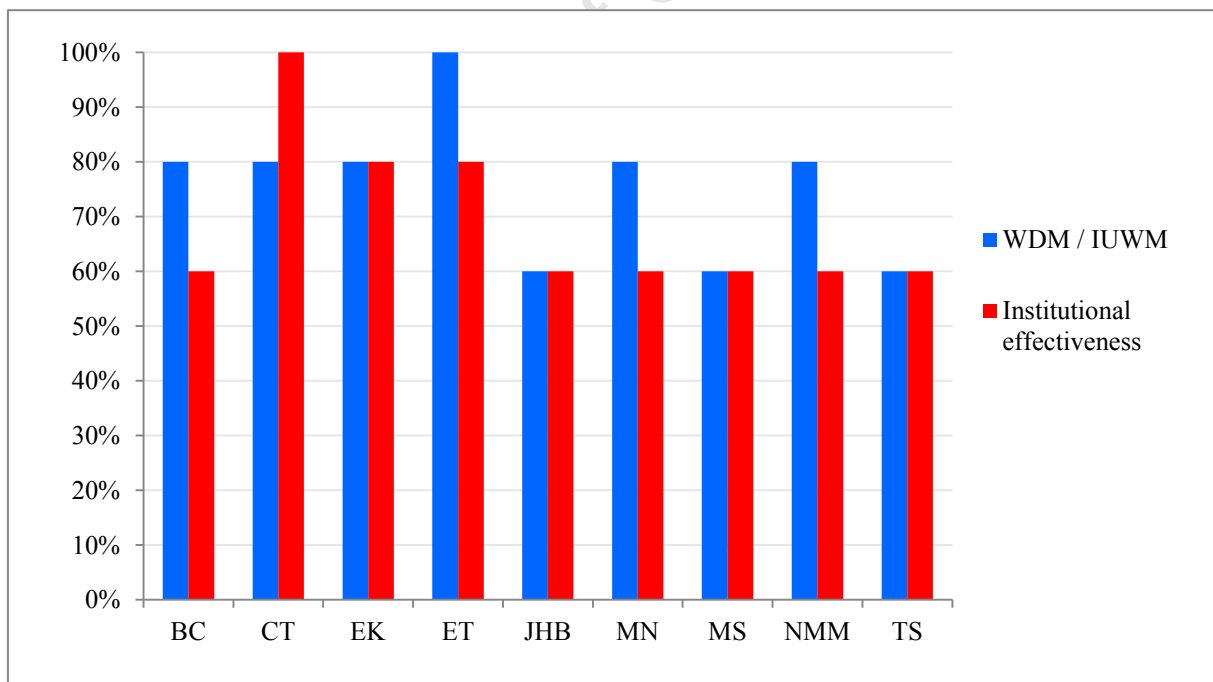


Figure 6.17: Institutional capacity variable scores

6.2 Evaluation of the index results

The overall scores conform to expected performance levels in most cities, with the possible exception of eThekweni where a better SIUWM result was expected based on their accomplishments in other benchmarking initiatives. However, on closer scrutiny of the index results, the reasons for their slightly poorer performance in terms of overall sustainability became clearer (see Appendix G4). The results attest to the robustness of the index and to the value of an analysis such as this which provides more than just an assessment of performance in individual areas of the urban water business.

It should be borne in mind though that the index development and application process is inherently biased and the need for qualitative or judgment-based decisions makes it inevitable that it reflects the views of those involved in its development. The aim is to keep this subjectivity to a minimum and clearly state where the case arises. The issue of what exactly constitutes a sustainable urban water system is a widely and hotly debated one, with no general agreement on what this is. In particular, the somewhat arbitrary scores from a once-off assessment such as this can only begin to contribute to a sustainability direction analysis once a time-series of results have been developed. It is also acknowledged that the assessment of sustainability of water systems by themselves – i.e. without consideration of the interactions with other urban systems, e.g. electrical – is likely to attract criticism. The SIUWM scores should therefore be considered as relative only to the vision of sustainability that was established, and which was used to select and develop the specific indicators for the index – and any reference to ‘potential for sustainability’ should also be considered with this in mind.

In order to simplify the process of interpreting scores, Figure 6.18 categorises the range of SIUWM scores into an easy-to-understand ‘traffic light’ diagram, which has been used to characterise the case study cities for the current assessment as per Table 6.3.





Category	Index score	Interpretation
	0% - 30%	no potential for sustainability
	31% - 60%	low potential for sustainability
	61% - 75%	reasonable potential for sustainability
	76% - 100%	considerable potential for sustainability

Figure 6.18: Traffic light diagram to categorise SIUWM scores

The colours representing the SIUWM scores provide an indication of a snapshot of progress towards meeting the vision of sustainability with respect to urban water management. The divisions in the colour categories have been determined in a similar manner to those adopted for the indicator / variable scoring system as described in Appendix C, which were based on the

comparison of results with sustainability targets. Essentially the categorisation shown in Figure 6.18 represents the expected SIUWM results from a range of indicator scores. A red classification shows that there is no potential for sustainability given current activities in a particular urban water management system. Similarly, orange and yellow classifications highlight situations where the current state is starting to support a move towards sustainability. A green classification represents an urban water system that has considerable potential for achieving sustainability. It should be noted however, that a green classification does not necessarily indicate the absence of vulnerabilities altogether, but rather a continued effort towards sustainability.

Table 6.3: SIUWM component scores for SACN cities

City	Overall SIUWM score (%)	Category	Measure of sustainability
Buffalo City	51	Orange	low potential for sustainability
Cape Town	65	Yellow	reasonable potential for sustainability
Ekurhuleni	56	Orange	low potential for sustainability
eThekweni	58	Orange	low potential for sustainability
Johannesburg	55	Orange	low potential for sustainability
Mangaung	52	Orange	low potential for sustainability
Msunduzi	54	Orange	low potential for sustainability
Nelson Mandela Metro	60	Orange	low potential for sustainability
Tshwane	53	Orange	low potential for sustainability
Average score	56	Orange	low potential for sustainability

As can be seen from Table 6.3 – and not unexpectedly based on the challenges that have been highlighted – all but one of the cities (Cape Town) falls into the category ‘low potential for sustainability’ for the period of assessment. This snapshot analysis is therefore able to highlight those characteristics of the urban water management system that may impact on its ability to maintain and improve upon its transition to a more sustainable state. Actual progress with respect to moving to a sustainable state can however only be measured by way of comparisons of city results over time.

6.3 Validating the results against other indices

It is suggested that comparing the SIUWM results against other appropriate water indices (such as, for example, the City Development Index and the Enhanced Water Poverty Index) could help in identifying targets for sustainability and provide a validation of the assessment approach that has been adopted. However, as discussed in Section 5.2.6, this would require a more directly-focused data collection process and was not achievable as part of this current research (see also Section 8.2 for a recommendation in this regard). Instead, a more general

comparison was carried out of the average SIUWM component results obtained for the nine case study cities against some globally-recognised indices (Table 6.4). Owing to the fact that there is a dearth of indicators in this field of urban water management, particularly at city scale, national index scores were used.

Comparisons were carried out across the four components of sustainability, and therefore the comparative indices selected were largely relevant to one of these components. For the social dimension, the Human Development Index (HDI) was selected; for economic considerations the Gross National Income (GNI) Index was used, as well as the Inequality adjusted HDI (IHDI); and for environmental concerns, the Environmental Performance Index (EPI). In the absence of global indicators which are indicative of institutional well-being, subsets of the 2005 Environmental Sustainability Index (ESI) which represent the following aspects were used: global stewardship, linked to political leadership; and social and institutional capacity, indicative of institutional and technological capacity.

Table 6.4: Comparison of average SIUWM component scores and SA country scores for related indices (¹UNDP, 2011; ²Yale, 2010; ³Yale, 2005)

SIUWM component	Average SIUWM city score	Similar indicator scores		Notes
Social	60%	0.619 ¹ (61.9%)	Human Development Index (HDI)	HDI measures the level of development of a nation.
Economic	43%	0.65 ¹ (65%)	Gross National Income (GNI) index	GNI per capita expressed as an index using a minimum value of \$100 and observed maximum value over 1980-2011
		0.409 ¹ 40.9%	Inequality HDI (IHDI)	IHDI measures loss in income due to inequalities in income.
Environmental	57%	50.8% ²	Environmental Performance Index (EPI)	The 2010 EPI ranks 163 countries on 25 performance indicators tracked across ten policy categories covering both environmental public health and ecosystem vitality.
Institutional	64%	54% ³	Social and institutional capacity (ESI)	ESI Social and Institutional capacity measures environmental governance, eco-efficiency and science and technology capacity.

This assessment indicated that there is generally good correlation between the average results obtained for the case study and their relevant country scores for other indices. There are some differences in the economic dimension scores for the SIUWM and those obtained from the GNI. This is however explained by the fact that the Economic component in the SIUWM comprises not only aspects of income and purchasing power, but also those relating to capacity

and ability to pay for services. The IHDI therefore provides a more accurate picture in this regard in the SA context.

The relatively minor deviation in the scores for the environmental dimension could be as a result of the fact that the EPI takes into account national assessments of a number of resources and resource management strategies, which are not represented in the SIUWM. The institutional dimensions also show some discrepancies, but this could be explained by the differences in indicators selected to assess these components, as well as the differences in the date of evaluation. Where the SIUWM components look to a more local level assessment, the indicators extracted from the ESI follow global and national trends in management and policy.

Overall the scores were within reasonably close ranges, leading to the deduction that the results obtained are likely to be largely representative of the current situation and therefore so is the sustainability index.

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7. Discussion and conclusions

“Sustainability is essentially about linkages, interconnections and interdependencies. The concept...is a challenge to conventional thinking and practice, and represents a need for positive alternatives to the present unsustainable path we are on” (Gibson, 2005)

Urban studies have undergone a fundamental shift from the dominant disciplinary influences of the latter half of the last century (i.e. history, politics and planning) and the city as an object of analysis in itself is no longer in vogue (Parnell *et al.*, 2009). Urban studies are now more focused on concepts such as ‘economic geography’, ‘resilience theory’ and the ‘politics of consumption’, which has ushered in a more systems-oriented way of thinking and changes to the way data is gathered and interpreted. Consideration of the complexities of society (particularly from a developing world perspective), the understanding of issues of informality and poverty, and cause-effect relationships have thus become more relevant. The latest Human Development Report (UNDP, 2011) for example, focuses on the challenge of sustainable and equitable development as “...the expansion of the substantive freedoms of people today while making reasonable efforts to avoid seriously compromising those of future generations”. Rising HDI figures worldwide have generally been associated with significant environmental degradation – largely traceable to economic growth and increasing per capita incomes – although there are countries who have achieved progress in HDI as well as equity and environmental sustainability. The Human Development Report notes that traditional methods of assessing environmental policies fall short; they might expose future environmental impacts but they are often silent on distributive issues, and broader equity concerns need to be brought into policy-making through stakeholder involvement (UNDP, 2011). Democracy is important, but beyond that, local and national institutions need to be accountable and inclusive, so as to empower and enable civil society. One of the recommendations from the HDR is thus that coordinated implementation, monitoring, reporting and verification systems are required to bring about long-term, efficient results and accountability to all stakeholders.

The sustainability assessment process needs to be well-informed so that implementation strategies have buy-in, are relevant and far-reaching (Pennington, 2010). It requires a clear understanding of sustainability as an agreed societal goal, defined by criteria which separate sustainable outcomes from unsustainable ones. A critical aspect of this research was therefore the development of a vision of sustainability as it relates to the provision and management of urban water services in South Africa.

Another important aspect of the research has involved the question of how best to ‘measure’ sustainability in the context of urban water management given the limited availability of reliable, regularly-updated and easily-accessible data. Once the vision had been determined, it was developed further into a framework to depict the various sustainability challenges in the sector and to help finalise the selection of indicators and data sources. There followed an extensive appraisal of what constituted key indicators, and how these could link

with the various regulatory assessment initiatives already underway in the South African water sector to form a common indicator set. It was decided to use the various key performance indicator results from the Department of Water Affairs' Regulatory Performance Management System (RPMS) as input to the associated indicators for the Sustainability Index for Integrated Urban Water Management (SIUWM) – in this way, the benchmarking capability of the RPMS could be employed to provide a more detailed and integrated sustainability analysis of the urban water systems in question.

The following sections will briefly discuss the contributions of this research as per the objectives set out in Chapter 1.

7.1 Urban water sustainability in South Africa

The development of the SIUWM has contributed to a better understanding of sustainability in the context of urban water management in South Africa. This has been achieved by way of the research effort and the discourse resulting from the assessment of overall system performance as well as that of the urban water system components and sub-components, thus enabling an analysis of the chain of causes and effects in the system. The visioning process also highlighted the 'leverage points' for moving towards sustainability.

The overall index results for the case study cities showed that, in a snapshot analysis based mainly on 2010 data and on the agreed vision of what sustainability might mean in this regard, the nine metropolitan areas in South Africa are displaying very limited potential for sustainability. It is clear from the results of the SIUWM assessments that urban water systems in SA are not homogeneous entities however, there are areas of poor performance and also areas of good performance; the challenge is to focus on what can be learned from these variations. It is postulated that the governance focus in the water sector has (unsuccessfully) been on "*designing highly sophisticated water management strategies and then attempting to build the capacity to implement them*" (Schreiner *et al.*, 2009), highlighting the fact that introducing new and complex governance systems can make capacity challenges all the more difficult. This has significant knock-on impacts on the sustainability of water services; for example, a lack of capacity to take water projects through to implementation has been cited as one of the main reasons for the systemic failure of municipalities to spend their resources effectively (RSA, 2011a). Likewise, the South African Local Government Association (SALGA) has identified several key factors affecting municipal performance with respect to service delivery, including the ability to attract and retain skilled staff, and the poor management of (insufficient) funding. The lack of technical skills in the sector is a problem for both implementation and maintenance of water services. This has also had serious environmental consequences and, without a radical change to the way in which urban water is managed in SA, the progressive worsening of water quality in core water supply systems has the potential to further undermine social and economic development in the country (CSIR, 2010).

Systems thinking and integrated planning approaches are key to the sustainability of any water services delivery / management program. This thesis was based on the assumption that sustainability is not possible unless there is proper integration within and between the management structures for urban water. An example of a holistic approach to water management that incorporates systems thinking and a solution-oriented, integrated planning approach is highlighted in a recent quote by the Director of Water Services at Gert Sibande District Municipality in Mpumalanga Province, South Africa, “*We are excelling because we work as a team, from political heads downwards. We do not use the top-down approach; we are equal partners and players operating horizontally. We see ourselves as a family of municipalities in a District with the vision to meet the expectations of our communities*” (WIN-SA, 2010). It is suggested that sustainability assessment is of itself a key driver of change; i.e. it promotes more sustainable practices and can also accelerate the process of establishing new policies and regulations in this regard. If one part of a system is not working, it does not necessarily mean that the whole system is failing – but it can indicate what needs to be fixed. It follows that the process of sustainability assessment such as is being promoted here, may also provide the ‘link’ between the various structures to enable more sustainable practices in urban water management, and in particular provide the impetus for setting up the required data collection and monitoring systems.

There is still room for greater integration of the water supply, stormwater and wastewater components of the urban water cycle in South African cities, but it is in the non-technical areas where the most significant changes can be made; i.e. information dissemination, skills enhancement, and performance assessment. Sustainable urban water services require a wide range of technologies, actions and behaviours, and IUWM solutions can take many forms, tailored to the specific requirements of the urban environment in which they reside. The results from the SIUWM analysis are intended for use as a tool to try and correct priorities in terms of the sustainable provision of water services by highlighting areas where more targeted interventions need to be made. In particular, it would appear that large-scale infrastructure systems are not going to be the solution to sustainability issues in South Africa; and that community-driven initiatives and local-scale options should be incorporated into decision making and policy. This is in line with recent thinking and increasing research into self-organisation as a structural characteristic in the provision of water and sanitation services; e.g. by way of community-based processes such as the household-centred environmental sanitation (HCES) approach. HCES is a multi-sector planning approach geared towards service delivery in poor urban areas which integrates water supply, stormwater and sewage management and utilises the concept of urban zones for enhancing the implementation of decentralised options (Luthi *et al.*, 2009).

The continued presence of large numbers of informal settlements in the urban areas of SA is likely to undermine any efforts to implement IUWM at scale. At the same time, the current housing policy in South Africa also does not appear to support sustainable urban water management and needs to be reconsidered if water sensitive cities are the ultimate goal. There are two aspects to this: the first is that the notion of housing being considered a basic right – as

articulated in the ANC's Reconstruction and Development Programme (RDP) in 1994 (Huchzermeyer, 2001) – is unlikely to solve the problem of informal settlements. The 1994 Housing Paper includes tenure and services in the provision of adequate housing stock (bungalow-type RDP housing on separate plots to each family), which is mainly driven by the funding policies for RDP housing (Huchzermeyer, 2001). Whilst the Government has had good intentions regarding the provision of housing, there are large backlogs and it is possible that other models like 'site and services' (in which residents construct housing themselves) could be more effective. Also, money for top structures may well be better spent on delivering water and sanitation infrastructure / services; research has highlighted the positive impacts of this type of investment on health, education and income and housing, with residents more likely to invest in housing themselves (Parikh, 2008). The South African Cities Network Report also questions the notion of RDP housing solving the informal settlement problem by suggesting that there are complex social, political and economic reasons behind the formation of these settlements and merely providing subsidised or free housing might not be the solution: "*The demand for subsidised housing will always remain inflated until every person eligible for a subsidy has received it*" (SACN, 2006).

Secondly, there is the issue of the sustainability of the RDP housing policy in the context of water sensitive cities; the requirements for which are unlikely to be met unless cities become denser and more efficient with respect to the provision and management of water services. It has been postulated that densification is a means towards more compact, efficient, sustainable and just cities, but it is not taking place in South Africa owing to prejudice, political resistance, policy constraints, and supply-side issues (Boraine, 2009). SA is experiencing painfully slow development of public land due to the complexities of dealing with four very different strategic elements; i.e. human settlements, land use, economics and spatial development / transport. Urban water management is also based on this current notion of the 'city' – but if the level of housing sprawl continues, with its widely-distributed reticulation networks, low levels of recycling and high levels of water losses, there will be fewer chances of attaining sustainability.

7.2 SIUWM as an advocacy tool

As a middle-income developing country with fragmented water management structures and massive social inequities, South Africa has not yet developed guidelines or a framework for transitioning towards water sensitive cities, although this is the subject of current research (Fisher-Jeffes *et al.*, 2012). It is acknowledged that the integrated approaches offered by concepts such as Water Sensitive Urban Design (WSUD) – or the recent European Union Seventh Framework Programme (FP7) project "Transition to urban water services of the future" (TRUST) – could offer a way forward in terms of achieving multi-objective, liveable cities in SA (Ward *et al.*, 2012). For this to become a reality, however, the vision for sustainable urban water management and the decision-support tools aimed at informing the process need to be widely shared within a trans-disciplinary governance context. This is supported by the recommendations from the latest State of the Cities Report (SACN, 2011) on

the need to reshape and reconfigure cities by way of strategic planning and investment. Prior to making these planning and investment choices, decision makers need to be made aware of the performance of the various city ‘systems’. An improved evidence base and understanding of urban trends is thus required; national government needs to commit to improving the availability of municipal-level data (on all aspects of sustainability), and every city should have some kind of ‘observatory’ function to assemble information, monitor important trends, conduct research and evaluate policy.

It is suggested that the development of the SIUWM is thus timely in terms of where SA is headed with respect to the consideration of a sustainable future, and provides a more integrated response to issues of water scarcity and management than the benchmarking and regulatory performance initiatives which mainly address water utility operational issues. Through its visioning process (and potential links to existing strategic municipal self-assessment processes), the SIUWM is also able to identify vulnerabilities in the water system and provide information that is potentially useful for mitigating the root causes of these problems. This information can help urban water managers to prioritise the development of strategy and policies for implementing sustainability approaches. In other words, it can be used as an advocacy tool to help decision makers establish urban water sustainability objectives and promote resilience of the urban water management system.

7.3 Benchmarking vs. sustainability assessment

“...we do not need new tools, we already have many. What we need is to apply the ones we already have and take the most advantage of their potentialities” (Tabara et al., 2008)

An analysis of the usefulness of indicators in assessing sustainability and in informing the linkages (integration aspects) in urban water systems has been undertaken by way of a comprehensive examination of the different indicator approaches in the SA water sector, and their links to sustainability assessment.

It has been claimed that benchmarking systems lack an articulated theoretical and contextual definition of sustainability and a clear epistemological link between the definition and indicators (Davidson, 2010). This is especially relevant in a developing country such as South Africa where a context-specific interpretation of sustainability needs to take into account social and institutional issues such as poverty alleviation, strengthening democracy, skills levels, biodiversity conservation etc. As Nleya (2008) puts it, *“Perhaps the biggest water and sanitation problem is how to achieve the triple objectives of efficiency, equity and sustainability”*. In order for water services to be sustainable in this context, economic growth has to be targeted towards the equitable distribution of benefits (i.e. the needs of the ‘poor’) as well as being sensitive to the needs of the environment.

None of the existing compliance monitoring and benchmarking initiatives provide the required information to make predictions about the potential sustainability of urban water

systems in South Africa, even though they can highlight their performance as business units. For example, data on the numbers of toilets provided in a city is all very well, but it does not give an indication on the state of those toilets and how they are operating, and what the levels of access actually are. “*Access to a toilet is of no use if the toilet no longer works*” (DHS, 2011), and similarly, the presence of a toilet is of no use if it is locked and the people for whom it is intended are denied access. A city’s water services may seem to be operating ‘efficiently’ in terms of the regulatory requirements, but if a significant proportion of its residents do not have access to services, the urban water system is not sustainable. The RPMS and Blue Drop / Green Drop initiatives have great intentions, and are ‘good’ systems, but they are also not necessarily fair assessments of the smaller / local municipalities who often do not have the skills or capacity to be able to provide the information required. Benchmarking systems such as the RPMS show that Metros outperform the other WSA categories for most of the indicators measured and small towns on average are the worst performers. This is mainly as a result of the financial component, with staff costs being higher, % sales lower, and debtor days higher in small towns. Thus, owing to the fact that these smaller municipalities are being measured based on their capacity and financial constraints, the numbers do not necessarily show that water or effluent quality is improving or not. As one district municipality official put it, “*it’s like competing in a horse race when you are riding a donkey*” (Gcali, 2011). Interestingly, the fact that Metros perform best in the benchmarking initiatives does not necessarily mean that they are more sustainable than the smaller urban centres – the integrated sustainability framework of the SIUWM allows the inclusion of other elements that add another dimension to the analysis thereby taking it a step further than benchmarking processes.

In the same vein, it is all very well to know for example, that a city’s sanitation infrastructure is meeting wastewater quality regulatory standards (and is awarded Green Drop status), but what about the volumes of untreated sewage and greywater being discharged into the environment from the significant proportion of the population without access to sanitation? It is often the case that actual access to services is considerably worse than the indicators used to monitor progress towards the targets seem to imply (McGranahan & Satterthwaite, 2006). There are thus important limitations to the use of benchmarks as a guide to policy as they do not consider important interactions between the various components of the urban water system. Similarly, it is not enough to only consider regulatory requirements if the intention is to show whether an urban water management system will be sustainable into the future. In order to be able to gauge the potential for sustainability, an integrated assessment is required which could highlight issues and trends over time, which may not be obvious at first glance from benchmarking figures. The SIUWM is able to do this by linking the annually-published results from the various other monitoring systems and using these to highlight crisis areas that could contribute to ‘unsustainability’, as well as priorities for action by decision-makers – provided, of course, that it is indeed applied on a regular basis in order to track changes in the aggregated scores which would reflect sustainability changes. The SIUWM results should be compared with other sustainability assessment initiative results in order to interpret them effectively and verify targets for sustainability. The results of the SIUWM analysis can be used to:

- Identify some of the less obvious water-related issues being experienced by cities by way of the systems approach that has been adopted to evaluate urban water management.
- Refine and coordinate service improvement programmes by providing results-based performance measurement and trends at indicator and/or variable level.
- Inform strategic processes designed to improve management performance.

Benchmarking initiatives make use of silo approaches (generally per service), while the SIUWM aims to be cross-cutting; it not only assesses the technical side of water services, but institutional and social aspects also. It can be used to highlight key urban water management issues and priorities for action by decision-makers. The SIUWM is not only a benchmarking initiative – the system is complex enough to take into account different stakeholders views, which are used to promote a sensible dialogue and ensure legitimacy of the process. This can then be utilised for strategic planning purposes towards an integrated urban water management approach, ultimately aimed at transitioning to water sensitive urban areas.

7.4 Impact of sustainability assessment on decision-making

Despite a wealth of knowledge about conducting and preparing State of Environment Reports (SoERs) and other performance measurement systems, there has been little research on the effect these assessment processes have on local-level decision-making. Retief *et al.* (2011) conducted a South African-based study on the effectiveness of such tools in relation to their effect on different tiers of decision-making and found that, specifically with respect to SoER, the process has limited effect beyond the environmental function. This is partly attributed to methodological issues with respect to designing criteria against which to evaluate effectiveness; usually by way of qualitative case study-based approaches. It is postulated though that the main reason for this limited effectiveness is that the assessment is viewed as a single event or product and not as a continually updated database or decision support system, and therefore informs decision-making only on an *ad hoc* basis (Retief *et al.*, 2011). There are two main challenges for improving the effectiveness of this sort of reporting at municipal level:

- i) Data – availability, cost of data collection, verification, analysis, and interpretation.
- ii) Dissemination of results within the organisation – there is a general lack of interdepartmental communication.

Retief *et al.* (2011) contend that one of the ways in which this could be addressed is to align the specific assessment process with various other status quo reports compiled by the municipality, by way of an integrated information system between various departments. Cooperative governance (horizontally, within municipalities, and vertically, with other departments at provincial and national level) is crucial in this regard (Retief *et al.*, 2011). With this in mind, and in order to succeed in informing policy at municipal level, the SIUWM was therefore

linked to the regularly-updated performance measurement initiatives undertaken by national Government.

The implementation of a tool such as the SIUWM could be undertaken at both national and local government level. Discussions with officials from the Department of Water Affairs (i.e. national government), responsible for the management of the Regulatory Performance Measurement System (RPMS), were initiated in early 2011 in order to ascertain their interest in using / adapting the SIUWM to link existing initiatives and provide an integrated sustainability assessment for the urban water sector. While the preliminary responses from DWA were positive, dialogue in this regard has been delayed pending the re-launching of the SALGA / WRC National Municipal Water Services Benchmarking Initiative (NBI). As discussed in Chapter 5, challenges were raised at the NBI workshop held in October 2011 in respect of the current regulation *vs.* benchmarking model, and the associated difficulties with indicator selection and data standardisation and gathering, specifically in smaller urban centres. This conversation will be restarted once further information is available on the status of the NBI, and whether there will be consequent impacts on the RPMS.

At local authority level, the SIUWM could be used as an advocacy tool towards the development of policy and for garnering support by politicians and/or funders to invest in water services. It is acknowledged that not all of the 278 municipalities in SA will have the in-house technical skills or capacity to conduct a SIUWM assessment, but this could be carried out in conjunction with the preparation of the five-yearly Water Services Development Plan (WSDP), which is mandatory in terms of Department of Water Affairs' requirements, and which is very often undertaken by private consultants. Linking the SIUWM results with the WSDP could also enable a clear identification of priority areas for improving the sustainability of the urban water system in question, and could result in a better-informed choice of indicators for input to the WSDP as well as other planning and policy documents (e.g. Integrated Development Plans). It is suggested that in order for a tool such as the SIUWM to be useful and used into the future, there should be a focus on:

- i) Legitimising it through the annual DWA RPMS and Blue / Green Drop processes by using it to create an overall sustainability measure linked to these (for example by possibly adding another or extending the Blue / Green drop scoring system); and/or
- ii) Combining it as an integrated sustainability assessment tool with local authority systems (including the vulnerability-based municipal strategic self-assessment (MuSSA) processes) aimed at achieving sustainability. In this respect it could form part of a 'Learning Alliance' process aimed at transitioning to water sensitive cities.

If the SIUWM is to be used effectively by water services authorities and/or municipalities to leverage politicians, it needs to be simple and transparent, it must be reproducible, and it must not be overly dependent on personal input and stakeholder participation. It is also important that the messages emanating from the index provide a positive outlook on the purpose of integrated urban water management for decision-makers; that they appeal to all stakeholders;

and that they create a platform for advocacy in this regard. Sustainability in SA is unlikely to be supported by politicians unless economic benefits can be shown, or there are clear links to development (e.g. through job creation). It is in this respect that the developing nation context is so different to that of the developed world where the idea of environmental sustainability generally does not have to be ‘sold’ to politicians and decision-makers – in SA, most of the focus at political level is on building houses, creating jobs and alleviating poverty. Owing to the fact that the SIUWM has been built around a SA contextual vision of sustainability however, the developmental linkages to the SIUWM results are easily highlighted.

It should be noted that simply looking at the overall results of a performance assessment and comparing cities with one another can be construed as contrary to cooperative governance, particularly if used in a ‘naming and shaming’ process. It is important therefore that structural and systemic issues are also questioned. The principles of IUWM as promoted through the index must engage decision-makers at both local and national level in such a way that they are encouraged to work together towards transforming the management of urban water services and instilling in water services authorities the confidence to address the challenges they face in a more sustainable way.

7.5 Concluding remarks

The concept of sustainability as it relates to sustainable water services is described by the South African Department of Water Affairs as a “*vision of a community’s future where the vision is community oriented and focused on long-term goals. It takes into account linkages between the social, economic, institutional and environmental aspects of the community*” (DWAF, 2008b). This research has hopefully advanced the debate further by investigating what sustainability means in the context of urban water management in SA, and specifically from a city-wide perspective. The call for a developmental state by the SA National Planning Commission (RSA, 2011a) is a step forward in addressing sustainability challenges in urban water services as their vision is one of transforming the public service and improving state performance through enhancing institutional capacity. In terms of this vision, all South Africans will have access to sufficient safe water and hygienic sanitation by 2030. As noted in Chapters 2 and 6, however, a critical lack of capacity and funding has seriously impacted on national and local government’s ability to control and manage the water sector. At municipal level in particular, political autonomy and the service delivery mandate granted by the Constitution have to be balanced within the realities of limited financial and human resources. It is likely therefore that in order to meet the goals that have been set, the decision will be taken to change to a ‘polycentric governance’ model; i.e. whilst local government will retain political responsibility for ensuring adequate service provision in its areas, regional authorities will provide services where municipalities have inadequate technical and financial capabilities (RSA, 2011b). Progress towards a capable, developmental state can be measured by improving performance at local government level, but it is essential that the national authorities responsible for water resource management coordinate their activities with local service providers, and monitor and

support them. It is suggested that one way of achieving this is by linking existing regulatory and performance measurement initiatives, which deal with only very specific aspects of water management, with a sustainability analysis based on a specified indicator framework which has the potential to include an analysis of interactions with other urban systems, such as electricity or transport. The development of a coordinated multi-dimensional sustainability analysis such as this at local government level, using national monitoring initiative outputs – by way of the SIUWM – could thus form part of this process towards an effective developmental state.

As was pointed out in the introduction to this thesis, developing a fact-based vision for the urban water sector is a critical first step to making a water sector transformation reform agenda possible (Addams *et al.*, 2009). Linking such a vision to action requires high-level energy and support however, as well as commitment from decision-makers at local and national level, particularly in respect of the regular collection and management of data required to inform such an exercise which addresses not only the technical aspects of water services, but the socio-economic and institutional aspects also. Once this has been achieved, policy makers, the private sector and civil society need to work together to put the transformation towards sustainability into practice, as the changing vision of governance will require policies to be put in place to support an infrastructure of sustainability, e.g. legislating approaches such as nutrient recovery, recycling, dematerialisation, re-engineering, and reuse (Jackson, 2009; Wilsenach, 2010). In effect, the challenge will be to specify and continuously refine new design criteria for cities – essentially engineered systems – based on the availability of resources and on socio-cultural-political demands. Keeping the visioning process current and linked to municipal strategic self-assessment processes is the first step towards building resilience and ensuring that what seems to be sustainable now will actually prove to be so in the future.

Sustainability assessment in the urban water sector, by way of initiatives such as the SIUWM, is not only about taking stock of progress – it is also about identifying shortcomings and challenges so as to contribute to initiatives and policy-making aimed at achieving sustainability. By clarifying what sustainability constitutes in the context of urban water management in SA through the use of a multi-dimensional approach to sustainability assessment (as is achieved by way of the SIUWM), the mindsets of decision-makers can hopefully be successfully shifted to embracing a more integrated approach towards sustainable urban development and water sensitive cities.

8. Recommendations

This research has highlighted several gaps in the way in which sustainability assessment is being approached in the urban water sector in South Africa, as well as possibilities for future research in this field.

8.1 Application of SIUWM

It is evident from the results of the case study analyses that urban water management systems in SA are not meeting the ideals of sustainability, and that the adoption of a more integrated approach (e.g. through IUWM) will be required if a move towards a more sustainable state is envisaged. It is recommended that multi-dimensional sustainability assessment such as provided by the SIUWM should be implemented by the institutions responsible for urban water management – water services authorities and local / national government – in order to inform and support this process. The following recommendations pertain to the application of the SIUWM by these authorities throughout South Africa:

- The annual determination of SIUWM results for all WSAs should be institutionalised by the local authorities concerned so that an analysis of trends towards sustainability in urban water management in SA can be established.
- Continued discussions with the Department of Water Affairs will be required to determine how the SIUWM can link with the annual activities of the RPMS and other relevant performance measuring / benchmarking systems in the sector. In particular it would be useful if the municipal strategic self-assessment processes could be incorporated to confirm the selection of indicators.
- The systems for data collection / storage concerning sustainability assessment initiatives in SA should be standardised so that duplication is avoided and rigorous checking of data is enabled; i.e. measurement uncertainties can be assessed and data can be checked and validated. This is particularly important for ensuring temporal validity within the assessment process. The concept of Urban Observatories needs to be revisited in this regard.
- The impasse between local authorities (involved with the benchmarking processes) and the DWA (as regulator) with respect to the identification of and collection of indicators / data for reporting should be urgently addressed.
- Water utilities in South Africa should consider conducting Climate Footprint analyses (see Howe *et al.*, 2010) to determine their energy use and contributions to greenhouse gas emissions and highlight strategies for mitigating these impacts. The results from these climate footprinting exercises could then be used to inform the urban water sustainability assessment process.

- A standardised carbon footprint assessment methodology should be developed for the water sector, to inform benchmarking / sustainability assessment initiatives and monitoring of climate change reduction targets (Frijns, 2012). This needs to be incorporated into the existing SA regulatory and/or benchmarking initiatives so that all water service authorities report climate-change related figures.

8.2 Further research

The present study has also revealed the following as possible improvements in terms of the formulation / calculation of the index, or as areas of further research:

- Widening the scope of the indicators – particularly those related to interactions with other urban systems (e.g. transport, electricity), as well as environmental issues and climate change – as more information becomes available on planning strategies, energy consumption by the local water sector etc.
- Investigating the linkages to other indicator initiatives, such as those reported in a recent WRC publication on determining the vulnerability and risks of water services infrastructure (Jack *et al.*, 2011) need to be explored. Determining how issues of risk and vulnerability can be integrated into the present SIUWM would also be useful.
- A more detailed investigation of the adoption of variable weights, including a sensitivity analysis. Consider the adoption of an analytical hierarchy process (AHP) in an attempt to incorporate comments from different sets of city stakeholders regarding the choice and prioritisation of sustainability indicators and their weighting. It may be necessary to provide different sets of variable weights for different cities.
- Consideration of alternative aggregation methods for the composite score, taking into account the use of advanced statistical techniques such as multi-criteria decision analysis (MCDA) and fuzzy inference approaches
- Consideration of a suitable institutional setting for sustainable urban water management in SA; this would require widespread ‘buy-in’ and adoption of sustainability principles at institutional level. This could be linked to current research on the development of a framework and guidelines for Water Sensitive Urban Design in SA.
- Further research on gauging the likely effects of this form of sustainability assessment on decision-making at local government level.
- Converting the existing SIUWM Excel spreadsheet into a more usable programmatic format; or linking directly to the RPMS and other existing systems (e.g. add another ‘drop’ to the Blue Drop / Green Drop system).
- Investigating the use of the SIUWM indicators in urban spatial planning through the use of a geographical information system (GIS) developed for this purpose (see Stylianidis *et*

al., 2012). Such a GIS could be used as a tool for managing and envisioning different policy scenarios towards sustainability; i.e. towards transitioning to water sensitive cities.

- Addressing the concept of meaningful scales within a city, and whether there are controlling factors (through a focus on specific indicators) that mean that UWM is better in one area than another. Also, the index could be applied across the different categories of municipalities, from small towns to metros (as described in Section 2.8.6.5), in an attempt to determine the differences between large and small WSAs in terms of their potential for sustainability in urban water management.
- Comparing the SIUWM results for particular cities with those from other similar indicator initiatives, e.g. The City Development Index (CDI) and the Enhanced Water Poverty Index (eWPI). This will however necessitate a more focused data collection process in order to be able to complete the calculations.

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Appendix A

Engagement with local authority officials

University of Cape Town

A1 Examples of general questions concerning sustainability in urban water management in selected study towns / cities

Selected questions were directed at different local authority officials responsible for the various sectors relating to water management. All interviewees signed ‘Authorisation of consent for participation in research study’ forms (as part of the Research Ethics requirements as part of this study – see Appendix H) before supplying answers to the following questions:

- i) In your opinion, what would be the defining features of a sustainable urban water system, and what currently are the biggest obstacles / challenges to achieving this?
- ii) Has a Water Services Delivery Plan (WSDP) been prepared for the city (when?), and is it available publicly?
- iii) What are the key aspects that drive Integrated Urban Water Management (IUWM) in the city?
- iv) Explain the organisational structures in the city? Is there an organogram explaining the management structures? Are there overlapping structures that ensure that separate departments work together when necessary? Are budgets ring-fenced?
- v) How many water management institutions are there in the city?
- vi) What makes your city different to any other, particularly in the context of water management?
- vii) In your opinion, what one aspect about water services in the city makes it a) sustainable, and b) unsustainable? What is your definition of sustainability?
- viii) Can you provide some insights into population growth rates / changes in the city?
- ix) Can you provide some insights into levels of risk management and disaster mitigation at the Municipality? How prepared is the city with respect to dealing with natural disasters, and how susceptible is it to a range of natural disasters, e.g. fires, flooding, earthquakes, droughts, tornadoes. Do you have any idea what percentage of the population would be vulnerable to these disasters, e.g. how many households are in flood-prone areas?
- x) How much time and money is spent by the city on dissemination of water services-related information to members of the public (to determine levels of awareness)? What about stakeholder consultation and public participation in the delivery of water services?
- xi) Do you have any idea of the amount of energy being consumed by the water sector?
- xii) Provide some detail on the sources of capital investment in the city – i.e. local / provincial / national government, NGOs, business, international aid agencies etc.
- xiii) Is there a river monitoring programme in place? Is it linked to the national River Health Programme?

- xiv) How does the volume of raw water withdrawn annually relate (as a percentage) to the available water at source?
- xv) Comment on the quality of water at source.
- xvi) Comment on the water resource distribution per sector, e.g. domestic, industrial, agricultural etc. – is this sustainable?
- xvii) Do you have any insights into governance issues in the city? Any comments on issues such as policy / corruption / levels of democracy and representation?
- xviii) Has Water Demand Management (WDM) been implemented in the city? What are the current levels of Unaccounted for Water (UAW)?
- xix) Does the city follow an Integrated Water Resources Management (IWRM) approach?
- xx) What alternative (sustainable) technologies are being implemented with respect to water supply and sanitation?
- xxi) Are Free Basic Services (FBS) being provided throughout the city?
- xxii) Comment on the incidence of public service delivery protests in your city.
- xxiii) What cost recovery mechanisms are being used / considered in the city, e.g. tariffs, restriction devices, indigent policies, credit control measures etc?
- xxiv) Is institutional learning seen as an important feature of the local authority function?
- xxv) Have any other sustainable development measures been applied to the city, e.g. City Development Index? Gini Coefficient?
- xxvi) Are there any other water services monitoring programmes in place?
- xxvii) Do you have current figures for housing backlogs and number of informal settlements in the city?
- xxviii) How reliable is service provision within the city? What is the incidence of service delivery failures?

A2 Specific information / data requested by email

The following questions are aimed at eliciting the required data for those variables for which public information is not available – please could you complete questions 1 to 8 and return to kirsty.carden@uct.ac.za, queries: 083 292 2647 / 021 650 5317.

1. Does the municipality have a current Disaster Management Plan? Please indicate the level of disaster management in place by selecting from the following:

Risk management and disaster mitigation	
	None
	Poor disaster management
	Compensative risk management
	Effective disaster mitigation
	Risk awareness and preparedness
	Risk avoidance by design

2. Please indicate current contribution per source to the municipal water supply (as a %):

Contribution to water supply per source (%)	
	Local Groundwater
	Rainwater
	Local surface water
	Imported water
	Grey and stormwater
	Brackish water
	Recycled / wastewater
	Saltwater

3. Have any studies been conducted on the quality of groundwater in the area? Please provide details.
4. Please provide an indication of the annual electricity (energy) consumption by water and sanitation services (in kWh).
5. Does the municipality have a climate change strategy? Please give an indication of its level of implementation, as follows:

Climate change strategy	
	Implemented
	Partially implemented
	Significant planning
	Limited planning
	Minimal planning
	No consideration

6. Please give an indication of the current domestic water demand (ℓ/c.d); the percentage of the total water demand to industrial uses; and an estimate of the percentage that goes to the environment (the ‘reserve’).
7. Please provide estimates for the levels of service for drainage / stormwater:

Drainage service type	% of households
Conventional (primary and secondary) and SUDS	
Conventional (primary)	
Greywater management only	
No formal drainage	
None	

8. Please give an indication of the governance model in terms of roles and responsibilities, inter/intra departmental integration, and the Water Demand Management (WDM) policy / Integrated Urban Water management (IUWM) approach:

Defined roles and responsibilities	
	Supporting policy, legislation, good implementation
	Inappropriate policy environment
	Poor implementation capacity
	Progress towards policy setting and capacity building
	Inappropriate policy and poor capacity
	Inaction (sterile environment)

Intra/inter-departmental integration / communication	
	Significant
	Above average
	Average
	Minimal
	Stalled processes
	None

WDM policy / IUWM approach	
	Fully adopted
	Good implementation
	Partial implementation
	Planning / minimal implementation
	Minimal planning
	No progress

Thank you for your time

A3 Environmental Management Department, City of Cape Town, 5 August 2008

A meeting was held with Ms Amy Davison of the Environmental Management Branch at the City of Cape Town on the 5th August 2008, to discuss the project and to brainstorm the choice of indicators for the SIUWM. Amy is responsible for the City's State of Environment reporting, and for the production of the Sustainability Report. The following indicators were discussed and noted as being relevant to sustainability in urban water management:

- i) Institutional capacity – e.g. ratio of technically qualified personnel to the general population (refer Alysson Lawless book “Needs and Numbers”)
- ii) River health / beach status
- iii) Dependence on energy / availability of generating capacity during periods of load shedding or power outage.
- iv) Organisational arrangements with respect to the integration of aspects of the urban water system. Relate this to urban planning capability; e.g. is IUWM included in the Spatial Development Frameworks of cities?
- v) Affordability of services (and spending) – household should not be spending more than 5% of their income on water services.
- vi) Key institutional / governance issues with respect to legislation / policy incorporating IUWM principles.
- vii) Proportion of effluent being reused / recycled.
- viii) Numbers of people in informal settlements / housing backlog. How does this connect to LOS?
- ix) Access to water – variables such as gender bias and conflict may not be relevant in urban areas.
- x) Average water use rather than per capita water availability?
- xi) % compliance with effluent standards rather than actual qualities, particularly where there are many WWTWs in an urban area.

A4 Water and Sanitation Department, City of Cape Town, 17 February 2011

Water & Sanitation falls under the Utility Services Directorate, along with Solid Waste and Electricity. CT is responsible for the full value chain of water and sanitation (as opposed to most other cities in SA), and this makes integration with the various relevant departments much easier. Their core business is described as follows: “*to equitably and efficiently provide access to water and sanitation services to all citizens of the City in a sustainable, safe, reliable, environmentally friendly and financially viable way, observing the dictates of sound governance principles*”. They currently have the WSDP for the period 2011/12 to 2015/16 in draft form. The Director of Water and Sanitation (W&S), Mr Philemon Mashoko, provided an excerpt from the latest Water Services strategy document, which is currently being reviewed and refined. In it they state that the Department’s strategic vision is “...to be a beacon for the provision of water and sanitation services in Africa”, which they aim to achieve by way of:

- Optimising resource utilisation.
- Implementing environmentally sustainable interventions.
- Continuous improvement and knowledge management.
- Good governance.
- Customer satisfaction and excellent stakeholder relationships.

Strategic objectives include *inter alia*:

- i) Reducing UAW to 15% in the next five years.
- ii) Providing basic or emergency sanitation services to all residents by 2015/16.
- iii) Being the reference city in the country for water matters.
- iv) Minimising river systems pollution by reducing sewage overflows by 20% by 2015/16.
- v) Improving security of supply for water systems to 120% of average demand by 2016/17.
- vi) Increasing effluent re-use by 15% by 2015/16.

In response to the question, “In your opinion, what would be the defining features of a sustainable urban water system, and what currently are the biggest obstacles / challenges to achieving this?”, Mr Mashoko responded as detailed below. The *features of a sustainable urban water system* can be classified into three categories:

- i) **External (exogenous) environment** – these are factors that fall outside of the water services provision itself; one of the most critical issues is legislation. The Bill of Rights confers right of access to services (mandate), but resources in the form of *supportive legislation* / policies / by-laws etc are required in order to manage this. Another aspect

concerns the external economic environment – in the form of supporting *budgetary frameworks*. It is also important that issues to do with the cultural, social and political environment are considered, in terms of the way people perceive water and sanitation issues, their willingness to take ‘ownership’, the effective use of resources etc – *literacy rates* are linked to peoples’ ability to comprehend issues; *demographics* (age / gender) dictate levels of understanding and sense of entitlement (older people still tend to think that the Government must provide); and *political dynamics* can also affect technical sustainability.

- ii) **Technical aspects** – soundness of engineering design (*infrastructure integrity*) has an impact on coverage rates, safety factors, maintenance programmes etc. The *sequential timing of investments* and *planning of projects* (particularly in respect of managing the growth in WS demand) is crucial for creating a system that has symbiotic relationships with other systems (i.e. relationships between projects). There should be an *investment mix* in the infrastructure portfolio so that not only the poor are being provided for; rich clients provide the revenue. *Availability of skills* to sustain programmes is vital, as is *knowledge management* and the ability to sustain the experience curve. The customer is becoming more complex and better informed – constant *improvement* is essential if the City wants to keep pace with the needs of its residents. Another key technical issue is the ability to *interact with the environment* so as to ensure sustainability of the water resource – the water and sanitation business is cyclical and each step affects the previous / next one. Lastly, the ability to respond to and mitigate *impacts of climate change* is a critical aspect.
- iii) **“Soft” aspects related to urban water management** – a crucial aspect is the ability to instil a *sense of ownership* on the part of beneficiaries, and to ensure that they are *able and willing to pay* for services. At the same time it is important that residents are getting value for money, and that there is efficiency in investments.

To summarise, the City needs to have a balance between the interactions of its residents with the technology aspects of water and sanitation, as well as with the external environment (natural, social, political). Key to sustainability is good governance and an ability to put in place the processes required to encourage this – it creates the right perceptions in consumers, it builds trust and a willingness to pay for services. At a higher level, inter-governmental economic arrangements and regional planning is key; sustainability is only assured if the environment beyond the boundaries of the City is also stabilised.

Whilst the City is doing well in terms of addressing most sustainability issues (through the implementation of various programmes, *current challenges* to achieving sustainability include:

- i) **Education** – literacy rate needs to be lifted in order to improve citizenship and for residents to be able to understand their responsibilities as stakeholders in the City.

- ii) **Inadequacy of financial resources** – also relates to residents’ way of thinking.
- iii) **Structure of government**; i.e. national/provincial/local – wasteful in terms of resource optimisation, needs restructuring.
- iv) Unprecedented **growth / demand for resources** – this is a Catch 22 situation; owing to the fact that Cape Town is an attractive investment centre, it has a high demand for services. The movement of people into the City is not in line with both resource and infrastructure availability.
- v) The **size of the City** – it is a huge administrative body, and integration of programmes and investments is highly challenging. In order for its vision for sustainability to be effective, it needs to cut across all departments.
- vi) **Strategies for climate change** – predictability and planning is difficult.
- vii) **Skills shortages** – an attempt has been made to address this in terms of the establishment of a training department which builds on existing capacity as well as having links with tertiary institutions. There is also a need for engineering programmes to teach people / relationship skills as well as all the technical aspects.
- viii) **Communication channels with stakeholders** – diverse views, political affiliations etc. Mr Mashoko believes that councillors should not be political representatives as this often prevents them from truly representing their communities as a whole.

A5 Roads and Stormwater Department, Catchment, Stormwater and River Management Branch, City of Cape Town, 18 February 2011

Mr Rod Arnold and Ms Candice Haskins explained that CSRSM's vision of sustainability is captured in various policies that have been produced for the branch, but that the over-riding notion is one of Water Sensitive Urban Design (WSUD). They stressed the importance of incorporating concepts such as this in high-level land-use planning, such as found in the Spatial Development Framework – in order to inform floodplain development and river corridor planning. The Roads and Stormwater Department's objectives, incorporated in the Integrated Development Plan for the City of Cape Town, are to: a) Reduce the impact of flooding on community livelihoods and regional economies, and b) Safeguard human health, protect natural aquatic environments, and improve and maintain recreational water quality. Over the past decade the City of Cape Town has experienced unprecedented development, both in greenfield areas as well as within existing developed / brownfield areas. The City's Roads and Stormwater Department, in recognition of the threats to already degraded rivers and wetlands, responded by introducing development guidelines which would limit these impacts, i.e.:

- Stormwater Management Planning and Design Guidelines for New Developments (2002) – this document promotes the principles of Water Sensitive Urban Design. It emphasizes planning and design solutions that are cost effective, sustainable in terms of future maintenance requirements, environmentally sensitive and that maximise, within these constraints, social as well as amenity value.
- Floodplain Management Guidelines (2003) – this document provides a framework for the management of land use, development, and activities near watercourses in a manner that minimises potential flood damages and protects and enhances the environment. These guidelines have now become policy (Floodplain and River Corridor Management Policy).
- Draft Policy for Provision of Stormwater Services to Informal Areas (2003) – provides a framework for flood control and management to at least minimum levels within informal areas on public land, until such time as the settlements are upgraded to full services, or relocated to alternative sites if the land is not suitable for development.

There are two recently published policies that are central to the work of the CSRSM branch:

- i) **Management of urban stormwater impacts policy** (City of Cape Town, 2009a) – this policy is intended to minimise the undesirable impacts of stormwater runoff from developed areas by introducing WSUD principles to urban planning and stormwater management in the Cape Town metropolitan area. It is intended to support the Stormwater Management by-law and strengthen the City's ability to introduce and implement measures which will arrest the deterioration of, and in the longer term improve, the state of its natural water assets as part of the stormwater system.

- ii) **Floodplain and river corridor management policy** (City of Cape Town, 2009b) – This document is an enhancement of the former Floodplain Management Guidelines (Version 1.0) published in 2003 and describes a merit based approach for dealing with land use, development or activity proposals near watercourses and wetlands. Various improvements have been effected to align the policy principles to corporate strategic objectives and to ensure that engineering, environmental and socio-economic elements are assessed and integrated as the vision for a particular watercourse / wetland system. It outlines the procedure for managing development adjacent to watercourses and wetlands taking cognisance of the flood regime, aquatic and riparian ecology as well as socio-economic factors. The policy statement is as follows:

“In order to ensure sustainable development and associated activities within or adjacent to natural and built stormwater systems, and that there is a balanced consideration of potential flood risk, environmental impacts and socio-economic needs, all developments within these areas shall be planned and designed in accordance with best practice and the requirements and conditions laid down in this policy.”

A5.1 Challenges

Policy roll-out has taken place via seminars with the various stakeholders, both internally and at different government levels. These policies are therefore now in use, but implementation of WSUD has been slow – mainly as a result of limited **funding** and **skills shortages**. There have also been major challenges with **ongoing maintenance and management** of systems that have been implemented. One of the suggestions for dealing with this is to implement stormwater levies / incentive schemes to developers – although this is not being used at present.

There are ongoing problems concerning **integration** with certain other departments, e.g. sanitation – particularly in respect of getting them to accept responsibility for what should/shouldn't be disposed of in the stormwater system. **Backyard dwellings** in formal areas are a major headache, and a task team has been formed to try and resolve some of these issues, particularly related to backyard dwellings on Council-owned property. The planning for backyarders' services needs to be coordinated with other departments, such as Housing. One of the areas where integration appears to be working is around the services that influence water quality – an inland and coastal water quality committee has been formed, and has reasonable representation across departments. This committee has identified certain areas that need improving however, and one of these is around a **communication strategy** for Water Services – there is an education unit in the Environmental Awareness department, which deals with issues such as health / sanitation links, leak detection etc; but there is no education person currently at CSRM.

A5.2 Actions

CSRM has recently started *servicing notices on other departments* in the City in terms of its stormwater by-laws; and are currently testing this process (e.g. environmental enforcement aspects could be elevated to the corporate risks register). A *large-scale planning process* is currently underway to determine future city growth options; three spatially different scenarios have been identified and the preferred one is also being considered in terms of its potential as an environmentally-sustainable alternative using the full suite of “green” development options. There is also a project underway in CSRM to determine what kind of resources would be required to deal with the problem of pollution – looking at contributors, quantifying the extent of the problem, and providing recommendations in a *guiding document on corporate WQM strategy*.

A5.3 Summary

Overall, CSRM seem to be aware of the major challenges in their area, but are struggling to find the means to deal with them, both financially and in terms of capacity. It was interesting to hear that they are not required to report any of the stormwater results as part of the DWA RPMS – and it seems that there is no link between the regulatory systems like Blue Drop / Green Drop and the work that CSRM are doing either; even though they clearly have an impact on each other. Again, stormwater / drainage seem to be the forgotten and/or neglected water service.

A6 Water and Sanitation Department, eThekweni Municipality, 24 February 2010

A6.1 Frank Stevens, Deputy Director: Technical Support (FS)

Water & Sanitation falls under Procurement and Infrastructure Department along with Roads, Stormwater and Electricity. FS is responsible for Asset Management, Water Losses, Planning, Design, Laboratory, and Fleet (1600 vehicles). Asset Management is the present focus of the department (e.g. all asbestos cement (AC) pipes are currently being replaced), with an asset value estimated at R6 Billion. Benchmarking by way of the City manager's Forum is also considered crucial and is being revived. FS referred also to the Africa Utility Performance Assessment (www.wsp.org) and the National Benchmarking Initiative. From comprising 14 organisations 10 years ago, eThekweni now has 1 Water Authority:

- 3.6 million people.
- 27 WWTW plus 2 marine outfalls (9 with Green Drop status).
- 700 Mℓ water supplied per day.
- 600 Mℓ water treated per day.
- Waterborne edge around city, beyond which waterborne sanitation is not envisaged for at least 20 years (urine diverting (UD) toilets are the sanitation option of choice in these areas).
- 12 000 km water pipelines.
- 8000 km sewer pipelines.
- 3000 manholes.
- 350 reservoirs.
- R2.6 billion annual budget (capital and operating).
- 2600 staff.

FS claimed that eThekweni's success is as a result of passionate staff, who are well looked after, encouraged and capacitated. All professional engineering staff get a 30% scarce skills salary benefit. The department also identifies promising students at schools and provides study bursaries for engineering.

The city has opted out of the Blue Flag beach status programme (although this may be reinstated) – but a Green Rivers program has been instituted and monthly reports on river quality are published on the municipal website (3000 km of rivers are monitored).

There are major initiatives afoot with respect to WDM; at present NRW is about 37% and 60% of this is related to physical losses, with 40% stolen / unpaid water. There is a good payment record at the municipality – 97% recovery on bills sent out. Water pressure has been

reduced significantly; community liaison / education programmes; no restrictive devices or cut-offs.

A6.2 John Harrison, Engineering Planning (JH)

JH is responsible for water and wastewater planning, as well as Research and Development. He cited lack of understanding of planning as the single biggest problem with his department. Whilst there are centres of excellence within eThekweni, they are not necessarily in critical, key areas. There is not enough connectivity between these critical departmental areas, and this is further eroded by the requirements of processes such as EIAs, carbon credit programmes etc. JH suggested that the following are the major problem areas in water services at the municipality:

- EIA processes.
- Procurement processes.
- Inversion of the natural hierarchy with respect to municipal functions (technical / institutional capacity) – the provision of critical municipal services relates almost entirely to engineering services, but this is not reflected in the municipal hierarchies which dictate that engineers function far more in an HR function, i.e. the technical function gets eroded due to the time spent on non-technical matters. Water and Sanitation are under enormous pressure to sort out delivery issues over a larger area, but with far fewer technical staff who also have increased non line function responsibilities. There are only three qualified engineers out of the 26-strong top management structure at eThekweni.
- Policy dictates planning rather than the other way round. Planning should be done as a leadership function; i.e. within the City Manager’s office. Even though Durban’s IDP is considered one of the best in the country, it is still a “wish list” full of contradictory statements. This in turn affects the Spatial Development Plans which are formulated out of the IDP. An example of this poor planning relates to the population growth scenarios for eThekweni which predict an additional 750,000 (average), 500,000 (low) or 940,000 (high) people in the municipal area over the next 25 years. In reality, even the high growth scenarios are an under-estimate; already one town in the outer West area (Hammarsdale / Mpumalanga) is being developed for 2 million people. It is getting increasingly difficult for the department to be able to predict the impacts of poorly planned development on water services delivery.
- Continuity / capacity of staff – half of the engineers in the department will retire over the next 4 years. Many engineering posts are being filled by technicians / technologists who do not have the required experience and skills.
- Inter-departmental connections – e.g. Housing department does not link well with Engineering. Town Planners should use infrastructure availability and requirements as major decision-making tools; i.e. engineers should be having a major input into Town Planning. From a systems point of view, there should be dynamic negotiation around

where people would like to live and where the City can accommodate them – this should drive development. At present this dynamic is constantly being undermined, particularly by politicians. Priority areas should be those people that do not have a roof over their heads or those settlements that are contributing to environmental degradation.

- Time horizons are too short for sustainability – planning for a city should be geared towards 50 to 100 years; political horizons are 5 years max, and City planning is of the order of 1 year.

JH noted that: *“collapse” is about 20 years behind a systems / engineering failure – and it is only at collapse that we realise what these failures are.*

A6.3 Chris Fennemore, Manager: Pollution and Environment Branch (CF)

The impact on water services from poor levels of communication between the various departments is the biggest area of concern.

River monitoring started about 6-7 years ago – prime indicator is *E.Coli*. Results are stored in a database and displayed monthly via the municipal website (summary results from Chris); the monitoring has made it easier to identify the impacts that an area like Cato Manor has on the Umbilo River. Various initiatives are underway to try and improve the quality of rivers, including: the health department installing communal sanitation blocks in informal settlements, Catchment Management implementing pilot projects for treating stormwater emanating from informal settlements (reedbeds / wetlands) etc.

The Green Rivers programme highlights problem areas such as those resulting from, e.g. maintenance / overflow issues at pump stations, and can initiate proactive responses by using telemetry systems on sewage pump stations and WWTWs. There are also ongoing projects to identify cross connections between stormwater/sewer systems. Stormwater by-laws are being changed; additional sewage rates will be levied for offenders. Monthly reports are supposed to be filled in by all departments regarding “Interventions to mitigate pollution”. Working procedures are also to be stream-lined. Compliance of effluent from WWTW is checked – SS, PV4/COD, NH₄, *E.Coli*.

The biggest challenge is capacity and getting (and retaining) technically-qualified and competent people. They have developed a training program with NORAD on permitting and auditing in the Water Sector – hopefully this can be used at municipalities throughout the country.

CF noted that Durban is currently exceeding the sustainable yield of its water resources, and will continue to do so until at least 2013 when the Springfield system comes on line. The city has a history of expanding upstream of its water resources, e.g. Umbilo and Shongweni which are now unusable as drinking water supplies. Cato Ridge area is having major negative impacts on Inanda Dam, resulting in impacts such as eutrophication and salinity. The City is not protecting its drinking water catchments.

Water loss management is being addressed. Low-level leachate from solid waste sites is directed to sewer. The two major solid waste sites run by the city treat their own leachate. The two privately-run sites have had some problems, with leachate going to the sea outfalls.

Virtually all water used in Durban is derived from surface water resources. The municipality are investigating desalination at present. Recycling up to 14Mℓ/day – used by Mondi and Sapref; looking at further recycling options.

A6.4 Teddy Gounden, Head: Customer Services (TG)

The nature of the municipality has changed considerably since the early 1970s when it comprised just the City of Durban, which was fully serviced (water and sanitation). eThekweni now comprises 90 km of coastline, and also stretches 50 km inland to Cato Ridge; a significant percentage of the areas that have been taken over are rural (55 – 60%), mostly with no services. There has also been rapid growth in large informal settlements. The focus of the municipality is not only on providing new infrastructure however, but also on maintaining existing services.

The rural backlogs have largely been addressed through the provision of 200ℓ ground tanks (daily provision has now been increased to 300ℓ/household/day, by way of automatic bailiff systems) for water supply. New rural projects now get **flow limiter devices** attached to the water meters that are installed at each house, thus giving more flexibility on the part of the local authority to allow residents to move up the water “ladder” (i.e. if people want a full-pressure, metered supply, it can easily be achieved). Colour coding is used on the meters to show which ones have been amended to supply full-pressure water.

Non revenue water (NRW) has been at very high levels (40% plus), but has started dropping quite significantly with the massive drive by the municipality to replace all AC pipes in the water network. Another issue affecting NRW is that of **illegal connections** (constitute about 25% of the NRW, i.e. 10% of the total water demand) – whilst demand has been increasing over the years, sales and revenue collection has remained static. The municipality is currently addressing this by announcing a three month amnesty period (from the 1st March) on illegal connections – for a once-off R250 connection fee, residents will get meters installed, with flow limiter devices for those who cannot afford to pay for water beyond the 9kℓ/month free basic allowance. This is a structured project with full political backing. A **debt relief** process has also been initiated through the use of customer service agents, who have been targeting priority areas with high levels of non payment. The debt relief is based on the value of the house – the home-owner signs an acknowledgement of debt and is required to pay off the debt over a specified period (without interest). A flow limiter device is installed, and once the debt is paid the home-owner can decide whether or not to back onto a full-pressure metered system. In all cases the service level agreement is well-documented, and widely publicised.

There are about 100 wards in eThekweni, structured within 17 zones. The “**Raising Citizens’ Voice** in the Regulation of Water Services” initiative being undertaken in various wards throughout the municipality is aimed at building partnerships between the three spheres of government (national, provincial and municipal levels) and civil society. It supports a

bottom-up approach to water services regulation by actively involving citizens in the local monitoring of water and sanitation services. It helps empower citizens to hold local government accountable through:

- Training citizens about their rights and responsibilities.
- Setting up “User Platforms” which serve as monthly meetings between the municipality and the community for ongoing civil society water services monitoring and problem solving.

Training functions are being split between civil society and councillors, and it has been found that, at community level, people are far more prepared to work together. Seven wards have been completed thus far (all wards to be completed by May 2010), with about 90-100 people attending each session (usually held over weekends). After training, representatives are elected from within the ward onto user platforms, which deal with more strategic policy issues at quarterly meetings. eThekweni aims to eventually have 17 such platforms – which can be used as an entry into communities, through spokespeople with a mandate. This system can also be used to feed valuable information back into the IDP development process, as well as being useful for other issues such as being able to identify people in the area with the greatest need (indigent register not yet complete). There is currently a major survey underway through Nielson Market Research looking at customer satisfaction throughout the municipality – what comes out of this will be used to inform the user platforms. At present there are no South African benchmarks for customer service with respect to utilities, so this will be a useful start.

Comments on the roll-out of urine diverting (UD) toilets

The biggest challenge in the roll-out of UD toilets was that there was no support from the municipal Health Department around issues of cultural acceptance, and Water & Sanitation were left to deal with this on their own. The programme also had to meet the requirements of the Extended Public Works Programme (EPWP) which meant training local people. W&S first got political support in terms of selection of the technology by conducting pilot studies at various WWTWs and inviting councillors to information-sharing events where it was made clear that waterborne sanitation was not an option. The twin vault / solid top structure option was promoted; local economic development was punted; and UD was accepted (political support even at the highest level).

The education process went ahead and the HSRC was appointed to monitor the implementation over a 2 year period, from construction to the 2nd vault emptying. Important issues were picked up as the roll-out continued, enabling both technical and social changes to be made, e.g. back covers, entry of rainwater through vent, child seats etc. It was found that there were often problems with the use of toilets in instances where two toilets were provided for larger households (the 2nd toilet was often being used as a storeroom, or something other than its intended purpose), but the decision around how many toilets are required per household is now being managed on a discretionary basis by W&S project managers. The HSRC found that the majority of people did not want to clean out the vaults although there was a better

acceptance by the end of the two year period. Vault contents are not used beneficially, but are buried on site.

There has been a gradual increase in political influence on the education process, by way of the involvement of ISD (Institutional and Social Development) consultants in what has become a very lucrative business. The decision was taken to cut back on the use of these ISDs as they were found to be exploitative and were pushing up the project costs. Using local facilitators for education purposes has also been problematic, as there was an assumption that they are experts in social aspects and behaviour change, which they are not. W&S now take on Environmental Health graduates from DUT and train them over a 12 month period to conduct the required training on Health and Hygiene and Operations and Maintenance. The UD toilet has been accepted in eThekweni as the basic sanitation service – the research focus now is on how people can maintain these toilets so that they can remain long-term assets. Personal circumstances (poverty / desperation) have a major impact on this. The Municipality are looking at various incentives to get people to accept UD toilets (through research initiatives) – one of these involves a portable reactor which converts urine to struvite (phosphate fertilizer); it can be taken from village to village and the bagged struvite can then be sold to farmers to generate some income. UKZN are currently working on struvite extraction methods and EAWAG (Elizabeth Tilley) are preparing a research proposal together with the Gates Foundation in this regard.

Sanitation in informal settlements has been taken over from the Health Department by W&S and usually consists of containerised communal facilities (male and female toilet blocks), each serving approximately 70 people. Each facility has a municipally-paid caretaker, who also provides maintenance. Approximately 100 ablution blocks such as this are being installed per month. In areas earmarked for in-situ upgrades, separate teams install sewer networks ahead of the container teams. There have been many challenges around politicians and councillors with this process – they wanted job creation opportunities and not containers. There has also been a comprehensive roll-out of the VIP emptying programme – 20,000 VIPs have been emptied so far, with about 20,000 more to go.

“The flexibility and creativity that is allowed in W&S makes for interesting working conditions and encourages excellence.”

Community Health Clubs (CHCs) – provide training on a wide range of issues; showing communities what they can achieve and the benefits of their actions. These clubs have resulted in significant changes at community level, particularly in terms of keeping the environment clean – greywater management, drainage, solid waste control, sanitation blocks etc. People in selected settlements choose to become members of the CHC and undergo specific training – in one settlement (400 people, densely settled), ‘Agritubes’ are being piloted amongst health club members to assess their usefulness in dealing with greywater in a beneficial way (research being conducted by Nick Alcock). The materials for assembling the ‘Agritubes’, as well as the soil and seedlings, are provided by the Municipality. W&S are working on getting a model

informal settlement – one where there are decent living and working conditions. The Council has made a decision to make informal settlements more accessible, dignified and liveable spaces.

The new Customer Services building being constructed will be a fully sustainable building together with green roof and energy saving / water recycling features.

A6.5 Siobhan Jackson, Senior Manager Scientific Services Laboratory (SJ)

In the past, eThekweni only analysed above and below wastewater treatment works to assess impacts on **rivers**, but this programme has now been expanded to full assessments of rivers including The South African Scoring System Version 5: Rapid bio-assessment method for rivers (SASS5), diatoms, and microbiological / chemical testing on about 200 points in all rivers in the metropole. These results are displayed as river quality maps on the eThekweni website on a monthly basis (results also feed into the River Health Programme).

Potable water is tested at point of purchase as well as in the distribution system itself (for pH, EC, turbidity, Total organics, *T.Coli*, and *E.Coli*) – once weekly on bulk supply (water treatment works and main reservoirs), every second week for other reservoirs and distribution points, and once monthly for smaller distribution points. A full SANS 241 (South African National Standard for drinking water) analysis is undertaken on major input and supply points once a year – this is geared towards the Blue Drop compliance programme.

Wastewater treatment works are sampled / tested from the head of works through the entire treatment system, depending on the process requirements, and then on the final effluent itself. Currently 11 of the 27 WWTWs in the metropole have Green Drop status. Sea monitoring for the marine outfalls is carried out by the CSIR. Beach monitoring is undertaken on a regular basis using the municipality's own grading system to ensure beaches are kept up to standard. Stormwater discharges onto beaches are tested for *E.Coli*, *Enterococcus* and turbidity.

Other analyses include those undertaken on **trade effluents** (compliance analysis for discharge to sewer), and **swimming pools** (health compliance). Very little **groundwater** analysis is undertaken apart from isolated pollution incidents – groundwater is not used as a potable water supply in eThekweni. **Solid waste leachate** is analysed for TCLP metals, NH₄ and toxins as necessary.

The main challenges in the laboratory concern the availability of competent staff – one of the ways this is being addressed is through the MOU that the Municipality has with UKZN (Pollution Research Group), where there is good collaboration between the institutions and exchange / training of students.

A6.6 Steve Pietersen, Manager: GIS (SP)

There are 140 GIS-enabled computers on public water counters throughout the Municipality, and data availability is excellent. eThekweni are hoping to be able to implement a “Cost Services” model as part of the public service – this could help developers to predict how much

it would cost to install services in buildings, depending on the area of development and the available infrastructure.

SP felt that some very **poor development decisions** have been made in the past, specifically concerning the issue of the provision of services attracting informal settlement. There has been a slow-down in the expansion of informal settlements within the urban edge, but at the same time hostel environments have been densifying.

Different management units within the Municipality (Roads, Water, and Sewage) have their own reasons for doing things, and there are also issues around **alignment of budgets** (rushed spending before financial year end) which influence questionable decision-making with respect to the installation of services. **Staff turnover and capacity** problems have identified a need for more defined operating procedures. There is **poor overlap between departments** and most budgets are ring-fenced – so, for example, Water and Sanitation’s roll-outs based on getting water services to people as quickly as possible may not tie in with the planning of other departments such as Roads. Whilst there is extensive interaction between the Housing department and W&S regarding servicing informal settlements (communal sanitation provisioned for later connections to individual houses), there is still a **need for more defined forward planning**. The **calculations for housing demand** are very challenging, with informal settlements presenting the biggest challenge. The W&S department has approached this by using aerial photography (annually updated) through counting roofs (e.g. number of roofs is equivalent to x number of water points, metres of road, and houses); the Department of Housing counts doors. A cross-correlation exercise is then done to try and come up with the most sensible planning figures.

The **in-situ upgrading process** in informal settlements seems to be **working quite well**, and there has been a move towards **cross-service discussions** in these areas, i.e. W&S allows the housing division to install water services (per W&S specifications) by contract during their building exercise), and once construction is finalised the operation and maintenance of these services is handed back to W&S. Getting cadastral information is however very challenging.

SP suggested that a good contact at StatsSA, Durban office, is Helen North – particularly for health and other related data. There is also a GISSA member in Pietermaritzburg that could be helpful?

A6.7 Geoff Tooley: Coastal, Stormwater & Catchment Management (GT)

The main issues with respect to stormwater concern flooding are as a result of pipe capacity problems and blockages. There is currently a major focus on developing an asset management register so that they can determine where the shortfalls are with capacity. In dense settlements the roads and footpaths provide a ‘midblock’ function when it comes to drainage. It is very difficult to provide information on the various levels of service with respect to drainage.

A7 Environmental Management Department, City of Johannesburg, 31 March 2011

A7.1 Jane Eagle, Assistant Director – Open Space Planning, Natural Resources Directorate (JE)

Ms Eagle explained the overall management structure of the “corporatized” city and described the way in which Johannesburg has divided up its responsibilities into several key departments that are mandated to deliver quality services to residents. The management structure is based on a “client / contractor” model, in that there is a top (Council) level providing a policy / regulatory function, which develops and monitors entities set up to deliver the services. As such, there 13 core municipal departments, and 16 municipal entities for which they are responsible, including *inter alia*:

- i) **Infrastructure and services (IS)** – this is a fairly new department, formed from the remnants of the oversight group (contract management unit) over municipal entities, and responsible for service capacity, delivery etc. “Its focus is three-fold, combining compliance and monitoring mandates with the formulation of a service policy and the subsequent effective delivery of services to all inhabitants through a well-maintained infrastructure”. Municipal entities include **Joburg Water (JW)**, City Power and Pikitup. *Contact person – Antonino Manus.*
- ii) **Development planning and urban management** – responsible for spatial development planning, control of capital budgets etc. It originally controlled the WSDP, but now responsibility for this has moved to IS, but with a much more limited focus. Municipal entities include Johannesburg Development Agency (JDA) and Johannesburg Property Company (JPC). *Contact person – Gis Ndelcu.*
- iii) **Transportation** – have regulatory authority over Roads and Stormwater, e.g. for WSUD implementation (although this still requires the building of alliances with IS and other departments who have oversight function). Municipal entities include Metrobus and the **Johannesburg Roads Agency (JRA)**. *Contact person –Lisa Seftel.*
- iv) **Health** (incl. Environmental health).
- v) **Environment** – now independent of Planning, although many of the functions are interlinked. Municipal entities include the Zoo and City Parks. *Contact – Jane Eagle.*
- vi) **Housing** – municipal entity is the Johannesburg Social Housing Company (JOSHCO).
- vii) **Community development** – municipal entities include the Roodepoort civic theatre and the Civic theatre.

The **Corporate Strategy Unit (CSU)** falls directly under the City Manager, and is responsible for the preparation of the IDP, international strategic policy alliances, participation in the SACN, strategic climate change and energy decisions, etc. *Contact person – Rashid Seedat / Jan Erasmus.*

The **Environment** department has links to several other departments – for example, the Water Conservation and Demand Management policies for the city have been developed by this department (in terms of resource use, protection of groundwater, pollution effects, irrigation best practices etc), as well as by Joburg Water (water conservation aspects as they affect the business model, e.g. water saving methods etc). The WC & WDM strategy (completed last year) is now being driven by IS. The water section in the Environment department has as its main objectives water quality and catchment management, with specific focus on aspects such as Total Water Balance, diffuse pollution, wetland health, and river health (by way of twice-monthly surface WQ sampling on the Klip and Jukskei rivers – chemical and bacteriological). It is worth noting that in the City restructure, the laboratory was ring-fenced with Joburg Water, meaning that many of the other monitoring functions of the Environment department (e.g. air quality, groundwater monitoring etc) fell away, although the WQ specialists and programme remained with Environment. This WQ monitoring is useful for the City to monitor where the “hot spot” areas of pollution are, and what may be causing them. Results get put into a WQ index for the various catchments and the results given to the mayor, with the intention of highlighting problem areas and generating interventions – this is not working particularly well at present. One of the reasons for this is that there are so many players, all contributing to the problem – the “devil is in the detail”. The Environmental Management Framework (EMF) provides policy goals for the department, and has introduced the concept of carrying capacities and environmental limits.

Stormwater management is a major concern, with many more developments taking place in floodplains (as well as existing developments). JRA signs off stormwater master plans, and sends comments to the technical co-ordinators in development planning, but often without proper consultation with Environment or other departments – this can result in poor development decisions, and resultant flooding impacts caused by shorter, sharper storm events, as well as pollution impacts on rivers. There is no policy on paving / hard surfaces, and WSUD does not form a specific part of the Johannesburg stormwater policy; hence making it very difficult to implement. The City does have a Catchment Management Policy which prevents planning encroaching on floodplains, as well as stormwater by-laws which have created a mandate for better stormwater management. A manual is still required – this would be useful in terms of shifting thinking around the new stormwater paradigm (SuDS approaches). There are also flooding task teams who look at flooding information to prevent disasters happening.

The municipal entities all have a two-way reporting function – 1) to their own boards (and bottom line), and 2) to the City department to which they are affiliated, and the service level agreements (SLAs) they are obliged to meet. The SLAs for the various municipal entities (companies) are linked to their business plans, and achievements translate into score cards for themselves (as well as into the score cards of their oversight departments) – the score cards are set up by IS and CSU. It should be noted that, in terms of managing outputs, the oversight departments end up being a sort of “bridge”; i.e. they cannot afford to alienate the municipal entities they govern.

A7.1.1 Challenges

Ms Eagle identified various sustainability challenges that the municipality is facing at present:

- Stormwater management.
- Water quality monitoring programmes, whilst still taking place, are not being managed properly in terms of the data that has been generated over time (10 years), and the results are therefore not being used strategically. Monitoring also does not cover all parts of the City, and both point and non-point source pollution is a major problem.
- The Johannesburg governance model is very complicated, and over-reliant on building personal relationships and/or strategic alliances with members of other departments and related entities in order to “get the work done”.
- Service delivery.
- Technical skills / capacity (particularly at JW) and training of staff.
- Capacity issues at the wastewater treatment works, and in local sub-catchment reticulation – due to major increases in housing developments. This leads to major problems with blockages, overflows and poor effluent quality.
- There are major issues implementing IWRM in the City because of a lack of integration. Water services are seldom linked to other affiliated services in an integrated manner; for example stormwater (Transportation) has a different policy oversight department to water services (Infrastructure services), and WC & WDM is supposed to be monitored by Environment, but IS manages the strategy.
- The concept of total water balance needs more attention – particularly in terms of promoting the retention of the City’s green infrastructure and drainage areas.
- River health – currently very poor.
- One of the biggest challenges facing the City is the link between Water Conservation strategies and pollution / flooding – if this were better understood, it could be used as political leverage for improved management systems.

A7.1.2 Indicator initiatives

There have been various indicators initiatives in recent years, including projects on Sustainability Indicators (using Wendy Ovens and Associates Consulting) in 2004 and 2008. The CSU has indicators linked to the IDP and the Growth and Development Strategy, Joburg Water has its own indicators programmes, and there is a current initiative looking at indicators for an Ecological Footprint analysis of the City. A study was done on high-risk flooding areas, using indicators on contours and weather patterns in a predictive modelling exercise. State of the Environment (SoE) reporting is also undertaken every few years, using a range of indicators. It appears that there is insufficient oversight by the municipality as a whole to link these initiatives, however, and as a result, there is seldom any action taken. Also, there are no

indicators tracking real environmental sustainability issues, and if there are, they are not linked to overall quality of life in the City.

There was a strategic document produced a few of years ago which aimed at highlighting high-level issues on water conservation and water demand management, as well as sanitation problems etc. A sanitation policy document has also been prepared for the City, but this is not being effectively used at present.

Ms Eagle sees the potential of the SIUWM as being able to highlight linkages between indicators and some of the less obvious water issues being experienced by cities.

University of Cape Town

A8 Planning and Regulation, Water and Sanitation Division, City of Tshwane, 30 March 2011

A8.1 Frans Mouton, Director (FM)

The Department of Public Works and Infrastructure Development is responsible for implementation and the technical aspects of water and sanitation in the City (and Electricity). Stormwater / drainage falls under Roads and Stormwater, in the Department of Transport and Roads. Billing and revenue collection is controlled by the Finance department, and low-cost housing is initiated through the Housing department and then transferred to Public Works and Infrastructure Development once the houses are built, for the O & M aspects. There is a small Consumer Management section within Water & Sanitation that is responsible for WATSAN education, health issues etc, as well as some water quality monitoring (mostly industrial effluent monitoring, through the Pollution Control section). Quality control of water treatment plants and sewage works falls under the bulk water and wastewater treatment plant sections respectively. The Environmental section in W&S initiates the required EIA processes and then sends them on to the Environmental Management department (and Province) for approval. The Planning and Regulation department (Frans Mouton) is responsible for master planning (IDP, WSDP, capital budgets), as well as infrastructure provision planning and project management (O&M aspects are controlled by the respective departments).

The size of the Tshwane municipal area will more than double (from 2300 km² to 6500 km²) after the 18 May local government elections, as the areas of Cullinan and Bronkhorstspuit are going to be incorporated into the city structure (population numbers will not change significantly but it will have a major impact on service delivery / management). Immigration from surrounding countries is also adding to the problem of being able to provide services to all.

Tshwane uses the Integrated Quality Management System (IQMS) information management system to process infrastructure and asset management data. They are currently working on the development of a module linked to IQMS that will automatically generate the WSDP on an annual basis (this is being hampered by DWA's ongoing format changes).

Tshwane was providing free basic water to all residents until 3 or 4 years ago when it was decided to provide 12 kℓ/household/month FBW (and first 6 kℓ sanitation free) to registered indigents only. Social services report about 63,000 registered indigents in the City, but there should be closer to 90,000 eligible for free services. 98% of the areas in Tshwane are metered (or are in the process of being metered), although there are ongoing problems in informal settlements. There are 150,000 – 180,000 households in informal settlements, and water is made available mainly through communal standpipes (bulk meters only) or JoJo tanks (filled by tankers). Sanitation mostly comprises chemical toilets and pit latrines. Informal settlements are managed by the Housing Department. The “traditional” areas north of Pretoria are more rural and used to be served with standpipes, but mostly now have metered yard connections which can be linked to individual properties for billing purposes. The backlog programme is being attended to, with waterborne sanitation systems being installed in the semi-formal areas

in the north (Winterton, Temba etc), and the eThekweni model (UD toilets) being adopted in the more rural areas. Large amounts of money are being spent on bulk infrastructure to meet the demand, both in water treatment as well as wastewater treatment. The 2011 capital budget is about R815 million (less than 10% comes from MIG, the remainder is self-generated) and half of this is being spent on upgrades to wastewater treatment works (once these have been completed, backlog eradication will be completed through the extension of the reticulation systems). Of the 10 WWTW in CoT, only 2 were awarded Green Drop status in the latest assessment – the Blue Drop / Green Drop programmes have proven to be very useful in terms of leveraging committed funds from politicians.

Tshwane receives 81.3% of its water from Rand Water and Magalies Water (both have Blue Drop certification). CoT supplies the remaining 18.7% from its own dams, boreholes and springs. There are three water treatment plants: Temba WTW at the Leeukraal dam, Roodeplaat WTW, and Rietvlei WTW. The latest reconciliation study has recommended that CoT needs to reduce its water demand by about 15% by 2020. Part of the WDM plan is to make better use of and increase the use of local water resources (through recycling processes).

A8.1.1 Challenges

Mr Mouton commented on the perceived ‘crisis’ in water services provision at the City as follows:

- Whilst recent DWA reports have shown that CoT is a financially viable municipality, it appears as though they still don’t get their ‘fair share of the cake’. Within the municipal structure there are many unfunded positions, and filling these positions is difficult to motivate.
- **Capacity** – 1669 approved posts at the City, just under 1000 filled.
- **Skills levels** – 13 local authorities were merged in 2001 to form what is now CoT, and many of the existing expertise within these municipalities was retained (particularly the middle management group in infrastructure and project management), but there has been insufficient succession planning for when these people retire. In order to try and address this, a SAICE engineer has been tasked with mentoring junior staff members in W&S.
- Quality of work by consultants is often questionable.
- **O&M** is problematic – the IQMS module for pipe replacements has highlighted the fact that many of the old ferro-concrete (FC) / asbestos pipes in the City are nearing the end of their life – however, they will need R100 million p.a. for the next 10 years to replace these pipes. At present R40-50 million is being spent p.a.
- **The town planning processes** required to finalise network services cause major delays – MIG funding is available, but planning delays hamper the process.
- No MIG funding for Roads and Stormwater.

- Politicians create problems by suggesting unachievable **deadlines** (e.g. Vision 2014 aims at reducing infrastructure backlogs, providing access to basic services, and formalising informal settlements by 2014 – this is unlikely to happen by at least 2025).
- **Water losses** – NRW (including physical losses, theft etc) currently at about 25 – 28%; i.e. still too high. Ronnie Mackenzie has been contracted to tackle the pressure problems; at a cost of R50M.
- Master planning is good, but the implementation is often problematic (management issues). It would be helpful to have more resources ring-fenced, as the W&S business is only one small part of the bigger municipality. **Procurement processes** in particular are a major problem (and this can have knock-on impacts, such as non-compliance issues at WTWs).

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A9 Roads and Stormwater Division, City of Tshwane, 30 March 2011

A9.1 Gawie Janse van Vuuren – Chief Engineer, Integrated stormwater planning (GJvV)

Stormwater falls under the Roads and Stormwater division of the newly-formed Transport and Roads department. About 50% of the department's capital budget is available for stormwater projects at present (but is often much less). The City of Tshwane has a well-developed stormwater section which has been active in producing development floodlines for all rivers in the metro. There is 1600 km of river frontage in the City, and about 45% has certified 100 year and 200 year indicative floodlines – the 50 year floodlines are available for nearly all areas. CoT has some good policies around flooding and flood attenuation, including the requirement for macro attenuation (to pre-development scenario), usually by way of retention dams. SuDS concepts are slowly being introduced (with resistance from developers in some instances). In areas where stormwater master planning has been completed (as in Arcadia and Hatfield) they have been able to dictate certain conditions, e.g. no discharge of anything more than pre-development runoff to the stormwater system; 70% hard surfaces only, etc. There has been good cooperation and buy-in from the City planners to relook at planning issues to take into account SuDS principles. For example, rezoning applications will be considered if the applicants submit a stormwater impact assessment showing WSUD principles (so that underground stormwater connections are not required). The biggest challenge is getting engineers / consultants to start thinking differently; and the UCT / WRC stormwater guidelines study will be a very helpful tool to encourage this change of behaviour. The Stormwater division is involved in various WRC projects around the use of SuDS.

CoT does river quality monitoring downstream of WWTWs, but there is only irregular monitoring of the stormwater system (through the use of an in-house laboratory) – stormwater is not regulated in any way, and the WQ of stormwater is therefore almost completely neglected. Recently there has been better cooperation between CoT, Gauteng Province and the Department of Water Affairs however – and monthly EIA forum meetings are held to discuss projects that require environmental evaluation, water use licences, development issues etc. The Environmental Management section does State of the Environment reporting, with a substantial input regarding climate change. The rainfall patterns appear to be changing, with long, dry periods and short, heavy rains (high intensity storms).

A9.1.1 Challenges

- **Separation of service delivery functions** makes integration particularly difficult, and joint projects are dependent on personal relationships being forged.
- Formalisation of **informal settlements** is problematic, particularly because stormwater is not seen as a basic service and is therefore not included in planning processes. National

policy describes the function of roads as to drain water only (i.e. no reference to SuDS or any form of treatment process).

- **Funding** – generally poor budgets for stormwater, although there is an agreement with Gauteng Housing that Tshwane will budget for top-up funding to reach the minimum standard for new developments, i.e. all services installed from the beginning. Estimated costs to eradicate stormwater backlogs in Tshwane amount to approx R1 billion, and increasing all the time as informal settlements are formalised. Also, funding for WSUD is not a priority. Availability of funds is often driven by flood events, e.g. the flooding of Jan/Feb 2006 in the northern parts of Tshwane resulted in major changes to the budget.
- **Groundwater pollution** – particularly as a result of poor sanitation services (e.g. pit latrines) in areas where drainage is not good (sandy gravel with shallow impermeable granite layers).
- **Stormwater planning** is a major problem (as it relates to City structure) – only 8% of new areas incorporated into the City have been developed (mainly rural). The existing old Pretoria by-laws (as well as the Open Space Framework, 2006) state that there should be no development within the 50 year floodplain, but not all the by-laws agree. They are in the process of revising stormwater standards, to be incorporated into a new set of metro-wide by-laws that should provide a more consistent authority over developers.
- **Institutional structures** act as an obstacle to WSUD principles as an integrated way of thinking and management is required and this is currently not being promoted. Also, some of the initial WSUD projects were fined or couldn't go out to tender because they didn't have the required Environmental authorisations for a 'listed activity' – anything that discharges to a river has to have a silt trap and an energy dissipation structure. After the new environmental legislation was promulgated in 2006, ROD's were taking up to 12 months to be processed; this has improved to about 3 months with good cooperation from the Province, but there are still issues with water use licenses from DWA (required for major systems discharging to rivers) – these can take between 7 and 39 months!
- **Stormwater pollution impacts** on rivers and dams – this is difficult to control, and source prevention is one of the strategies. An example of this is on one of the major stormwater outlets from an informal settlement, where they are out on tender for a gross pollutant trap and a sand filter to be installed before discharge to the river.
- **Promotion of development** is extremely challenging.
- **Climate change** – rainfall patterns changing; increased flooding events.
- **Sink-holes** are problematic in dolomitic areas, linked to both stormwater drainage issues as well as poor infrastructure provision. WSUD / SuDS cannot be implemented here.

One of the biggest challenges is to change developers minds such that open space does not get developed within the floodplain.

Appendix B

**Recommendations from trial Sustainability Index
applications and structure of indices – SI 2007 and SI 2009**

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B1 Application of SI 2007

The following sections reflect the recommendations as quoted directly by the different researchers arising from the application of SI 2007 to various urban centres.

B1.1 SI 2007 structure

Table B1(a): List of components, indicators and variables for SI 2007

Component (5)	Indicator (20)	Variable (64)
1. Social security and cultural acceptability (Social fairness and equitable resource distribution)	1. Access to water supply	1.1 Total collection time
		1.2 Gender bias
		1.3 Conflict over water sources
		1.4 % with access to protected water
	2. Access and use of sanitation facilities	2.1 No. people per sanitation facility
		2.2 Safety of use and safety to access facilities
		2.3 Cultural and social acceptability (type, odour issues, visual and physical contact with excreta)
	3. Levels of Service (LOS)	3.1 Water supply
		3.2 Sanitation
		3.3 Drainage
		3.4 Waste collection
	4. Vulnerability to disasters	4.1 Susceptibility to natural disasters
		4.1.1 Dolines and sinkholes
		4.1.2 Earthquakes
		4.1.3 Droughts
		4.1.4 Tornados
		4.1.5 Cyclones & floods
		4.1.6 Tsunamis or shock waves
		4.1.7 Fires (impact of inadequate water supply)
	4.2 Risk Management and disaster mitigation	
	5. Health (morbidity and mortality)	5.1 Under 5 mortality rate
		5.2 Malaria-related mortality rate
		5.3 Reported cases intestinal / infectious diseases per 1000
		5.4 HIV/AIDS prevalence
	6. Education and awareness	6.1 Level of dissemination (various forms of advertising accessible to all income groups)
		6.2 Level of stakeholder consultation and public participation
7. Capacity (to pay or access services)	7.1 % people with secondary education	
	7.2 Unemployment rate	
	7.3 Income levels	
	7.4 No. of days per year taken off work due to water related diseases (loss of income due to sickness)	
	7.5 Minimum / Basic water tariff	
8. Cost Recovery	8.1 % users paying for water	
	8.2 % of unaccounted for water (UFW)	
	8.3 % of free basic water (FBW)	
2. Economic (Economically sound: economic growth and cost-returns)		

Table B1(b): List of components, indicators and variables for SI 2007

Component (5)	Indicator (20)	Variable (64)
Economic	9. Investment levels	9.1 % budget increase for water supply
		9.2 % budget increase for sanitation
		9.3 % of budget increase for O&M
		9.4 Sources of investment
3. Environmental performance (Environmental protection and preservation of ecological systems)	10. Fresh water resources	10.1 Per capita water availability (l/capita/day)
		10.2 Reliability or variability
		10.3 Water quality at source
	11. Sustainability / Feasibility of water sources	11.1 Sustainability of source
		11.1.1 Local Groundwater
		11.1.2 Rainwater
		11.1.3 Local surface water
		11.1.4 Imported groundwater
		11.1.5 Stormwater
		11.1.6 Greywater
		11.1.7 Imported surface water
		11.1.8 Brackish water
		11.1.9 Treated effluent (wastewater)
	11.1.10 Salt water	
	12. Use (resource distribution per sector)	12.1 Domestic
		12.2 Industrial
		12.3 Agricultural and livestock
		12.4 Maintenance of ecosystems
	13. Wastewater management	13.1 Effluent quantity
		13.2 Effluent quality
14. Stormwater management	14.1 Effluent quantity	
	14.2 Effluent quality	
15. Comp with environ	15.1 Close to solid waste dump or landfill site	
16. Compatibility of sanitation systems with the surrounding environment	16.1 Located on flood prone area	
	16.2 Steepness	
	16.3 Depth to groundwater table	
	16.4 Soil permeability	
	16.5 Ground stability	
17. Environmental stresses	17.1 % of polluted water sources	
	17.2 % of total area identified as severely water stressed	
4. Political support	18. Governance	18.1 Democracy and representation
		18.2 Measure of corruption
		18.3 Defined roles and responsibilities
	19. Compliance with policy	19.1 Government policies
		19.2 MDGs
5. Institutional capacity and technological progress	20. Institutional and technical capacity	20.1 Adoption of IWRM approach
		20.2 No. of water management institutions
		20.3 Adoption of alternative water supply technologies
		20.4 Adoption of 'sustainable' sanitation
		20.5 Corresponding education levels for O&M
		20.6 Monitoring capability (including issues of data quality)
		20.7 Reliability of service provision
		20.8 Service del. failure due to dependence on other sectors

B1.2 Hermanus and Maputo (de Carvalho, 2007) – Research recommendations

The following recommendations were made for the improvement of the index in order for it to be more relevant and reliable:

- Engagement with relevant stakeholders and experts to identify pertinent issues and formulate appropriate indicators.
- Vary indicator selection and test SI applicability to the selected two and other relevant case studies; maintaining flexibility and adaptability.
- Develop weighting schemes through the adoption of a more robust methodology for selecting weights. It is recommended that, where possible, a combination of stakeholder input and statistical analysis be employed.
- Ensure the quality of data used, and where this is not possible either eliminate the variable/index/component, or provide relevant proxies for which quality data is available.
- Undertake wider application of the index and broader testing to a variety of settings to determine the applicability and use of index. More detailed sampling will enable the application of statistical techniques to validate assumptions made in the development and application process.
- Apply statistical analysis methods to gauge the sensitivity and uncertainty in underlying assumptions as well as due to data gaps (imputation).
- Test the issue of scale by applying the index at local (neighbourhood, district) and national level rather than simply at city level. Explore the option of scaling up or down; firstly, as the indicator stands and, secondly, by readjusting the structure to suit the context. This might result in different indices for different scales.
- Address the temporal dimension by tracking progress over time and maintaining good records. It is proposed that the indicator be applied on a yearly basis. This will enable recording of relevant changes, and can be aligned with specific institutional annual cycles to ensure commonality of interest and increase potential for acceptance and use. It is also important to identify past trends, and determine how these have influenced current behaviours and events as well as what effects these can have in future practices.
- Alternative methods for calculating the index should be pursued to determine whether improved results can be obtained and/or whether less data intensive, hence resource-exhaustive approaches are possible. This also involves the investigation of whether a set of indicators is more appropriate for a particular setting rather than the composite index as used here.

The following recommendations are aimed at institutions linked to or interested in the research:

- Greater emphasis must be placed in the collection and storage of data, but more importantly, there is need for continuity in this process. It must not be a once-off endeavour which is driven by particular research objectives or a specific project. Many of

the variables considered here require a considerable number of yearly records to provide an actual measure of change. It is therefore proposed that data collection be undertaken by a dedicated team or incorporated into the work performed by organisations involved in similar work.

- Complementarily, there should be wider inclusion of SI-related questions in formal data collection exercises such as: School level questionnaires; Community polls; Water-related questionnaires of surveys at national level i.e. National Census. This is to avoid duplication of initiatives and where possible make optimal use of existing resources.
- Aside from the actual pursuit of information, organisations directly involved with the collection of data and tasked with monitoring i.e. CRA in Maputo and Umvoto (temporarily) in Hermanus; must ensure that the data is widely accessible to the public. The difficulty in accessing data is perhaps the biggest contributor to an uninformed public.
- It is proposed that other researchers elsewhere undertake further work in the development of indices in this particular field of study, to enable comparisons and allow for the verification of results obtained.
- Develop and disseminate specific targets/target ranges for some of the issues raised. Initiatives such as the MDGs as well as the target dates adopted by African countries for the introduction and implementation of IRWM approaches are good examples of this.
- Improvements in quality data collection and storage are needed: regular updates and more indicators for better information. This must be undertaken by qualified and skilled personnel who will ensure the quality of data and will report on potential sources of error.

B1.3 Franschhoek (Hotchkiss, 2008) – Research recommendations

The following are recommendations are based on the evaluation of the SI 2007 and the discussion points presented in the thesis:

- It has been recommended that data collection processes should be improved so as to ensure more accurate and regular sustainability monitoring. This should work hand in hand with the use of the SI 2007. Once the SI data requirements are finalised, the most efficient method of obtaining this data should be researched.
- The measure of vulnerability (Indicator 4) needs to be better defined in terms of spatial and time context and it should take into account that the poor are generally much more vulnerable to disasters especially those living in informal settlements. It is recommended that this indicator measures the % of the population susceptible to levels of vulnerability where vulnerability risk is the product of probability and consequence of disaster.
- Consider population growth rate as an indicator.
- Consider the financial cost of water supply to the local authority as an alternative indicator of economic sustainability.

- Consider energy consumption of the local water sector (measured per capita) as an economic indicator. Note that energy consumption also has relevance to environmental issues. Firstly, power generation can contribute to climate change, and secondly, reliance on power may result in significant environmental impacts during power failures.
- Indicator 11: *Sustainability/Feasibility of water sources* needs to be revised. It is recommended that it be combined with Indicators 10 (*Freshwater Resources*) and 17 (*Environmental stresses*) to form two different indicators: “Quantity of water resources” and “Quality of water resources” giving a measure of river health and water resource scarcity. For “Quantity”, a possible indicator is ‘annual withdrawal as a % of available water at source’ in addition to the existing variables of water availability and reliability. “Quality” variables such as pollution and biodiversity levels need to be researched and will depend on available financial / human resources for the necessary data collection.
- Indicators 15 and 16 which address the compatibility of urban water and sanitation systems with the surrounding environment need to be re-evaluated. The current data requirements are too variable over a large area and are difficult to accurately ascertain. It is therefore recommended that these indicators are substituted for an indicator which more directly assesses the groundwater quality in the study area.
- In the case where variables apply to more than one component it is recommended that they only be measured once in order to assist in down-sizing the SI 2007.
- Although South Africa’s Strategic Framework for Sustainable Development has not been published yet, compliance with this framework should be considered when addressing Indicator 19: *Compliance with policy*.
- The implementation of a water demand management strategy is very important and should also be considered when addressing Indicator 19.
- Consider combining the Political and Institutional components of the SI into a single component.
- Ensure that the SI does not lead to misinterpretations. The results must highlight priority areas within the study area as well as poorly achieving components which need addressing.
- The traffic light diagram categorisation which gives a definitive “measure of sustainability” needs to be re-evaluated. “Highly sustainable” should refer to a study area which receives over 90% or even 95%.

The SI Excel workbook can be easily adapted and is thus far more useful than the SI 2007 program during the development stages of the SI; however, it is recommended that an updated program similar to SI 2007 be used once the final SI is produced.

B1.4 Stellenbosch (Makgalemele, 2008) – Research recommendations

The Sustainability Index should be further revised according to the availability of data and should take into account the issue of missing data such that the lack of essential data affects the scores of sustainability. In this way the index reflects the fact that a lack of data will lead to subjective-laden information and will produce bias in the application of knowledge through decision making. Only 50% of the information gathered pertained to the town of Stellenbosch. The index would have been more reflective of the municipality if the data for it had been specific to Stellenbosch. Thus, where such a situation occurs, the municipality urban regions should be used as opposed to the town itself. It is noted that within a municipal region the towns may differ in their demographic, environmental or socio-economic settings. This problem can be overcome through compartmentalizing the urban areas that are linked or that are similar in nature. In South Africa, many municipalities have one main town which serves as the economic hub of the area. Through compartmentalizing the towns, a more reflective indicator of levels of sustainability can be attained as opposed to standardizing the whole municipality.

The guidelines presented in the discussion of the SI should be further scrutinized in any attempt to reduce the numbers of variables in SI 2007. This should be done with ample participation of stakeholders and experts. Especially worth investigating is the use of a systems-based approach as presented by Bossel (2001). This may better emphasise the interconnectivity of the socio-economic, natural, political and technical/institutional facets. It could also better highlight the benefits of optimizing the connectivity of the urban water cycle.

Ground-truthing exercises outlined in the thesis for the town and index should be applied with more vigour. These exercises aid in identifying areas where the SI 2007 falls short of its own objectives and alternatives can then be investigated. An exercise of this sort will require substantial resources and thus could be used as an academic exercise to which students can apply their minds. This would introduce a different dynamic to the index by testing its user friendliness. In addition to this, the communities of the town should undergo a similar exercise using the knowledge they themselves have of their section of town.

A greater focus on the role of water management in poverty alleviation should be investigated. In most African cities it is acknowledged that poverty is one of the most pressing issues. The reduction of poverty has impacts on all facets of water management such as increased awareness and income, thus leading to better maintenance and cost recovery for the services provided. The levels of understanding of SI 2007 as an advocacy tool for non-technical people should be investigated. This should be done to better inform its presentation and the manner in which the information from it can be disseminated. Such an investigation could be conducted on people of different socio-economic levels by means of a survey observing their responses to the outcome presented by SI 2007. In addition, a presentation to the municipality or town councilors should be made about the state of their town based on the SI experiences and results. Their feedback would make the SI tool much more applicable to the environments it is trying to change.

B1.5 Dar es Salaam (Mrema, 2009) – Research recommendations

The following aspects should be considered by future sustainability index evaluators:

- Consider population as part of the index.
- In the tariffs consider including the amount paid by the people to other supplies especially in a city where a large population do not pay their bills to the water institutions.

B1.6 Ekurhuleni (Siboiboi, 2009) – Research recommendations

The following recommendations were made during the course of the research:

- Data collection should be taken as a top priority in the research. Data should be collected in such a way that even future researchers can use them or improve on them.
- Field testing for more information should be done to improve the quality of the data.
- The municipalities should contribute to collecting data to be used in the index analysis. This will allow more time to be spent on the data collection need for the SI 2007.
- The results obtained for the SI 2007 should be compared with results of other sustainability performance measurement systems used by the municipalities to check the efficiency of the results.
- “Number of water sources” in the area should be considered as a variable.
- In future the research should be based on developing the index same as SI 2007 for use in rural areas; this can be a key for poverty alleviation in rural areas. Many people in urban areas today are from rural areas they immigrated looking for jobs.

B1.7 Windhoek, Namibia (Urban, 2009) – Research recommendations

A number of suggestions were made in the thesis regarding possible improvements to the SI 2007 following the application of the index in Windhoek. The recommendations are based on the key characteristics of a good indicator as described in the thesis, and are mainly aimed at reducing the number of variables and/or indicators in the current index, while making it easier to use and more applicable:

- Elimination of Indicator 1 *Access to water supply* and Indicator 2 *Access and use of sanitation facilities* as these repeat trends already measured by Indicator 3 *Levels of Service*.
- Revision of Variable 4.1 *Susceptibility to natural disasters* in Indicator 4 *Vulnerability to disaster* due to the ambiguity in the way this variable is assessed by implementing a new scoring system.
- Replacement of Variable 7.3 *Income levels*, and possibly Variable 7.1 *% people with secondary education* and Variable 7.2 *Unemployment rate*, in Indicator 7 *Capacity (to*

pay or access services) with a variable measuring inequality (such as the Gini coefficient) to give a better representation of the socio-economic environment in the city assessed.

- Elimination of Variable 7.4 *No. of days taken off work due to water-related illnesses* as data is difficult to obtain.
- Revision of Variable 8.1 *% of users paying for water* in Indicator 8 *Cost recovery* in order for it to measure the percentage of users paying regularly, since arrears in payments have a negative impact on the sustainability of urban water management.
- Revision of Variable 10.2 *Reliability or variability* in Indicator 10 *Freshwater resources* due to the difficulty in assessing this variable by focusing the variable on either short-term or long-term reliability of freshwater resources, or by creating a separate variable for each.

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B2 Application of SI 2009

The following sections reflect the recommendations arising from the application of SI 2009.

B2.1 Structure of SI 2009

Table B2: List of components, indicators and variables for SI 2007

Component (5)	Indicator (14)	Variable (36)
1. Social security	1. Levels of Service (LOS)	1.1 Water supply
		1.2 Sanitation
		1.3 Drainage
		1.4 Waste collection
	2. Vulnerability to disasters	2.1 Susceptibility to natural disasters
		2.2 Risk Management and disaster mitigation
	3. Health	3.1 Under 5 mortality rate
		3.2 HIV/AIDS prevalence
	4. Education and awareness	4.1 % of people with secondary education
		4.2 Level of stakeholders consultation and public participation
2. Economic	5. Capacity (to pay or access services)	5.1 Unemployment rate
		5.2 Income levels
	6. Cost Recovery	6.1 % users paying for water
6.2 % of unaccounted for water (UFW)		
7. Investment levels	7.1 % budget increase for water supply	
	8. Fresh water Resources	8.1 Per capita water availability (l/capita/day)
9. Sustainability of water sources		8.2 Water quality at source
	9.1 Sustainability of source	9.1 Sustainability of source
9.2 River Health Index		9.2 River Health Index
	10. Use (resource distribution per sector)	10.1 Domestic
10.2 Industrial		
10.3 Agricultural and livestock		
10.4 Maintenance of ecosystems		
11. Wastewater management	11.1 Effluent quantity	
	11.2 Effluent quality	
4. Political support and international stewardship	12. Governance	12.1 Democracy and representation
		12.2 Measure of corruption
		12.3 Defined roles and responsibilities
	13. Progress with meeting the MDGs	13.1 % with access to protected water
		13.2 % with access to adequate sanitation
5. Institutional capacity and technological progress	14. Institutional capacity and technological progress	14.1 Adoption of IUWM approach
		14.2 Adoption of alternative water supply technologies
		14.3 Adoption of 'sustainable' sanitation
		14.4 Monitoring capability
		14.5 Reliability of service provision

B2.2 East London and Port Elizabeth (Mureverwi, 2009) - Research recommendations

The research presented in this thesis was informed by some of the recommendations for future research suggested by De Carvalho (2007). The following are recommendations based on the revision and evaluation of the SI and the discussion points presented:

- Adjust or modify the component structure of the index, and give consideration to the concept of the “Prism of Sustainability” (Valentin & Spangenberg, 2000) so as to combine the institutional and political components. The combination of these two components may result in results that are a better representation of IUWM in a particular city.
- With regard to data sources for the political component, it is suggested that alternative sources be used because those interviewed were not necessarily objective about the questions asked. Independent reporting by organizations such as the United Nations on corruption and democracy in cities may be useful. The concern would be whether the data is reported at the scale needed for the SI.
- Engagement with relevant stakeholders and experts to identify pertinent issues and formulate appropriate indicators. This will help in getting expert knowledge on the issues regarding IUWM that should be addressed in the SI.
- Undertake a wider application of the index and broader testing to a variety of settings to determine the applicability and use of index. This is important because different study areas highlight various issues with regard to the effectiveness of the SI.
- Test the issue of scale by applying the index at local (neighbourhood, municipality) and national level rather than simply at city level. Applying the index at a municipality level may prove to be advantageous because most data in South Africa is reported at a municipality level.
- Address the chronological dimension by tracking progress over time and maintaining good records. It is proposed that the indicator be applied on a yearly basis. This will enable recording of relevant changes, and can be aligned with specific institutional annual cycles to ensure commonality of interest and increase potential for acceptance and use.

Appendix C

**Background to and details of indicators / variables and
scoring for SIUWM calculations**

This Appendix provides the background to and particulars of the variables / indicators for the four components of the SIUWM, and outlines the rating and scoring that was adopted for the index calculation. For ease of reference, Table C1 reproduces the list of indicators / variables that make up the final SIUWM and numbers them according to the sections that follow.

Table C1: Indicators and variables for SIUWM

Component (4)	Indicator (16)	Variable (35)
C1 Social	1.1. Levels of Service	1.1.1 LOS Water supply
		1.1.2 LOS Sanitation
		1.1.3 LOS Solid waste collection
		1.1.4 LOS Drainage
	1.2. Health	1.2.1 Under 5 mortality rate
		1.2.2 HIV/AIDS prevalence
	1.3. Vulnerability	1.3.1 % population living in informal dwellings
		1.3.2 Risk management / disaster mitigation
	1.4. Skills and awareness levels	1.4.1 Customer service standards
		1.4.2 Secondary education levels
C2 Economic	2.1. Capacity to pay or access services	2.1.1 Unemployment rate
		2.1.2 Levels of inequality (Gini coefficient)
	2.2. Cost recovery / funding	2.2.1 WSA financial performance
		2.2.2 Water use efficiency / NRW
	2.3. Asset management	2.3.1 Strategic asset management
C3 Environmental	3.1. Resource sustainability / feasibility (quantity)	3.1.1 Per capita water availability
		3.1.2 Sustainability of source
		3.1.3 Demand for water resources (average population growth rate)
	3.2. Sustainability of water resources (quality)	3.2.1 Potable water quality (Blue Drop)
		3.2.2 Water resource quality (River health)
		3.2.3 Groundwater quality
	3.3. Climate change response*	3.3.1 Energy consumption by water sector
		3.3.2 Climate change strategic planning
	3.4. Use (resource distribution per sector)	3.4.1 Domestic water demand
		3.4.2 Industrial water demand
		3.4.3 Ecosystems water demand
	3.5. Wastewater management	3.5.1 Wastewater quality (Green Drop)
	3.6. Stormwater management	3.5.1 WSUD / SuDS policy and implementation
C4 Institutional	4.1. Governance model	4.1.1 Defined roles and responsibilities
		4.1.2 Departmental integration
	4.2. Progress with meeting targets (MDGs etc)	4.2.1 Access to water supply
		4.2.2 Access to sanitation
		4.2.3 Access to Free Basic Water (FBW)
	4.3. Institutional capacity / policies	4.3.1 WDM policy / IUWM approach
		4.3.2 Institutional effectiveness

*Note: Climate change response indicators were not included in current sustainability assessment – see Chapter 5 for details

C1 Social component

The social component assesses the impacts on society from current water management and service provision practices. Four indicators were selected to represent the social component, and these in turn are detailed through the use of several variables.

C1.1 Levels of Service

The term ‘levels of service’ refers implicitly to the degree to which the combination of different services satisfies social, cultural and economic requirements, taking into account concerns of acceptability, accessibility and convenience (De Carvalho, 2007). The first step in moving towards sustainability is to ensure that basic levels of service (LOS) are provided in a fair and equal manner – the provision of water services has both direct and indirect benefits for individuals and society as a whole. These include *inter alia*: improved health through reduction of disease; economic gains from improved efficiency, increased incomes and improved productivity; and environmental benefits stemming from efficient sourcing and provision of water services, as well as the management and disposal of wastes. De Carvalho (2007) notes that service provision in the developing world continues to fall short of current (and future) demands, and that this has compromised the well-being and development of many people. The importance of water service provision in the efficient functioning of cities can therefore not be overstated. It should be stressed however that whilst efficient service provision is essential for growth, it is not sufficient to ensure sustainable development, and complementary inputs (and indicators for measurement) are required to address issues such as community participation, appropriate technologies, improved capacity etc.

The stipulation of LOS has been established by organisations such as the WHO for whom the minimum basic supply of water is 20ℓ/c.d at distances no greater than 1000 m; and an intermediate level of access is defined as 50ℓ/c.d at distances no greater than 100 m (Howard & Bartram, 2003). In SA the term ‘basic level of service’ refers in most cases to on-site dry latrines (VIPs or similar) and 25 ℓ/c.d of drinking water within a cartage distance of 200m (DWAF, 2003). The services accounted for in this research include the three major water-related services, namely; water supply, sanitation (including the disposal of wastewater) and drainage (also includes greywater management). In the case of wastewater, the level and type of service often dictates under which category this will be addressed; whether it is a sanitation issue or a drainage problem. A fourth service is therefore also included, solid waste management, which includes both domestic waste and litter. The issue of urban litter is one that is experienced in every city worldwide. In developing countries, where urbanisation is leading to a growing consumerist movement and the capacity for solid waste management continues to fall behind the growth level of cities, the term ‘pollution of poverty’ has been coined (De Carvalho, 2007). Practical solutions have thus been put forth for the efficient management of urban litter, with the ultimate aim of preserving water environments (Marais & Armitage, 2003). Table C2 presents the five levels of service for each category that was adopted in this research, including examples of the type of system and the frequency of the service.

Table C2: Levels of Service (LOS)

LOS	Water Supply	Sanitation	Drainage	Solid waste
LOS 1	Individual house connection	Conventional sewerage Simplified sewerage Alternate sewerage, i.e. vacuum sewerage	Conventional SuDS	Frequent & reliable (weekly)
LOS 2	Roof tanks Yard tanks & taps	Septic tanks On-plot sanitation (improved)	Conventional	Regular but infrequent (two weekly)
LOS 3	Standpipes	On-site communal facilities	Greywater management	Infrequent (once monthly)
LOS 4	Communal standpipes Vendors	Bucket toilets	Informal drainage only	Informal collection only
LOS 5	None	None	None	None

Obtaining LOS for drainage was not a simple task, and in most instances involved attempting to question relevant officials in the stormwater departments at local authorities, who were often unable to give the required information. In some instances therefore, the LOS figures for drainage were inferred from the average LOS for the other three services. Taking into account issues such as health impacts, income levels and ability to pay, a subjective rating system was adopted for service levels as shown in Table C3. Scores for each variable are determined by multiplying the percentage of the population with access to different levels of service (expressed as a number between 0 and 1; total to add up to 1) with the relevant rate and summing the results for all LOS.

Table C3: Rates for LOS

LOS	C1.1.1 Water Supply	C1.1.2 Sanitation	C1.1.3 Solid waste	C1.1.4 Drainage
LOS1	5	5	5	5
LOS2	4	4	4	4
LOS3	3	2	2	2
LOS4	1	1	1	1
LOS5	0.1	0.1	0.1	0.1

C1.2 Health

Despite the common perception that water supply can ensure improvements in health, there are many other factors, many of which are not related to the water sector, which can have significant detrimental health impacts. Having said this however, the causational link between

the two as well as scientific backing as to the diseases which can and do result from poor water supply (quantity and quality) and inadequate sanitation are well acknowledged. To address the water-health relationship, it is common to look at the most vulnerable groups to be affected by poor access to water i.e. children.

Table C4: Health status and water related diseases

C1.2.1 Under-5 mortality rate	C1.2.2 HIV/AIDS prevalence	Score
0%	0%	5
1%-5%	1%-5%	4
6%-10%	6%-10%	3
11%-20%	11%-20%	2
21%-30%	21%-30%	1
>30%	>30	0.1

In South Africa data from different sources point to increasing infant and child mortality figures, meaning that the country is unlikely to be able to reduce infant mortality to the MDG target of 18 deaths per 1000 live births. There are three major killers of children under five years of age in South Africa: HIV & AIDS, neonatal causes and childhood infections such as pneumonia and diarrhoea (RSA, 2010).

The Under-5 mortality rate has therefore been adopted as the first variable to be measured, followed by HIV/AIDS prevalence. Whilst this is not directly related to water, the symptoms and treatment of HIV can be severely impacted by the availability or lack of water services. Sufficient supply of water and safe sanitary facilities improve immunity to diseases and hence contribute to the ability to resist the more debilitating effects of HIV/AIDS and reduce the risks of spreading the virus.

C1.3 Vulnerability

The notion of risk and its relationship to vulnerability and sustainability has already been introduced (see Section 2.3 in the main thesis). The following variables have been selected to determine vulnerability of an urban population to water-related risks, specifically in a developing nation context; note that as the risk increases, so does vulnerability:

- % population living in informal dwellings – informal settlement dwellers are far more vulnerable to risks from natural disasters (flooding, fires, droughts, tornadoes etc) than those people living in formal dwellings.
- Risk management and disaster mitigation – in the event of a disaster or in awareness of susceptibility to it, risk can be mitigated by good management, and appropriate design and awareness creation. In the event of poor preparedness and handling of the situation, there is an option for remediation.

Table C5: Risk management

C1.3.1 population living in informal dwellings (%)	C1.3.2 Risk management (qualitative assessment)	Score
0%	Risk avoidance by design	5
0.1%-5%	Risk awareness and preparedness	4
5.1%-10%	Effective disaster mitigation (good response)	3
10.1%-20%	Compensative risk management (remediation)	2
20.1%-30%	Poor disaster management	1
>30%	None	0.1

C1.4 Skills and awareness levels

Key to sustainability is good governance and an ability to put in place the processes required to encourage this – it creates the right perceptions in consumers, it builds trust and a willingness to pay for services. A crucial aspect is the ability to instil a sense of ownership on the part of beneficiaries, and to ensure that they are able and willing to pay for services. In this regard, education is crucial, as literacy rates are linked to peoples’ ability to comprehend issues. This indicator therefore considers both education levels of the general population, as well as how efficiently information gets disseminated by the local authority, and what the relationships / services standards are like between the municipality and its customers. Customer services standards and levels of dissemination on water-related matters are measured by way of the Department of Water Affairs’ Regulatory Performance Measurement System (RPMS) KPI 7, which comprises the following information:

- Customer relations management systems within the local authority – a Customer Charter; adequately-staffed customer service centre; system to manage customer queries and log faults; escalation of complaints through an incident tracking system.
- Service interruptions – total number and number of interruptions in continuous service, greater than 24 hours long.

Table C6: Skills and awareness levels

C1.4.1 Customer services standards (RPMS KPI 7)	C1.4.2 % of population with secondary education	Score
4.5-5.0	100%	5
4.0-4.49	99%-70%	4
2.5-3.99	69%-40%	3
1.5-2.49	39%-20%	2
0.0-1.49	19%-10%	1
No data	<10%	0.1

C2 Economic component

Whilst it is acknowledged that water services are essential for the preservation of life, there is also an economic cost which must be duly reflected (De Carvalho, 2007). This component addresses the economic dimension of water management, exploring the necessary investments for the adequate provision of services, infrastructure development and maintenance of work. At the same time it assures the need for cost recovery. It recognises the Dublin principles which state that access to water should be made available to all, but it also acknowledges that water has an economic value, both as a resource and also regarding the need for collection, treatment, distribution, and discharge. This component attempts to balance social priorities with economic concerns.

C2.1 Capacity to pay or access services

This indicator provides a measure of people's ability to access and pay for water services, based on their income security, determined by way of the percentage of unemployed people in the city. The levels of inequality (as provided by the Gini coefficient figures for a particular urban area) are also included as they point to potential difficulties with social equity and people's chances to improve their economic and social situation. This has knock-on impacts in terms of their ability to pay for and access services.

Simply, capacity looks at people's ability to pay, given how much they must pay and how much they have, therefore indicating whether, from an economic point of view, people have access to this essential resource.

Table C7: Capacity for accessing and paying for services

C2.1.1 % unemployment	C2.1.2 Gini coefficient	Score
0%	<0.4	5
1%-20%	0.4-0.49	4
21%-40%	0.5-0.59	3
41%-60%	0.6-0.69	2
61%-80%	0.7-0.79	1
>80%	>0.8	0.1

C2.2 Cost recovery / funding

A significant contributor to poor service provision is the lack of financial resources for expansion and maintenance of water services infrastructure. In the interest of self-sufficiency and sustainability, providers should aim for high cost recovery, provided it does not jeopardise social and developmental precepts. In developing countries, the problem of cost recovery is one

of poor payment levels and revenue collection combined with unacceptable resource wastages. This indicator comprises two variables, both of which are measured through the RPMS:

- Water Services Authority (WSA) financial performance (KPI 9) – includes aspects such as revenue collection efficiency, financial integrity (ring-fenced WSA, audit report evaluation), creditor and debtor days, financial effectiveness (total provision for bad debt) and financial sustainability (total costs for water and sanitation vs. income).
- Water use efficiency / Non-revenue water (KPI 11) – one of the ways of measuring technical efficiency in water utilities is to assess non-revenue water. This variable refers to the percentage of water which is unaccounted for, and includes both unbilled authorised consumption, apparent (unauthorised consumption through theft or illegal use plus all technical and administrative inaccuracies associated with customer metering) and real (physical water losses from the pressurised system) losses. The RPMS scores are calculated as shown in Table C8.

Table C8: Cost recovery

C2.2.1 WSA financial performance (RPMS KPI 9)	C2.2.2 Water use efficiency / NRW (RPMS KPI 11)	NRW scores	Score
4.5-5.0	5	>5% and <15%	5
4.0-4.49	4	16%-20%	4
2.5-3.99	3	21%-25%	3
1.5-2.49	2	26%-30%	2
0.0-1.49	0-1	31%-35%	1
No data	No data	<5% and >35%	0.1

C2.3 Asset management

Inadequate investments in water infrastructure and human capacity have proven to be the biggest constraints in efficient management of water resources and service delivery. Previous discussions on the issue of resource scarcity indicate a problem of both water scarcity and water insecurity affecting great parts of South Africa. As already discussed, in order to prompt change and encourage improvements, an assessment of the current state of service delivery is required. The Department of Water Affairs' RPMS indicator for strategic asset management was used to provide a measure of the assets investment in the South African water sector, specifically in terms of operations and maintenance expenditure as well as rehabilitation and replacement saving. This indicator also assesses asset management effectiveness, and asset register monitoring in the WSAs.

According to the Infrastructure Barometer (DBSA, 2006), municipal infrastructure investments were financed from the following sources in 2002/3, with the larger municipalities

relying more on loans and internal cash generation, while the smaller ones depend more on grants and other sources of funding:

- 24% through municipal and provincial grants (12% each).
- 15% through loans.
- 42% through internal cash generation.
- 19% through other sources.

Table C9: Asset management / investment levels

C2.3.1 Strategic asset management (RPMS KPI 10)	Score
4.5-5.0	5
4.0-4.49	4
2.5-3.99	3
1.5-2.49	2
0.0-1.49	1
No data	0.1

C3 Environmental component

C3.1 Resource sustainability / feasibility (quantity)

This component proposes that the environmental dimension of sustainability be equally addressed alongside socio-economic considerations, in order to ensure that basic preservation of ecological systems is maintained. Three variables have been adopted:

- Per capita water availability in cubic metres per capita per annum ($\text{m}^3/\text{c.a}$) – usually measured as total actual annual renewable water resources (TARWR) per person in order to provide an indication of the amount of potentially available water resources (see Glossary). The Falkenmark indicator (Falkenmark, 1986) proposes a basic per capita water threshold of $1700 \text{ m}^3/\text{annum}$. This is based on estimates of household water requirements, the needs in agricultural, industrial, and energy sectors, and the call for ecosystem maintenance. Areas for which the per capita (yearly) water availability falls below this figure are considered water stressed, while areas with basic water availability targets of $500 - 1000 \text{ m}^3/\text{c.a}$ and $<500 \text{ m}^3/\text{c.a}$ are considered water scarce and extremely water scarce respectively. SA is already categorised as water stressed according to this indicator, and is rapidly moving towards water scarcity as the population grows – the TARWR in the country for 2008 equated to 1007 m^3 per person per annum (UNEP, 2010). TARWR figures at city scale in SA are not available however, and the decision was taken to use the information on total cumulative storage capacity as supplied in the latest DWA report on Integrated Water Resource Planning (DWA, 2010d) instead.

According to the report, total available water in 2000 was about 12 800 million m³ per annum with surface water accounting for about 75% and groundwater, return flows and water used by afforestation making up the rest. A very significant proportion of the surface water yield (3000 million m³ per annum) is moved via inter-basin transfers to areas in the country where demand exceeds supply (ibid). Based on these figures, estimates have been made on the current and future system yields / resource availability in the supply systems providing water to the main cities in the country. These have been used to define a range of values for the variable to match the Falkenmark categories (Table C10).

- Average population growth rate – this variable was selected as a proxy for demand for resources, as it is assumed that high population growth rates have the potential to put strain on existing water systems. Conversely, urban areas with negative growth rates are also not considered sustainable.
- Sustainability of source – this is assessed on the basis of a number of criteria; whether water supply is local or ‘imported’, easily available, and whether it is abundant in its natural form and of good quality. A list of possible sources is presented and the variable is scored on the basis of what is employed and why.

Table C10 shows the variables for resource feasibility (in terms of quantity), while table C11 highlights the various different sources of water from which a local authority can draw to make up its total yield.

Table C10: Resource feasibility (quantity)

C3.1.1 Per capita water availability (m ³ /c.a)	C3.1.2 Average population growth rate p.a.	Score
≥500	0%-0.5%	5
250-499	0.5%-1.5%	4
150-249	1.5%-2.5%	3
100-149	2.5%-3.5%	2
50-99	>3.5%	1
<50	< 0%	0.1

The scores for the variable ‘Sustainability of water source’ are determined by multiplying the percentage contribution to the water resources from each source (expressed as a number between 0 and 1; total to add up to 1) by the rate for the source, and adding up the total score for all sources.

Table C11: Sustainability of water source

C3.1.3 Sustainability of source	Rate
Local groundwater	5
Rainwater harvesting	5
Local freshwater	4
Imported groundwater	4
Greywater	3
Stormwater	3
Imported freshwater	2
Brackish water	2
Wastewater	1
Saltwater	1

C3.2 Sustainability of water resources (quality)

The issue of water quality for supply is directly linked to source water. It gives an indication of the state of fresh water resources; the degree of pollution and ultimately the cost of treating those resources for human use. The variables for this indicator include potable water quality (by way of the Department of Water Affairs' Blue Drop initiative); River health; and a qualitative assessment of groundwater quality. River health in particular, indicates the level of human impact on a river system, and could highlight problems even when all other indicators point to an efficient system. In this way it can reveal aspects of urban water services which may need more focused attention.

Table C12: Resource quality

C3.2.1 Potable water quality / Blue Drop (RPMS KPI 5)	C3.2.2 River health	C3.2.3 Groundwater quality	Score
4.5-5.0	91-100%	Excellent	5
4.0-4.49	71-90%	Good	4
2.5-3.99	51-70%	Fair	3
1.5-2.49	26-50%	Unacceptable	2
0.0-1.49	10-25%	Unknown	1
No data	<10%	Highly polluted	0.1

C3.3 Ability to respond to climate change impacts

Two variables were considered for evaluation of this indicator: Amount of energy consumed by the water sector (expressed as kWh/Mℓ) and Climate change strategic planning. As was noted

in Chapter 5, engaging local authority officials in discussions around these issues was extremely problematic, as were any attempts to gather the required information / data for the indicator calculation. The decision was ultimately taken to abandon these variables in the SIUWM calculations for the case study cities. This indicator is considered crucial for a sustainability analysis such as this, however, and the detail for the calculation has therefore still been included here for future reference. Similarly the indicator has remained in the SIUWM spreadsheet, but is not being calculated at present. It is acknowledged that the choice of variables could also change as more information becomes available.

Considerable challenges are associated with the energy / water nexus. Without water, energy cannot be produced; and without energy, water cannot be transported or treated (Winter, 2011). Whilst there are ambitious plans in place to bolster energy generation and transmission capabilities, South Africa is currently in a situation where electricity demand outstrips supply, leading to periodic black-outs and load shedding. This has potentially very serious impacts on the water services supply chain – including abstraction, water treatment, distribution / reticulation, and wastewater treatment. Studies have shown that wastewater treatment is by far the largest consumer of electricity in the water sector, but the range of energy consumption differs significantly depending on conditions at specific treatment plants (Section 2.8.3). There are also particular energy requirements within each portion of the water value chain. This makes it extremely difficult to model energy utilisation and / or determine targets. Winter, 2011 has determined a range of values for the energy consumed by each process (Section 2.8.3) and, in the absence of a more indicative set of values for South African conditions, these have been summarised for the SIUWM scoring system (Table C13).

The second variable is an attempt to gauge (on a qualitative basis) how well prepared a WSA is in terms of approaching climate change issues, i.e. whether any form of climate change strategies have been planned or implemented with respect to the urban water management business, and at what level.

Table C13: Ability to respond to climate change impacts

C3.3.1 Energy consumption by water sector (kWh/Mℓ)	C3.3.2 Climate change strategy	Score
<500	Implemented	5
500-999	Partially implemented	4
1000-1499	Significant planning	3
1500-1999	Limited planning	2
2000-2999	Minimal planning	1
>3000	No consideration	0.1

C3.4 Use (resource distribution per sector)

This indicator aims to illustrate the water distribution per category of user, highlighting the areas which are either under or over-consuming and the need for balanced (but not equal) distribution. Table C14 shows the scoring system for the three variables.

Table C14: Water use per category

C3.4.1 Domestic (ℓ/c.d)	C3.4.2 Industrial (%)	C3.4.3 Ecosystem maintenance (%)	Score
<100	<5%	>25%	5
101-150	9%-5%	24%-20%	4
151-200	19%-10%	19%-15%	3
201-300	39%-20%	14%-10%	2
301-500	59%-40%	9%-5%	1
>500	60%	<5%	0.1

- Domestic – this variable addresses basic human water requirements for drinking and hygiene maintenance. Under-consumption or over-consumption is undesirable since it can indicate that people either don't have access to sufficient water for their basic needs or have too much (i.e. are wasting). An optimal threshold is proposed at 100ℓ/c.d. This is double what is proposed by the World Health Organization as a minimum requirement and therefore has a positive correlation with sustainability. Conversely, exceeding this limit implies that there is potential for wastage and inefficient use. (Sullivan, 2002).
- Industrial – industrial water consumption varies significantly and is dependent on the level of the development, as well as for different industries. Guidelines for the variance were taken from estimates provided by Rijsberman (2004) in his assessment of water consumption per category of users.
- Maintenance of ecosystems – a basic share of freshwater should be reserved for the maintenance and preservation of ecosystems. The need for ecological preservation and maintenance of ecosystems and the role of water in this has been well emphasized (Seckler, 2000; Seckler *et al.*, 1998; Sullivan *et al.*, 2002). A ballpark figure of 25% for ecosystem maintenance has been proposed as the optimal upper limit.

C3.5 Wastewater management

This indicator monitors the discharge of treated wastewater from municipal sewage treatment works, both in terms of quantity and quality, to the environment, by way of the Department of Water Affairs' Green Drop programme (measured as KPI 6 of the RPMS). While wastewater management is linked to the type of sanitation system employed, in the context of developing countries it is not uncommon to observe high service levels without the accompanying attention

to wastewater management. The Green Drop programme includes aspects such as wastewater quality compliance, monitoring programme efficiency, skills levels etc.

Table C15: Wastewater management

C3.5.1 Wastewater quality / Green Drop (RPMS KPI 6)	Score
4.5-5.0	5
4.0-4.49	4
2.5-3.99	3
1.5-2.49	2
0.0-1.49	1
No data	0.1

C3.6 Stormwater management

Assessment of stormwater management has been isolated from wastewater management for two reasons; firstly because in South Africa they are treated separately and are served by different systems. Secondly, there appear to be real issues with respect to the lack of integration of stormwater with other urban water services, with stormwater often being the forgotten / neglected service in the full suite of urban water services. In essence, all water in an urban area is at some stage stormwater; and the management of this resource is a vital aspect of a sustainable urban water system. In this research, performance of this variable is associated with the levels of service available to each area, although there are alternate measures such as: the percentage of the city area covered by some form of drainage system; and frequency of flooding in urbanised areas. The LOS for drainage have already been reported in Variable 1.4. The assumption is that the higher the LOS, the more formalised the drainage system hence there are improvements in stormwater management. Drainage is a service which is grossly under-managed – to the benefit of more highly prioritised services such as water supply, electricity, roads etc. The impacts of urbanisation on the natural environment are easily forgotten. It is only in extreme cases, where flooding becomes a threat to humans and disruptive to societal functions, that drainage considerations take prominence.

Table C16: WSUD / SuDS policy and implementation

C3.6.1 WSUD / SuDS policy and implementation	Score
Supporting policy, good implementation	5
Appropriate policy, some implementation	4
Poor implementation capacity	3
Progress towards policy setting	2
No policy, poor capacity	1
Inaction / no progress	0.1

Going beyond the immediate provision of sanitation and drainage, both wastewater and stormwater management highlight the potential for linking with resource management aimed at recharging, complementing or substituting current sources. It is with this in mind that the variable selected to monitor stormwater management is an assessment of the implementation of aspects such as water sensitive urban design (WSUD) and sustainable drainage systems (SuDS) by the relevant local authorities; in order to gauge their commitment to a sustainable future.

C4 Institutional component

C4.1 Governance model

The ideals of democracy and the concept of sustainability are inherently connected. One can go so far as to say that democracy is the first step in ensuring that equality and sustainability issues are addressed. Two variables have been selected for this indicator in order to provide a measure of the level of support for the goals of sustainable development, towards the fulfilment of basic service provision; such as water and sanitation. These are both qualitative variables, as shown in Table C17:

- Defined roles and responsibilities – it is useful to determine whether there is a good level of governance support within the WSA, specifically in terms of the implementation of supporting policy to inform and enforce sustainable urban water services.
- Departmental integration – one of the main assumptions in this research is the fact that sustainability is not possible in urban water services without a certain level of integration between the different departments responsible for the various aspects of water management in an urban area. Generally this is easier to achieve in smaller municipalities where there is a significant amount of cross-disciplinary management at all levels.

Table C17: Governance model

C4.1.1 Defined roles and responsibilities	C4.1.2 Departmental integration	Score
Supporting policy and legislation, and good implementation	Significant	5
Appropriate policy environment	Above average	4
Poor implementation capacity in a good policy environment	Average	3
Progress towards policy setting and capacity building	Minimal	2
No policy and poor capacity	Stalled processes	1
Inaction (sterile environment and no progress, regression)	None / no data	0.1

C4.2 Progress with meeting targets (MDGs and others)

A measure of compliance with legislative directives and international development goals provides an indication of commitment to addressing the issues at hand. This indicator is

assessed by way of the three RPMS indicators concerning access to services: water supply, sanitation and free basic water (FBW). It measures compliance with various associated policies as well as with the Millennium Development Goals targets for water supply and sanitation. As part of this assessment, the following is considered: backlog rates, project spending on water supply and sanitation services, and the percentage of poor households in a particular area served with FBW. At present the RPMS KPI for Free Basic Sanitation (FBS) is not being measured, but is likely to be included by DWA at a later stage.

Table C18: Progress with meeting targets

C4.2.1 Access to water supply (RPMS KPI 1)	C4.2.2 Access to sanitation (RPMS KPI 2)	C4.2.3 Access to FBW (RPMS KPI 3)	Score
4.5-5.0	4.5-5.0	4.5-5.0	5
4.0-4.49	4.0-4.49	4.0-4.49	4
2.5-3.99	2.5-3.99	2.5-3.99	3
1.5-2.49	1.5-2.49	1.5-2.49	2
0.0-1.49	0.0-1.49	0.0-1.49	1
No data	No data	No data	0.1

C4.3 Institutional capacity and policy dictates

As previously noted, many of the challenges with the management of urban water services arise from the difficulties with implementing and enforcing the different policies in place, mainly as a result of fragmentation and poor integration within the municipal structures. If the urban water sector is to be sustainable, integrated approaches and the efficient management thereof are crucial. The institutional capacity and technical / policy effectiveness of administrations is evaluated through the following variables:

- Water Demand Management (WDM) policy / Adoption of IUWM approach – if long-term water stability is to be attained throughout cities, urban water management strategies that are socially specific, flexible and dynamic (i.e. context-driven), need to be developed. Urban WDM approaches offer multiple benefits, including: reductions in demand make available additional water for serving the un-served, and reduced treatment costs and energy requirements. WDM is usually part of an overall IUWM approach, together with associated management systems and initiatives aimed at sustaining urban water services in a particular area.
- Institutional effectiveness (RPMS KPI 8) – this variable gives an overall assessment of how the water services authority operates, in terms of its staffing, grant fund spending, and general institutional efficiency. It also indicates whether the WSA produces (and submits to the Minister) an Annual report, and highlights the percentage of filled posts on the Council-approved organogram.

Table C19: Institutional capacity and policy dictates

C4.3.1 WDM policy / IUWM approach	C4.3.2 Institutional effectiveness (RPMS KPI 8)	Score
Fully adopted	4.5-5.0	5
Good implementation	4.0-4.49	4
Partial implementation	2.5-3.99	3
Planning / minimal implementation	1.5-2.49	2
Minimal planning	0.0-1.49	1
No progress	No data	0.1

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Appendix D

Data sources for SIUWM variables

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Table D1: Data sources for SIUWM variables

Variable	Examples of data source	
	Regularly updated public data	Unpublished / unquoted municipal-level data
1.1 LOS Water supply	Census surveys	
1.2 LOS Sanitation	Census surveys	
1.3 LOS Solid waste collection	Census surveys	
1.4 LOS Drainage		Interviews
2.1 Under 5 mortality rate	Gaffneys / State of the cities	
2.2 HIV/AIDS prevalence	Gaffneys / State of the cities	
3.1 % population in informal dwellings	Census / State of the cities	
3.2 Risk management / disaster mitigation		DMP / interviews
4.1 Customer service standards	RPMS – KPI 7	
4.2 Secondary education levels	Gaffneys / State of the Cities	
5.1 Unemployment rate	Gaffneys / Census surveys	
5.2 Levels of inequality (Gini coefficient)	State of the world's cities	
6.1 WSA financial performance	RPMS – KPI 9	
6.2 Water use efficiency / NRW	RPMS – KPI 11	
7.1 Strategic asset management	RPMS – KPI 10	
8.1 Per capita water availability		WSDP / SoE / interviews
8.2 Sustainability of source		WSDP / interviews
8.3 Demand for water resources (average population growth rate)	IDP / State of the Cities / Census	
9.1 Potable water quality (Blue Drop)	RPMS – KPI 5 / Blue Drop	
9.2 Water resource quality (River health)	SoE / River Health program	
9.3 Groundwater quality		SoE / interviews
10.1 Energy consumption by water sector		Interviews
10.2 Climate change strategic planning		Interviews
11.1 Domestic water demand		WSDP / interviews
11.2 Industrial water demand		WSDP / interviews
11.3 Ecosystems water demand		WSDP / interviews
12.1 Wastewater quality (Green Drop)	RPMS – KPI 6 / Green Drop	
13.1 WSUD / SuDS policy, implementation		Interviews
14.1 Defined roles and responsibilities		Interviews
14.2 Departmental integration		Interviews
15.1 Access to water supply	RPMS – KPI 1	
15.2 Access to sanitation	RPMS – KPI 2	
15.3 Access to Free Basic Water (FBW)	RPMS – KPI 3	
16.1 WDM policy / IUWM approach		WSDP / interviews
16.2 Institutional effectiveness	RPMS – KPI 8	

RPMS – Regulatory Performance Measurement System; WSDP – Water Services Development Plan; DMP – Disaster Management Plan; IDP – Integrated Development Plan; SoE – State of Environment report

Appendix E

City data for final SIUWM calculation

University of Cape Town

Table E1(a): City data for SIUWM calculation

Indicator	Variable	Source of data	Qual / Quant	Study cities - data								
				BC	CT	EK	ET	JHB	MN	MS	NM	TSH
Levels of Service	% of people with access to LOS 1 - w supply	Nonfin 2010	Quant	51.9	87.5	57.1	59.4	58.7	54.3	64.8	95.1	64.6
	% of people with access to LOS 2 - w supply	Nonfin 2010	Quant	0.0	11.5	19.4	16.3	17.4	41.2	28.1	0.0	19.5
	% of people with access to LOS 3 - w supply	Nonfin 2010	Quant	48.1	1.0	21.0	24.3	23.8	4.5	6.6	4.9	12.1
	% of people with access to LOS 4 - w supply	Nonfin 2010	Quant	0.0	0.0	2.0	0.0	0.1	0.0	0.5	0.0	3.6
	% of people with access to LOS 5 - w supply	Nonfin 2010	Quant	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2
	% of people with access to LOS 1 - sanitation	Nonfin 2010	Quant	95.5	90.2	97.0	51.8	79.7	55.1	41.1	92.6	52.4
	% of people with access to LOS 2 - sanitation	Nonfin 2010	Quant	0.2	1.3	0.0	11.2	6.0	25.7	37.5	0.7	23.3
	% of people with access to LOS 3 - sanitation	Nonfin 2010	Quant	3.0	4.8	3.0	20.2	7.0	18.9	21.0	0.0	18.2
	% of people with access to LOS 4 - sanitation	Nonfin 2010	Quant	0.0	0.7	0.0	0.0	0.0	0.3	0.0	6.7	0.0
	% of people with access to LOS 5 - sanitation	Nonfin 2010	Quant	1.3	3.0	0.0	16.8	7.3	0.0	0.4	0.0	6.1
	% of people with access to LOS 1 - solid waste	CS2007	Quant	71.0	94.2	88.2	87.6	90.2	80.5	70.6	70.0	75.5
	% of people with access to LOS 2 - solid waste	CS2007	Quant	1.0	1.0	0.5	0.9	1.7	2.1	1.8	10.0	1.6
	% of people with access to LOS 3 - solid waste	CS2007	Quant	1.0	0.0	3.3	1.4	2.3	2.2	2.7	5.0	2.1
	% of people with access to LOS 4 - solid waste	CS2007	Quant	22.0	2.6	4.4	7.6	3.9	9.8	22.2	5.0	15.2
	% of people with access to LOS 5 - solid waste	CS2007	Quant	5.0	2.2	3.6	2.5	1.9	5.4	2.7	10.0	5.6
	% of people with access to LOS 1 - drainage	Interviews	Quant	80	80	85	66.3	76.2	63.3	58.8	80	64.2
	% of people with access to LOS 2 - drainage	Interviews	Quant	0	5	3	9.5	8.4	23.0	22.5	0	14.8
	% of people with access to LOS 3 - drainage	Interviews	Quant	0	2	2	15.3	11.0	8.5	10.1	0	10.8
	% of people with access to LOS 4 - drainage	Interviews	Quant	10	10	5	2.5	1.3	3.4	7.6	10	6.3
	% of people with access to LOS 5 - drainage	Interviews	Quant	10	3	5	6.4	3.1	1.8	1.0	10	4.0
Health	Under 5 mortality rate (deaths per 1000 births)	Gaffneys	Quant	8.63	3.73	5.47	8.64	5.47	8.12	8.64	8.63	5.47
	HIV/AIDS infections (as % of population)	Gaffneys	Quant	11.1	6.0	14.8	15.8	14.8	14.2	15.8	11.1	14.8
Vulnerability	% of population living in informal settlements	CS2007	Quant	24.5	15.5	26.0	17.1	18.8	18.2	2.9	13.7	26.8

Table E1(b): City data for SIUWM calculation

Indicator	Variable	Source of data	Qual / Quant	Study cities - data									
				BC	BC	BC	BC	BC	BC	BC	BC	BC	
Vulnerability (cont.)	Risk management and disaster mitigation:	Int / IDP	Qual										
	- No risk awareness or disaster management												
	- Poor disaster management												
	- Compensative risk management												
	- Effective disaster mitigation								√	√	√		
	- Risk awareness and preparedness					√	√	√	√	√			
	- Risk avoidance by design												
Skills levels	Customer service standards (RPMS 7)	RPMS	Quant	5.000	5.000	5.000	4.125	5.000	4.125	4.700	5.000	3.500	
	% population with secondary education	Gaffneys	Quant	30.7	28.3	28.9	30.8	28.9	26	26.5	29	28.9	
Capacity to pay	% of population who are unemployed	Gaffneys	Quant	33.1	16.9	21.9	21.1	21.7	18.4	23.8	28.25	21.7	
	Gini coefficient (levels of inequality)	SoWC 10/11	Quant	0.72	0.67	0.72	0.74	0.75	0.74	0.73	0.72	0.72	
Cost recovery	Financial integrity of WSA (RPMS 9)	RPMS	Quant	1.368	3.161	2.326	3.112	3.284	2.472	4.257	3.557	4.050	
	Unaccounted for Water (RPMS11)	RPMS	Quant	0.000	4.000	1.000	0.000	0.000	0.000	0.000	0.000	1.000	
Asset man.	Strategic asset management (RPMS 10)	RPMS	Quant	2.658	3.757	4.274	3.042	3.708	3.587	2.275	4.155	3.401	
Resource sustainability (quantity)	Per capita water availability (m ³ /capita/annum)	DWA 2010d	Quant	100	160	150	90	150	110	90	160	150	
	% Local Groundwater	WSDP /Int	Quant	10	1.5	1	1	0	5	0	5	8.5	
	% Rainwater	WSDP /Int	Quant	0	0	0	0	0	0	0	0	0	
	% Local surface water	WSDP /Int	Quant	90	93.6	90	97	0	95	100	95	10.8	
	% Imported groundwater	WSDP /Int	Quant	0	0	0	0	0	0	0	0	0	
	% Stormwater	WSDP /Int	Quant	0	0	0	0	0	0	0	0	0	
	% Greywater	WSDP /Int	Quant	0	0	0	0	0	0	0	0	0	
	% Imported surface water	WSDP /Int	Quant	0	0	0	0	100	0	0	0	80.7	
	% Brackish water	WSDP /Int	Quant	0	0	0	0	0	0	0	0	0	
	% Treated effluent (wastewater)	WSDP /Int	Quant	0	4.9	9	2	0	0	0	0	0	
	% Salt water	WSDP /Int	Quant	0	0	0	0	0	0	0	0	0	
	Average annual population growth rate	SoC 2010	Quant	1.28	1.65	2.49	1.56	2.5	1.74	0.89	1.41	2.17	

Table E1(c): City data for SIUWM calculation

Indicator	Variable	Source of data	Qual / Quant	Study cities - data								
				BC	CT	EK	ET	JHB	MN	MS	NM	TSH
Resource sustainability (quality)	Blue Drop score (RPMS 5)	RPMS	Quant	3.000	5.000	5.000	5.000	5.000	4.000	4.000	4.000	5.000
	River Health (% rivers in good state, or better)	SoE/ RHP / IDP	Quant	50	13	15	25	23	25	30	40	15
	Quality of groundwater resources:	SoE / Interviews	Quant									
	- Excellent											
	- Good			√								
	- Fair				√					√		
	- Unacceptable					√		√				√
	- Unknown						√		√	√		
- Highly polluted												
Climate change response	Amount of energy consumed (kWh/Mℓ)	Interviews	Quant	nc	nc	nc	nc	nc	nc	nc	nc	nc
	Climate change strategic planning:	Interviews	Qual	nc	nc	nc	nc	nc	nc	nc	nc	nc
	- Implemented											
	- Partially implemented											
	- Significant planning											
	- Limited planning											
	- Minimal planning											
- No consideration												
Use	Domestic water demand (ℓ/c.d)	WSDP / Int	Quant	150	220	180	175	185	170	175	76	155
	Industry water demand (% of total)	WSDP / Int	Quant	7.6	17.8	15	15	5	5	15	10.1	15
	Ecosystems water demand (% of total)	DWA 2010d	Quant	10	15	10	10	10	15	10	10	10
Wastewater	Green drop score (RPMS 6)	RPMS	Quant	4.000	4.000	3.000	4.000	4.000	1.000	3.000	4.000	3.000
Stormwater management	WSUD / SuDS policy and implementation:	Interviews	Qual									
	- Supporting policy, good implementation											
	- Appropriate policy, some implementation				√		√	√			√	
	- Poor implementation capacity					√			√			
	- Progress towards policy setting			√					√		√	
	- No policy, poor capacity											
	- Inaction / no progress											

Table E1(d): City data for SIUWM calculation

Indicator	Variable	Source of data	Qual / Quant	Study cities - data									
				BC	CT	EK	ET	JHB	MN	MS	NM	TSH	
Governance	Defined roles and responsibilities:	Interviews	Qual										
	- Supporting policy, good implementation				✓	✓	✓				✓		
	- Appropriate policy environment			✓				✓	✓	✓		✓	
	- Poor implementation capacity												
	- Progress towards policy setting												
	- Inappropriate policy, poor capacity												
	- Inaction, sterile environment												
	Departmental integration:	Interviews	Qual										
	- Significant												
	- Above average			✓								✓	
	- Average				✓	✓	✓		✓	✓		✓	
	- Minimal							✓					
- Stalled processes													
- No data													
Progress with meeting MDGs and other targets	Access to water supply (RPMS 1)	RPMS	Quant	0.296	3.000	2.966	2.885	2.917	2.000	3.154	2.668	1.362	
	Access to sanitation (RPMS 2)	RPMS	Quant	0.329	1.421	1.087	3.399	1.264	0.107	3.188	3.023	1.106	
	% population receiving FBW (RPMS 3)	RPMS	Quant	5.000	2.561	4.554	4.128	4.252	5.000	5.000	3.116	3.608	
Institutional and technical capacity	WDM policy / IUWM approach:	Interviews	Qual										
	- Fully adopted						✓						
	- good implementation			✓	✓	✓			✓		✓		
	- partly implemented							✓		✓		✓	
	- planning / minimal implementation												
	- minimal planning												
	- no progress												
Institutional effectiveness (RPMS 8)	RPMS	Quant	3.986	4.531	4.321	4.021	3.863	2.791	3.823	3.868	3.957		

- Notes:**
1. nc: not calculated
 2. Light grey shading: Data inferred from other sources
 3. BC: Buffalo City, CT: Cape Town, EK: Ekurhuleni, ET: eThekweni, JHB: Johannesburg, MN: Mangaung, MS: Msunduzi, NMM: Nelson Mandela Bay, TS: Tshwane

Abbreviations for data table

Nonfin 2010	StatsSa Non Financial Census 2010 (StatsSA, 2010)
CS2007	StatsSA Community Survey 2007 (StatsSA, 2007)
Gaffney's	Local government in South Africa 2009 – 2011 (Gaffney, 2011)
RPMS	DWA Regulatory Performance Measurement System 2010/2011 (DWA, 2011b)
SoWC 10/11	State of the world's cities 2010/2011 (UN-HABITAT, 2011)
SoC 2011	SACN State of the cities report 2011 (SACN, 2011)
DWA 2010d	Integrated water resource planning for South Africa (DWA, 2010d)
RHP	River Health Programme (RHP, 2003; RHP, 2004; RHP, 2005)
SoE	State of the Environment (RSA, 1999)
WSDP	Water Services Development Plans (selected municipalities)
IDP	Integrated Development Plan (selected municipalities)
Int	Interviews

Appendix F

Instructions for using SIUWM in MS Excel

University of Cape Town

F1 Data capturing

Use the 'Fill in SIUWM' worksheet to capture the relevant city's data. Refer to Appendix C for specific details on the data required for each variable. Fill in the worksheet according to the following instructions:

- Fill in the appropriate box with an 'X' for each individual variable, unless otherwise instructed. Do not fill in more than one 'X' for each variable.
- For the Level of Service section, fill in the percentage (%) column according to the % of people served by each service. The different LOS as well as their ratings are described in Table F1 and Table F2.
- For the Sustainability of water source section, fill in the % provided by different water sources.
- Ensure that for the above-mentioned sections all fill-ins add up to 100%.
- If LOS for drainage are not available, leave blank. Then calculate LOS for drainage as average of other three services on Calculations sheet.
- Note that the red text for Indicator number 10 – 'Ability to respond to climate change impacts' – shows that this indicator is not being measured at present.

Table F1: Description of Levels of Service (LOS)

LOS	Water Supply	Sanitation	Drainage	Solid waste
LOS 1	Individual house connection	Conventional sewerage Simplified sewerage Alternate sewerage, i.e. vacuum sewerage	Conventional SuDS	Frequent & reliable (weekly)
LOS 2	Roof tanks Yard tanks & taps	Septic tanks On-plot sanitation (improved)	Conventional	Regular but infrequent (two weekly)
LOS 3	Standpipes	On-site communal facilities	Greywater management	Infrequent (once monthly)
LOS 4	Communal standpipes Vendors	Bucket toilets	Informal drainage only	Informal collection only
LOS 5	None	None	None	None

Table F2: Rates for Levels of Service (LOS)

LOS	Water Supply	Sanitation	Drainage	Solid waste
LOS 1	5	5	5	5
LOS 2	4	4	4	4
LOS 3	3	2	2	2
LOS 4	1	1	1	1
LOS 5	0.1	0.1	0.1	0.1

F2 Calculations

- Using the 'Calculations' worksheet, check that the data captured is accurately recorded in Table 2: Determining the rates.
- This worksheet also allows the user to see how each indicator and variable is categorised and rated. These rates determine the final scores.
- The 'Calculations' worksheet has pre-set formulas that automatically calculate the rates to be assigned from the data captured in 'Fill in SIUWM'.

F3 SIUWM results

- The 'SIUWM weighting and results' worksheet has pre-set formulas that calculate the overall index, component, indicator and variable scores.
- The results of the component and overall index scores are then displayed in a chart.

F4 Comparing SIUWM performance with other cities

- To compare the performance of two or more cities, the 'Comparison of cities' worksheet can be used.
- Final component scores are entered into the table and a chart which illustrates the difference in performance is produced.

F5 Interpreting the results

Using the scale table in the worksheet 'Interpreting the results', ascertain into which range the final SIUWM result fits.

Appendix G

SIUWM assessment results for SACN cities

University of Cape Town

G1 Buffalo City Local Municipality

Buffalo City Municipality (BC) is situated in the Eastern Cape Province in south-eastern South Africa, and encompasses East London, King William's Town and Bisho. East London is the main urban centre in the area and was initially established as a river port. Average annual rainfall is approximately 921 mm and temperatures range from 18-26°C in summer and 11-21°C in winter. The current population of the whole Buffalo City municipal area is about 760,000 with approximately 205,000 living in the city of East London.

Water supply is the responsibility of the municipality. As a Water Services Authority (WSA) and Water Services Provider (WSP), BC has various obligations and responsibilities in terms of achieving efficient and adequate water services for the whole municipal area. Residents get household water in a number of ways, including: piped directly into the houses from the mains, from public standpipes, from boreholes, rainwater tanks, or from dams and rivers. Water is sourced from the Bridle Drift (main source), Rooikrantz, Nahoon, Laing and Sandile Dams and the Peddie Scheme. The system is made up primarily of surface water resources, with the limited groundwater resources suitable for only a few localised schemes. The latest Water Services Development Plan (WSDP) noted that a new raw water source needs to be urgently identified and developed if the basic service backlogs are to be addressed and if there is to be significant future industrial development in the city (BCM, 2007). Relatively high levels of non-revenue water are experienced. This occurs either through physical losses (leaks etc.), billing inaccuracies, users who are not on the database or illegal connections. The result is an increased demand on water resources, wastage of water and loss of income. According to the WSDP a comprehensive study has been undertaken and strategies to address these problems are currently being finalised.

The largest informal settlement in the area is Duncan Village in East London, with an estimated population of 60,000. The current poor state of sewage infrastructure and lack of proper sanitation in informal and peri-urban settlements are contributing to the significant pollution levels of many rivers and streams in the area, particularly the Buffalo River. Coastal waters between Quinera and Leaches Bay show 100% non-compliance with national water quality guidelines (BCM, 2005). The high incidence of pollution in these areas negatively impacts specifically on initiatives to promote East London as a tourism destination. In addition, the city is legally obligated in terms of environmental management to ensuring the health of its citizens and protecting the environment (BCM, 2005).

G1.1 Component analysis

Table G1.1 details the SIUWM percentage scores for Buffalo City. Buffalo City attained an overall SIUWM score of 51% meaning that it falls into the category 'low potential for sustainability'. BC achieved mediocre scores in the environmental (58%), social (57%) and institutional (57%) components and a low score in the economic component (35%). Refer to Appendix E for a summary of the data that was used in the analysis.

Table G1.1: SIUWM scores for Buffalo City Local Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	57	Levels of Service (LOS)	83.7	Water supply	80.8
				Sanitation	96.9
				Solid waste	76.6
				Drainage	82.0
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	40.0	Population living in informal dwellings	20.0	
			Risk management and disaster mitigation	80.0	
	Skills and awareness levels	63.2	Customer service standards - RPMS 7	100.0	
			% people with secondary education	40.0	
Economic	35	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
	Cost Recovery / funding	20.0	WSA financial performance - RPMS 9	20.0	
			Water use efficiency / NRW - RPMS 11	20.0	
	Asset management	60.0	Strategic asset management - RPMS 10	60.0	
Environmental	58	Resource sustainability / feasibility (quantity)	64.0	Per capita water availability (m ³)	40.0
				Sustainability of source	82.0
				Average annual population growth rate	80.0
	Sustainability of water resources (quality)	57.7	Potable water quality / Blue Drop	60.0	
			River Health	40.0	
			Groundwater quality	80.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	57.7	Domestic	60.0	
			Industrial	80.0	
			Maintenance of ecosystems	40.0	
Wastewater management	80.0	Wastewater quality / Green Drop	80.0		
Stormwater management	40.0	WSUD / SuDS policy and implementation	40.0		
Institutional	56	Governance model	80.0	Defined roles and responsibilities	80.0
				Departmental integration	80.0
	Progress with meeting targets (MDGs and others)	34.2	Access to water supply - RPMS 1	20.0	
			Access to sanitation - RPMS 2	20.0	
			Access to FBW - RPMS 3	100.0	
	Institutional capacity and policy dictates	69.3	WDM policy / IUWM implementation	80.0	
Institutional effectiveness - RPMS 8			60.0		

nc = not calculated

G1.2 Indicator analysis

Figure G1.1 shows a breakdown of the indicator scores for Buffalo City, and highlights the specific issues for action as those relating to low levels of social development in the area; i.e. ‘Vulnerability’, ‘Capacity to pay’, ‘Cost recovery’, ‘Stormwater’ and ‘Meeting targets’.

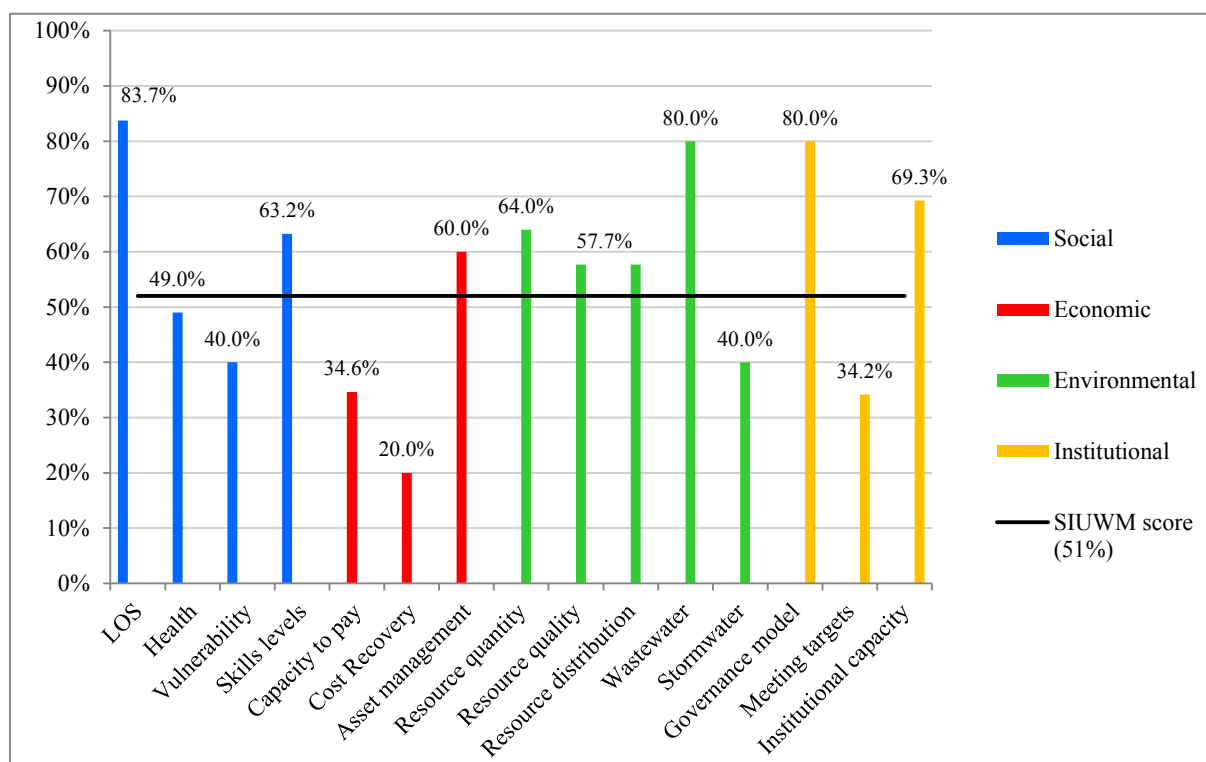


Figure G1.1: SIUWM indicator scores – Buffalo City

G1.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability assessment, and highlights some of the linkages between the components and their indicators.

G1.3.1 Social component

Buffalo City attained a score of 57% for the social component. There was significant variation in the individual variable scores which resulted in this score (Figure G1.2). Whilst the reported numbers for access to services are relatively good, the reality is that residents in informal settlements either have no access to basic services or have to rely on communal standpipes and sanitation systems that are poorly maintained and often non-functional. The very high figure for access to sanitation as quoted in the StatsSA Non-financial census 2010 (StatsSA, 2010) is therefore misleading and could be questioned. According to the latest WSDP (BCM, 2007), 27% of the population of East London (the main city) does not have access to an individual house connection. However, those in formal residential areas in East London have high levels of service, such as access to full water supply inside the house and waterborne sanitation.

Formal drainage systems are confined to the developed parts of the cities only, and are prone to occasional flooding. There are significant drainage problems in the informal settlement areas and these are not being adequately addressed due to budgetary constraints. Waste collection in all areas is undertaken regularly and efficiently. There is a comprehensive Disaster Management Plan in place and well-trained response teams, as validated by information on past disaster response operations.

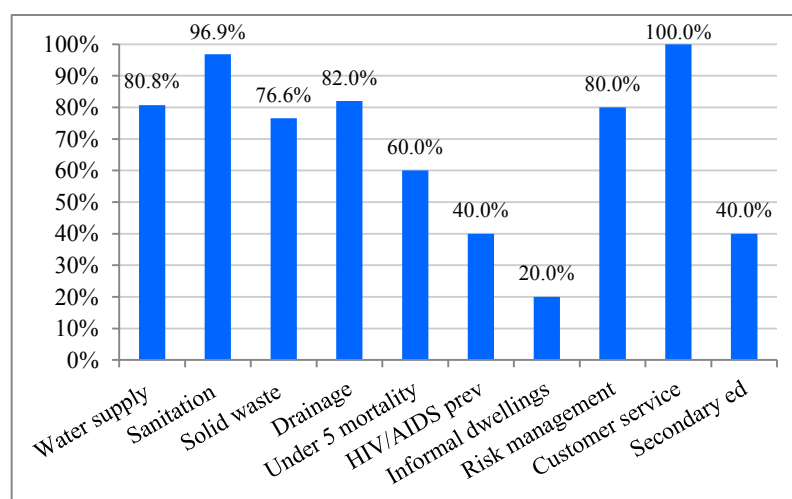


Figure G1.2: Social component variable scores – Buffalo City

With regard to health, the number of deaths under 5 years per 1000 live births (Under-5 mortality rate), is relatively high (8.63) and this can partly be attributed to waterborne diseases to which children below 5 years old are highly vulnerable. The observed HIV/AIDS prevalence rates (11.1%) reduce the overall health scores even further. While HIV/AIDS prevalence is not directly related to water provision, a sufficient and accessible supply of water as well as adequate provision of sanitary services, amongst other things, can contribute significantly to building immunity and hence help mitigate the more immediate effects of HIV/AIDS.

Poor scores were obtained for the variables ‘Informal settlements’ and ‘Secondary education’ – both of which point to vulnerability and weaknesses in the social fabric of the city. On the other hand, the variable ‘Customer service’ scored very high, showing that the municipality is making concerted efforts to provide a good service to all their residents, and have put in place the necessary institutional arrangements to support this.

G1.3.2 Economic component

Buffalo City received its lowest score of 35% for the economic component. Whilst none of the indicators and variables in this component scored particularly well (Figure G1.3), this low performance is largely due to the very high levels of inequality in the city and the high percentage of non-revenue water (NRW) as well as poor scoring in the RPMS variable for WSA financial performance. NRW figures are as a result of inadequate infrastructure maintenance leading to leaks, and damaged meters (BCM, 2007). Unmetered water and theft of

infrastructure components also contributes to NRW. The city is developing strategies to reduce losses however, and one such initiative is replacing meters with a new system that does not require municipal workers having to constantly read and record them.

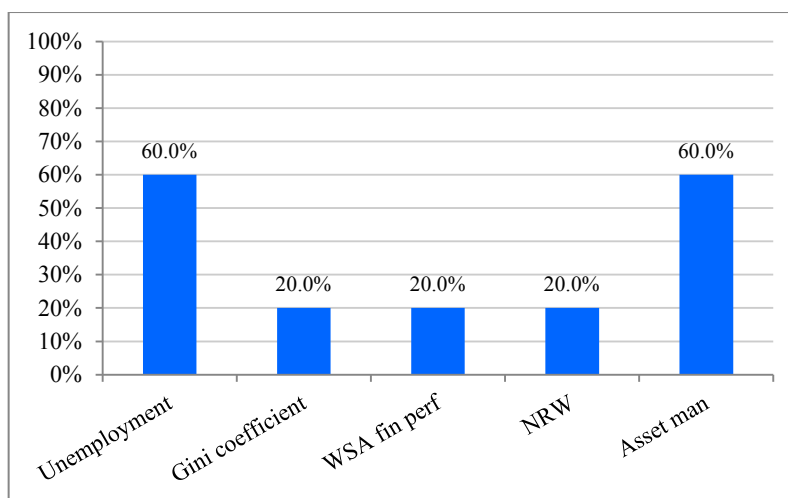


Figure G1.3: Economic component variable scores – Buffalo City

G1.3.3 Environmental component

Buffalo City scored 58% in the environmental component. The main issues with environmental management concern the low availability of fresh water resources, pollution of rivers, and poor progress towards the implementation of WSUD and SuDS policy (Figure G1.4).

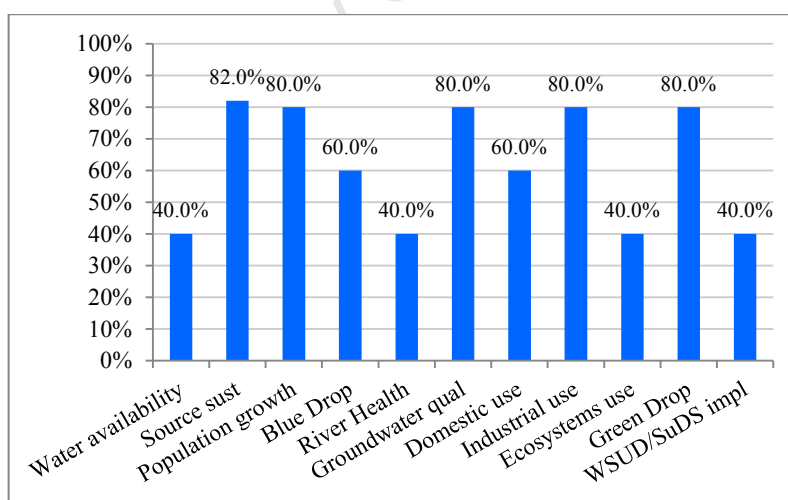


Figure G1.4: Environmental component variable scores – Buffalo City

The majority of rivers in the area are non-compliant with National Environmental Act (NEMA) regulations (BCM, 2007). The Buffalo River for example, received a River Health Index of 'poor' (RHP, 2004). The river passes through the informal settlement of Duncan Village, and the water that flows into it from this settlement is heavily polluted. Also of concern is the issue

of balanced resource use and distribution. The main category of users in the area is domestic, with a small component of industrial. Ecosystem maintenance is largely ignored.

G1.3.4 Institutional component

The institutional component received a score of 57%, and would have been much higher if it was not for the two variables concerned with meeting MDG water and sanitation targets, as measured through the RPMS – both of which scored very poorly (Figure G1.5). The city appears to have a strong legislative and policy-oriented water environment, but whilst there is reasonable departmental integration, there is an issue of under-performance at management level. This highlights the under-capacity of the entire WSA. Buffalo City is only at the planning stage with regard to adopting an IUWM approach. Reasons given for the delay in implementing an integrated approach are divisions in the city planning and operation structures.

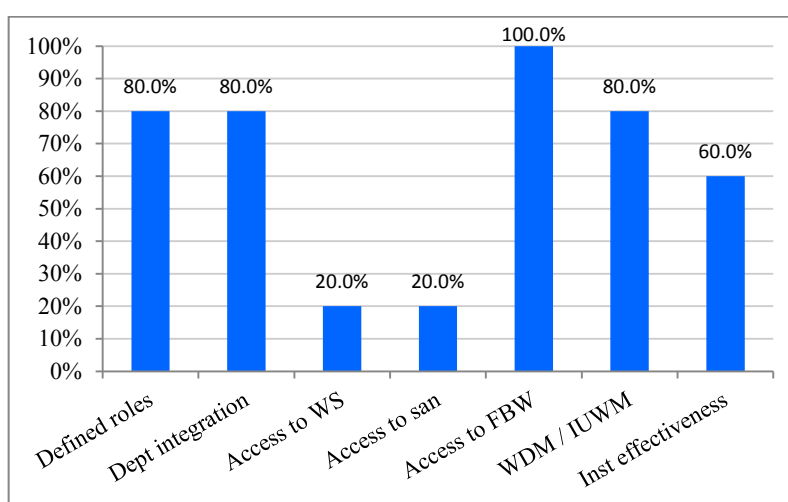


Figure G1.5: Institutional component variable scores – Buffalo City

G2 City of Cape Town Metropolitan Municipality

The City of Cape Town Metropolitan Municipality (CT) is home to most of the Western Cape Province's population and the seat of the South African Parliament. Cape Town is a major city on the southern-most coast of South Africa, with a population of about 3.5 million. It is an important driver of regional, provincial and national development, generating 76% of the Western Cape region's Gross Domestic Product (GDP) and 11% of the national GDP (City of Cape Town, 2008). It is home to some beautiful and unique natural environments, and possesses a diverse cultural heritage. In contrast to its natural beauty however, it faces several developmental challenges. For instance, CT had a housing backlog in the order of 300,000 units in 2007, including some 150,000 in an estimated 220 informal – and generally illegal – settlements, meaning that approximately 1 million of its residents (about 30%) live in informal settlements. The lack of formal services to these areas means that the City's environmental quality remains under pressure and continues to decline. Resource use and consumption is increasing, while the ability to absorb urban-generated waste is decreasing.

Average water use per capita is approximately 230 ℓ/c·d, down slightly from the 270 ℓ/c·d recorded in 2000 after water restrictions were introduced in 2001 and again in 2004/2005. Surface water resources represent 440.5 Mm³/year, or 97% of the total yield. The City currently obtains 70 to 75% of its raw water requirements from dams owned by the DWA and the remainder from its own sources. Approximately 15% of the raw water requirements are obtained from sources within the Cape Metropolitan Area (CMA). Groundwater resources make up 6.64 Mm³/year, representing only 1.5% of the total yield. With the implementation by DWA of the Berg River scheme, the existing water resources supplying water to Cape Town will be sufficient until approximately 2013, as long as the low water demand projections are followed. To reduce over-exposure to climate change and the potential decrease in system yield due to environmental reserve requirements, the strategy is to diversify water resources to lessen the dependence on surface water. Schemes to be pursued under this strategy are the exploitation of the Table Mountain Group Aquifer and other groundwater schemes, desalination, and treated wastewater effluent re-use (Carden *et al.*, 2009).

The latest Water Services Development Plan (City of Cape Town, 2010) highlights the following critical challenges to the provision of equitable and sustainable urban water services:

- Eradication of sanitation services backlog and expansion of basic services for influx of residents.
- Intensification of Water Demand Management Strategy.
- Meeting wastewater effluent standards to reduce impact on receiving waters.
- Greywater runoff quality in informal settlements.
- Timely provision and maintenance of infrastructure to meet development growth needs.
- Financial sustainability of service and cost recovery; affordability of service; reduce bad debt.
- Increasing performance and efficiency; sufficient staffing; establishing more effective institutional arrangements.

G2.1 Component analysis

Table G2.1 details the SIUWM percentage scores for the City of Cape Town (CT). CT attained an overall SIUWM score of 65% and is the only local authority to have scored in the category ‘reasonable potential for sustainability’. CT achieved similar scores in all components, with highest for social (69%) and the lowest for the economic component (62%). The environmental and institutional components scored 64% and 66% respectively.

Table G2.1: SIUWM scores for City of Cape Town Metropolitan Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	69	Levels of Service (LOS)	93.1	Water supply	97.3
				Sanitation	93.3
				Solid waste	95.5
				Drainage	86.8
	Health	69.3	Under 5 mortality rate	80.0	
			HIV/AIDS prevalence	60.0	
	Vulnerability	56.6	Population living in informal dwellings	40.0	
			Risk management and disaster mitigation	80.0	
	Skills and awareness levels	63.2	Customer service standards - RPMS 7	100.0	
			% people with secondary education	40.0	
Economic	62	Capacity (to pay / access services)	56.6	Unemployment rate	80.0
				Gini coefficient	40.0
	Cost Recovery / funding	69.3	WSA financial performance - RPMS 9	60.0	
			Water use efficiency / NRW - RPMS 11	80.0	
	Asset management	60.0	Strategic asset management - RPMS 10	60.0	
Environmental	64	Resource sustainability / feasibility (quantity)	65.3	Per capita water availability (m ³)	60.0
				Sustainability of source	77.4
				Average annual population growth rate	60.0
	Sustainability of water resources (quality)	49.3	Potable water quality / Blue Drop	100.0	
			River Health	20.0	
			Groundwater quality	60.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	52.4	Domestic	40.0	
			Industrial	60.0	
			Maintenance of ecosystems	60.0	
Wastewater management	80.0	Wastewater quality / Green Drop	80.0		
Stormwater management	80.0	WSUD / SuDS policy and implementation	80.0		
Institutional	66	Governance model	77.5	Defined roles and responsibilities	100.0
				Departmental integration	60.0
	Progress with meeting targets (MDGs and others)	41.6	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	20.0	
			Access to FBW - RPMS 3	60.0	
	Institutional capacity and policy dictates	89.4	WDM policy / IUWM implementation	80.0	
Institutional effectiveness - RPMS 8			100.0		

nc = not calculated

G2.2 Indicator analysis

Figure G2.1 shows a breakdown of the indicator scores for Cape Town and highlights the specific problem areas for action as mostly those relating to environmental concerns, such as ‘Resource quality’, ‘Resource distribution’ and ‘Meeting MDG targets’.

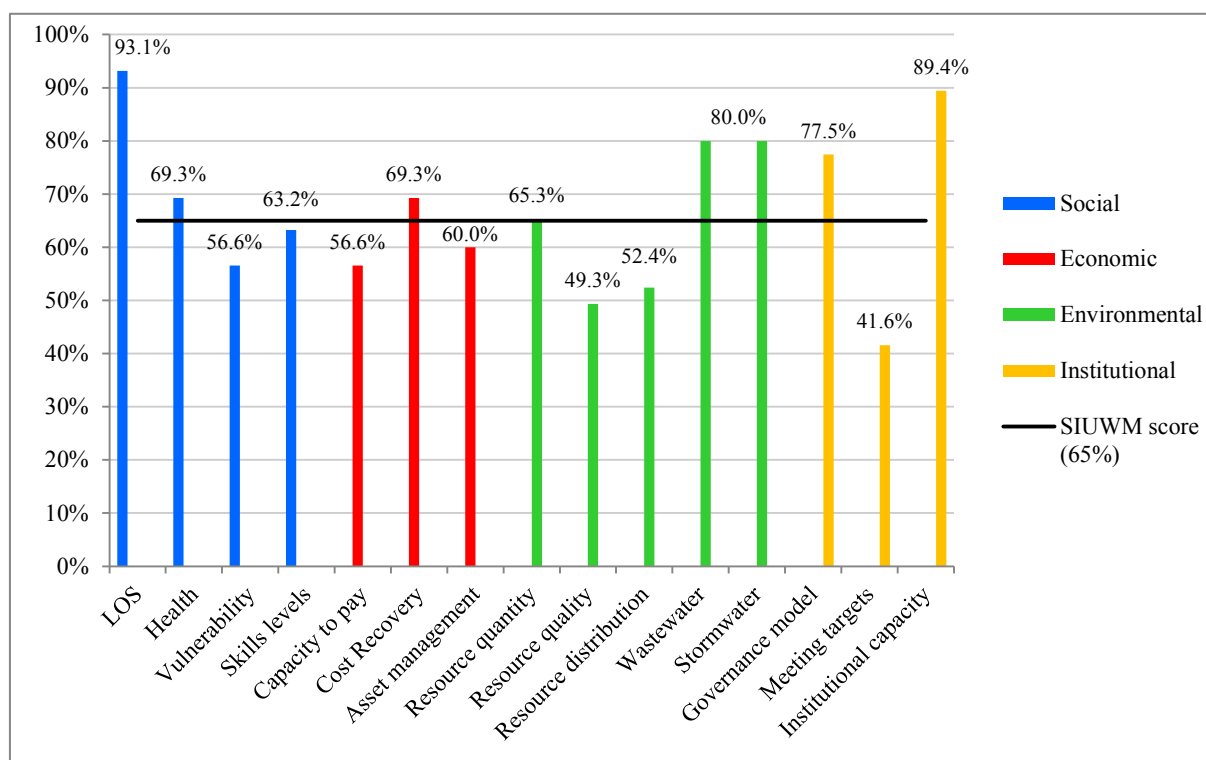


Figure G2.1: SIUWM indicator scores – Cape Town

G2.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G2.3.1 Social component

CT attained a score of 69% for the social component, and would have been even higher if it were not for the two variables, ‘Informal dwellings’ and ‘Secondary education’ (Figure G2.2). Whilst the scores for access to services appear to be excellent, it is a fact that residents in the informal settlements of the city either have no access to basic services such as water and sanitation or have to rely on communal standpipes and sanitation systems that are poorly maintained and often non-functional. In reality therefore, over 300 000 households are limited to basic and/or emergency access to water and sanitation services. A critical feature of a sustainable urban water system is the ability to instil a sense of ownership on the part of beneficiaries – this can only be achieved if education levels are maintained owing to the fact that literacy rates are linked to peoples’ ability to comprehend issues.

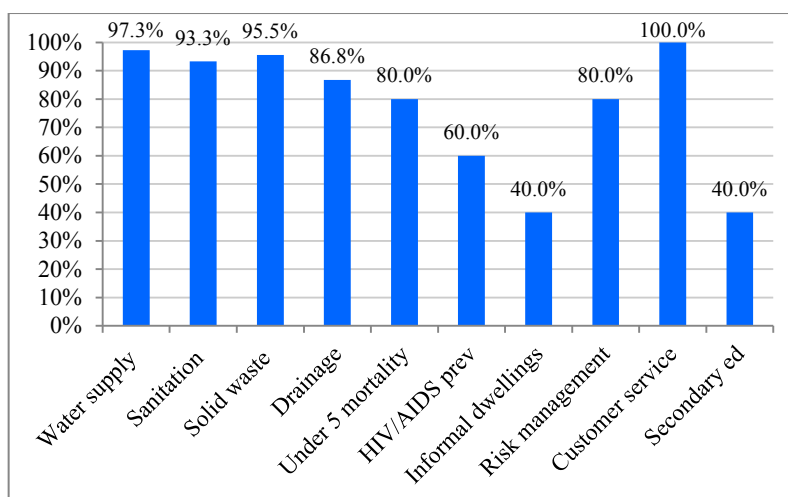


Figure G2.2: Social component variable scores – Cape Town

As far as health issues are concerned, whilst infant mortality is always a concern, it is the observed HIV/AIDS prevalence rates that are having an impact on component score. The variable ‘Customer service’ scored extremely high, showing that the municipality are making concerted efforts to provide a good service to all their residents, and have put in place the necessary institutional arrangements to support this.

G2.3.2 Economic component

CT received a score of 62% for the economic component, with most of the variables having moderate scores except for the one, ‘Gini coefficient’. Sustainability of the urban water system is unlikely unless city residents are able and willing to pay for services (Mashoko, 2011). This is reflected in the high levels of inequality in the city. NRW levels are currently being kept at reasonable levels through concerted effort.

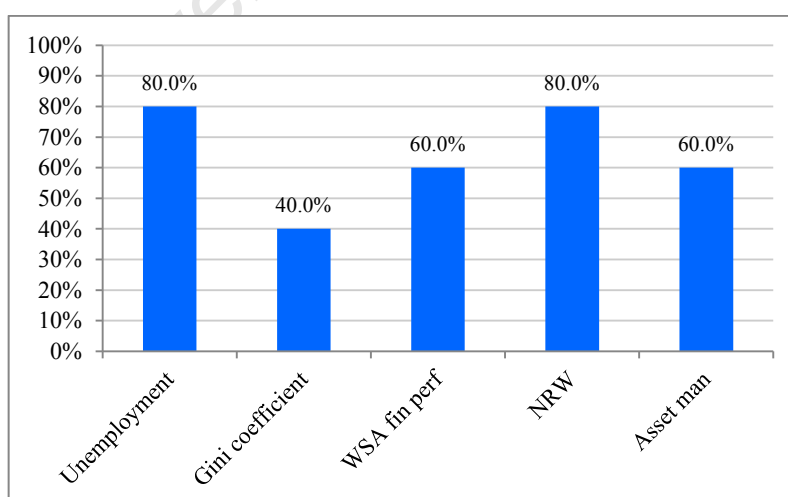


Figure G2.3: Economic component variable scores – Cape Town

The WSA is currently performing relatively well financially, as measured through the RPMS. The block tariff approach ensures that the majority of the costs are recovered by users who use more than the Free Basic Water (FBW) whilst those unable to pay for water benefit from this FBW. CT has prioritised several measures in this regard: 1) the sequential timing of investments and planning of projects (particularly in respect of managing the growth in water services demand) and creating a system that has symbiotic relationships with other systems (i.e. relationships between projects); 2) an investment mix in the infrastructure portfolio so that not only the poor are being provided for (Mashoko, 2011).

G2.3.3 Environmental component

CT scored 64% in the environmental component. The main issues with environmental management concern pollution of rivers and high household water consumption (Figure G2.4). The majority of rivers in the metropolitan area are in a poor condition, mostly as a result of non-point source pollution emanating from poorly serviced low income and informal settlements. Domestic water demand is unacceptably high (52% of total), and more effort is required with respect to water demand management programmes in the city. Whilst the figures for water availability and source sustainability are not yet critical, there are major uncertainties about water resource availability in the future with supply depending on the effects of climate change and the implementation of ecological reserves for existing schemes. There are also concerns about the quality of groundwater systems as potential future water sources.

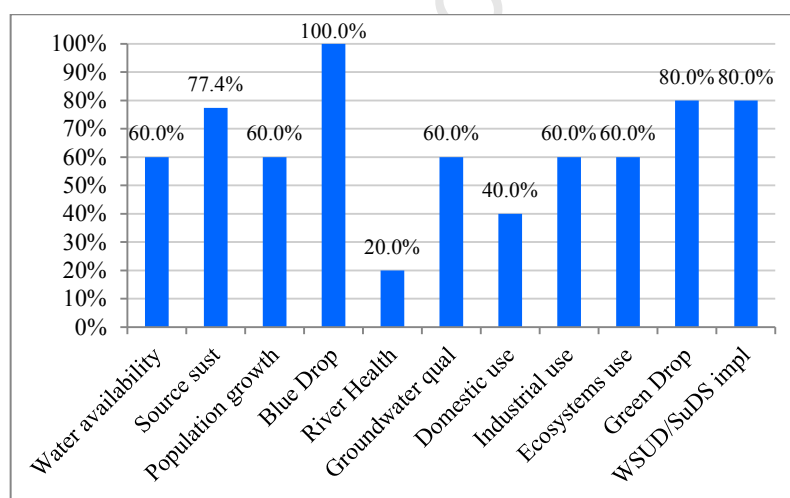


Figure G2.4: Environmental component variable scores – Cape Town

G2.3.4 Institutional component

The institutional component received a score of 66%, and would have higher if it was not for the variables concerned with meeting the MDG sanitation target, as measured through the RPMS (Figure G2.5). The city appears to have a strong legislative and policy-oriented water environment, and reasonable departmental integration. There are however reports of skills shortages and limited critical personnel to manage key technical services.

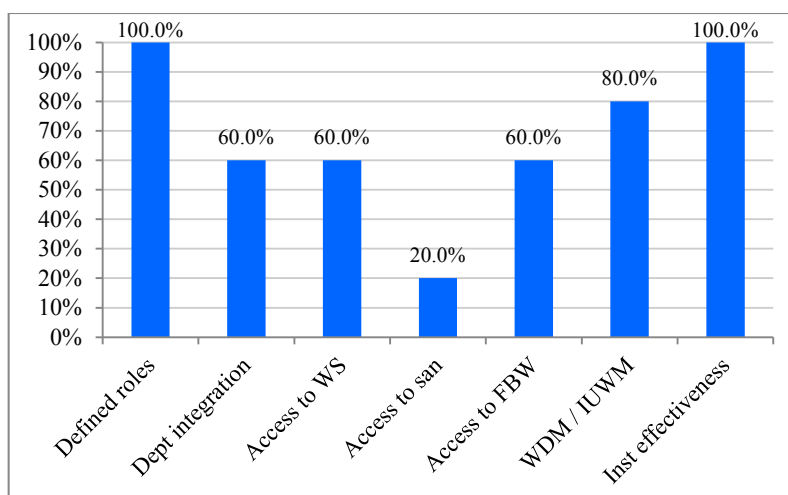


Figure G2.5: Institutional component variable scores – Cape Town

G3 Ekurhuleni Metropolitan Municipality

The Ekurhuleni Metropolitan Municipality (EK) has a population of approximately 3 million people and is located on the East Rand in the Gauteng Province and was formed in 2000 from the merging of several local municipalities of the former East Rand. It is one of the six metropolitan municipalities in South Africa, and is known as the industrial hub of the country, covering most of the historical mining area of Gauteng Province. Ekurhuleni includes the towns of Alberton (Thokoza), Benoni (Daveyton, Actonville, Wattville, Etwatwa), Boksburg (Vosloorus, Reiger Park), Kempton Park (Tembisa), Germiston (Katlehong, Palm Ridge), Springs (Kwa-Thema, Bakerton), Nigel (Duduza), Brakpan (Geluksdal, Tsakane), Edenvale/Lethabong and the Eastern Gauteng Services Council (Ekurhuleni, 2009).

Whilst water services provision is generally good, EK is one of the fastest urbanising areas in SA and keeping pace with service provision has been problematic. EK is in a summer rainfall region with more than 80% of the annual rainfall (715mm to 730mm) occurring from October to April. Most of the potable water comes from the Vaal River system via the Lesotho Highlands water scheme; this water is distributed to the Gauteng area under the authority of the water board, Rand Water. Groundwater abstraction for limited domestic use, irrigation and animal watering also occurs. Natural stream flows in EK are boosted by significant contributions of treated sewage effluent, the quality of which is monitored by the East Rand Water Care Company (ERWAT). Past and current mining activities in the area have resulted in significant environmental damage as a result of acid mine drainage; groundwater quality in particular is being impacted. Table G3.1 details the SIUWM percentage scores for the Ekurhuleni Metropolitan Municipality.

Table G3.1: SIUWM scores for Ekurhuleni Metropolitan Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	58	Levels of Service (LOS)	90.8	Water supply	85.6
				Sanitation	98.2
				Solid waste	90.8
				Drainage	89.2
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	40.0	Population living in informal dwellings	20.0	
			Risk management and disaster mitigation	80.0	
	Skills and awareness levels	63.2	Customer service standards - RPMS 7	100.0	
			% people with secondary education	40.0	
Economic	43	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
	Cost Recovery / funding	28.3	WSA financial performance - RPMS 9	40.0	
			Water use efficiency / NRW - RPMS 11	20.0	
	Asset management	80.0	Strategic asset management - RPMS 10	80.0	
Environmental	55	Resource sustainability / feasibility (quantity)	64.6	Per capita water availability (m ³)	60.0
				Sustainability of source	74.8
				Average annual population growth rate	60.0
	Sustainability of water resources (quality)	43.1	Potable water quality / Blue Drop	100.0	
			River Health	20.0	
			Groundwater quality	40.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	52.4	Domestic	60.0	
			Industrial	60.0	
			Maintenance of ecosystems	40.0	
Wastewater management	60.0	Wastewater quality / Green Drop	60.0		
Stormwater management	60.0	WSUD / SuDS policy and implementation	60.0		
Institutional	67	Governance model	77.5	Defined roles and responsibilities	100.0
				Departmental integration	60.0
	Progress with meeting targets (MDGs and others)	49.3	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	20.0	
			Access to FBW - RPMS 3	100.0	
	Institutional capacity and policy dictates	80.0	WDM policy / IUWM implementation	80.0	
Institutional effectiveness - RPMS 8			80.0		

nc = not calculated

G3.1 Component analysis

EK attained an overall SIUWM score of 55% which puts it into the category ‘low potential for sustainability’. EK scored highest for the institutional component (67%) and lowest for the economic component (43%). The social and environmental components scored 58% and 55% respectively.

G3.2 Indicator analysis

Figure G3.1 shows a breakdown of the indicator scores for Ekurhuleni and highlights the specific areas which contribute to unsustainability in the water sector as being ‘Vulnerability’, ‘Capacity to pay’, ‘Cost recovery’ and ‘Resource quality’.

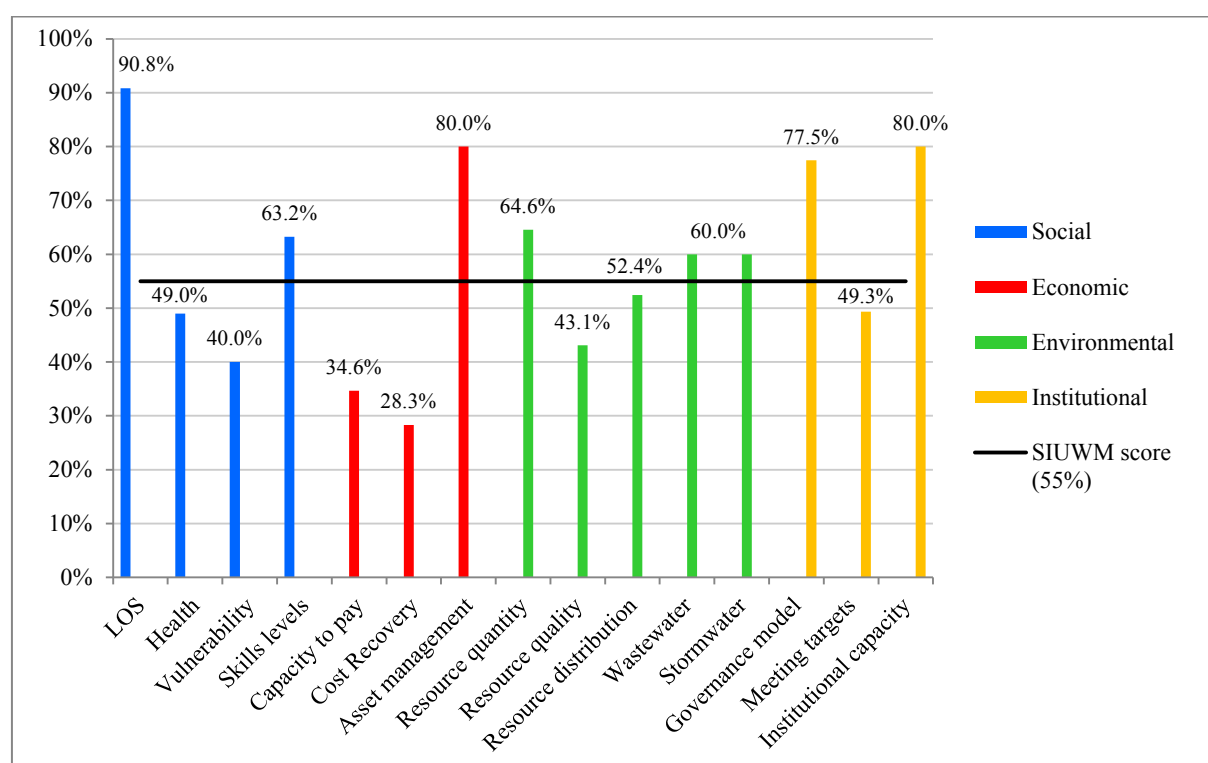


Figure G3.1: SIUWM indicator scores – Ekurhuleni

G3.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability assessment, and highlights some of the linkages between the components and their indicators.

G3.3.1 Social component

EK attained a score of 58% for the social component. There was considerable variation in the individual variable scores which resulted in this score (Figure G3.2). Whilst the scores for access to services are relatively good (as calculated from the reported figures), the very low score for the variable ‘Informal dwellings’ means that there are significant numbers of people

in the city who either have no access to basic water services or rely on communal facilities that are poorly maintained and often non-functional (Siboiboi, 2009).

Other areas of concern include health issues ('Under 5 mortality' and HIV/AIDS prevalence') as well as education levels. High levels of HIV/AIDS and other poverty related diseases such as TB are experienced in the poor communities, there is a lack of access to health care in some informal settlements and infant mortality and malnutrition rates are high (Ekurhuleni, 2009). As discussed previously, the high levels of industrial activity and population growth rates in EK have resulted in pressures on the municipality to keep pace with the delivery of housing and other services; for example, at present 26% of the population live in informal settlements. Similarly, there are still large numbers of the adult population that have not completed secondary education.

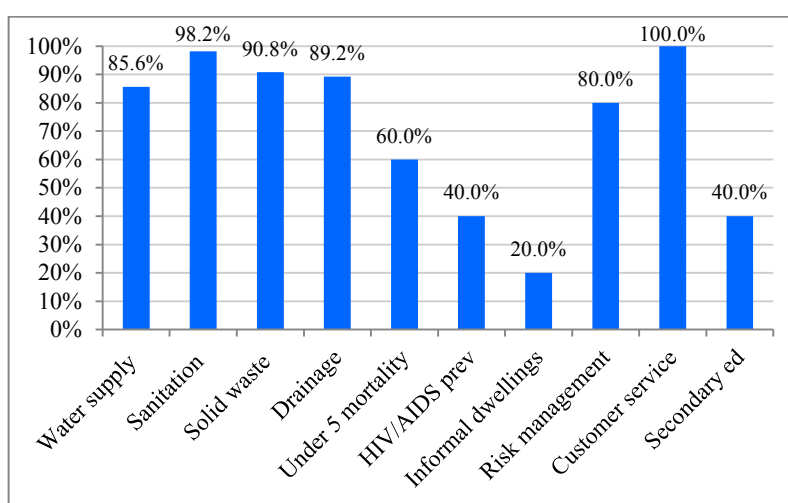


Figure G3.2: Social component variable scores – Ekurhuleni

G3.3.2 Economic component

As with all the other SACN cities, EK received its lowest score (43%) for the economic component. Whilst none of the variables in this component scored particularly well, with the exception of the variable 'Asset Management', Figure G3.3 shows that the low performance is largely due to the very high levels of inequality in the city (as measured by the Gini coefficient) and the high percentage of non-revenue water (NRW), currently around 40%. The main cause of water losses stems from leakages in the water supply systems as a result of management, technical and administrative inefficiencies (Siboiboi, 2009). Another contributing factor to NRW is the low level of payment for water services, especially in low income areas. The municipality has tried to resolve this by installing prepayment water meters, but this has resulted in conflict and protests. In general, the WSA scored very badly with respect to its financial performance as measured through the RPMS. The relatively high unemployment rates also contribute to the poor score in the economic component.

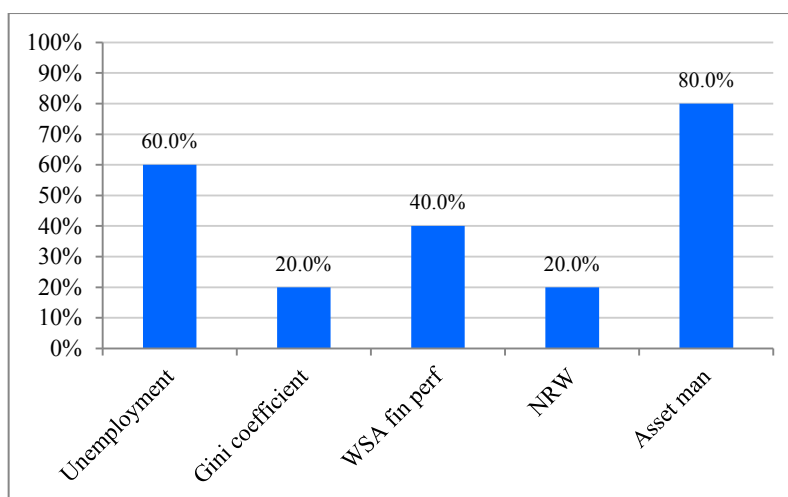


Figure G3.3: Economic component variable scores – Ekurhuleni

G3.3.3 Environmental component

EK scored 55% in the environmental component. The main issues with environmental management concern pollution of rivers, groundwater quality and resource protection, ‘Ecosystems use’ (Figure G3.4). Natural water resources in Ekurhuleni are dominated by the effects of upstream activities as well as internal activities i.e. industries and mining which have impacts on the quality of water in almost all rivers in the EK area (Siboiboi, 2009). As already mentioned, groundwater quality is of particular concern, resulting from mining activities in the area. Also of concern is the issue of balanced resource use and distribution. The main category of users in the area is domestic, with a small component of industrial. Ecosystem maintenance is largely ignored.

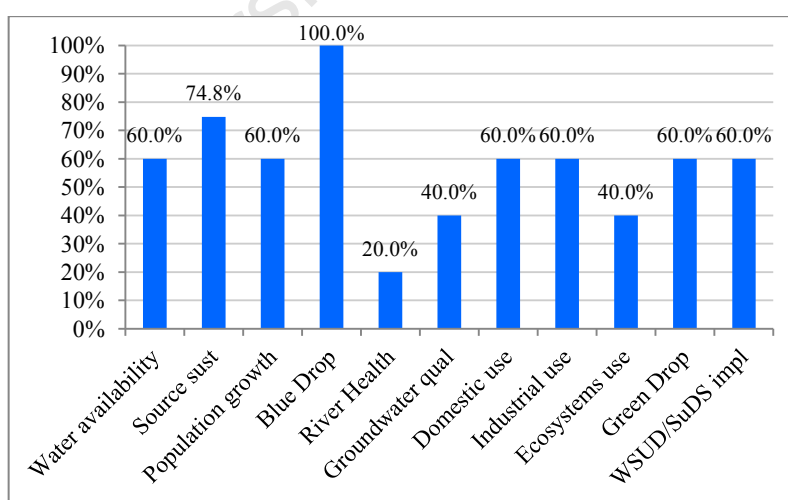


Figure G3.4: Environmental component variable scores – Ekurhuleni

G3.3.4 Institutional component

The institutional component received a score of 67%, and would have been higher if it was not for the variable concerned with meeting the MDG sanitation target, as measured through the RPMS (Figure G3.5). The city appears to have a strong legislative and policy-oriented water environment and has adopted IWRM strategies, but there are still challenges with low levels of capacity and skills to implement IUWM initiatives within the Municipality.

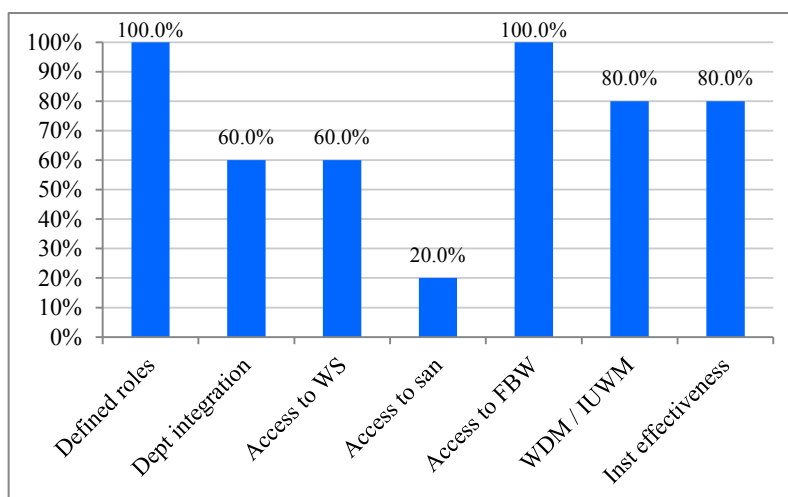


Figure G3.5: Institutional component variable scores – Ekurhuleni

G4 eThekweni Metropolitan Municipality

The eThekweni Metropolitan Municipality (ET) on the eastern seaboard in the province of KwaZulu-Natal was formed in 2000 as an amalgamation of 38 municipalities; it includes the city of Durban which is the busiest container port in Africa. The metropolitan area stretches from Umkomaas in the south, including some tribal area in Umbumbulu, to Tongaat in the north, moving inland to tribal areas in Ndwedwe, and ending at Cato Ridge in the west. The municipality also has to cater for poorly-serviced rural areas with 50% of the metropolitan area being used for subsistence farming and only 2% under urban settlement. One of ET's main areas of business is the provision of water services to its population of about 3.6 million people. Owing to the fact that the metropolitan area encompasses such a large number of rural settlements, the decision has been taken to implement a waterborne edge around the city, beyond which waterborne sanitation is not envisaged for at least 20 years. In these areas urine diverting (UD) toilets and ventilated pit (VIP) latrines are the sanitation options of choice. ET has invested significant research funding into the implementation and management of these alternative sanitation options, particularly around community acceptance and the use / disposal of sewage by-products (e.g. fertilizer (struvite) products from urine).

Several projects are also currently underway in an effort to improve the water and sanitation business including, *inter alia*, the replacement of 2000 km of asbestos cement water pipes, the provision of communal toilet facilities for about 300 shack settlements, and pressure

management projects aimed at reducing NRW (from very high levels of about 40%) in the municipal area. Extensions to the city's aqueducts in two major areas are also underway. Virtually all potable water is derived from surface water resources, the sustainable yield of which is currently being exceeded. There are significant issues with poor planning in terms of development in the city however, and concerns that service delivery will continue to be problematic (Harrison, 2010).

G4.1 Component analysis

Table G4.1 details the SIUWM percentage scores for the eThekweni Metropolitan Municipality. ET attained an overall SIUWM score of 57% which puts it into the category 'low potential for sustainability'. ET scored highest for the institutional component (77%) and lowest for the economic component (42%). The social and environmental components scored 60% and 55% respectively.

G4.2 Indicator analysis

Figure G4.1 shows a breakdown of the indicator scores for eThekweni and highlights the specific areas which contribute to unsustainability in the water sector as mainly concerning 'Capacity to pay' and 'Cost recovery', as well as the quantity and quality of water resources.

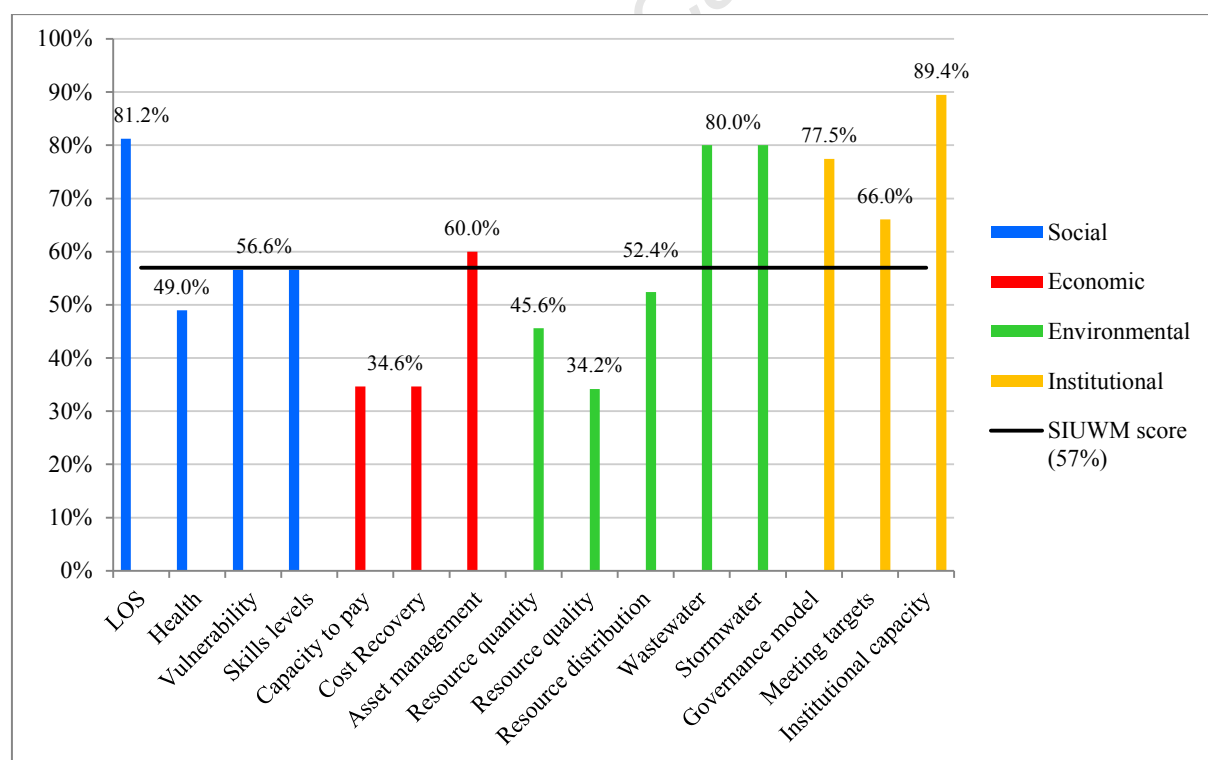


Figure G4.1: SIUWM indicator scores – eThekweni

Table G4.1: SIUWM scores for eThekweni Metropolitan Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	60	Levels of Service (LOS)	89.2	Water supply	87.0
				Sanitation	68.8
				Solid waste	90.4
				Drainage	80.5
		Health	49.0	Under 5 mortality rate	60.0
				HIV/AIDS prevalence	40.0
		Vulnerability	56.6	Population living in informal dwellings	40.0
				Risk management and disaster mitigation	80.0
		Skills and awareness levels	56.6	Customer service standards - RPMS 7	80.0
				% people with secondary education	40.0
Economic	42	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
		Cost Recovery / funding	34.6	WSA financial performance - RPMS 9	60.0
				Water use efficiency / NRW - RPMS 11	20.0
		Asset management	60.0	Strategic asset management - RPMS 10	60.0
Environmental	55	Resource sustainability / feasibility (quantity)	45.6	Per capita water availability (m ³)	20.0
				Sustainability of source	79.0
				Average annual population growth rate	60.0
		Sustainability of water resources (quality)	34.2	Potable water quality / Blue Drop	100.0
				River Health	20.0
				Groundwater quality	20.0
		Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc
				Climate change strategy	nc
		Use (resource distribution per sector)	52.4	Domestic	60.0
				Industrial	60.0
				Maintenance of ecosystems	40.0
Wastewater management	80.0	Wastewater quality / Green Drop	80.0		
Stormwater management	80.0	WSUD / SuDS policy and implementation	80.0		
Institutional	77	Governance model	77.5	Defined roles and responsibilities	100.0
				Departmental integration	60.0
		Progress with meeting targets (MDGs and others)	66.0	Access to water supply - RPMS 1	60.0
				Access to sanitation - RPMS 2	60.0
				Access to FBW - RPMS 3	80.0
		Institutional capacity and policy dictates	89.4	WDM policy / IUWM implementation	100.0
Institutional effectiveness - RPMS 8	80.0				

nc = not calculated

G4.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G4.3.1 Social component

ET attained a score of 60% for the social component, with the main problem areas resulting from the high numbers of people still living in informal settlements, the high incidence of HIV/AIDS, and low levels of secondary education (Figure G4.2). There has been rapid growth in the numbers of large informal settlements and the densification of hostel environments in the city, which has provided serious challenges to the municipality in respect of water services provision, particularly with respect to sanitation. This is largely being addressed by way of in-situ upgrading programmes and the provision of containerised communal facilities each serving about 70 people. The ultimate aim of the municipality is to make informal settlements more accessible, dignified and liveable urban spaces (Gounden, 2010).

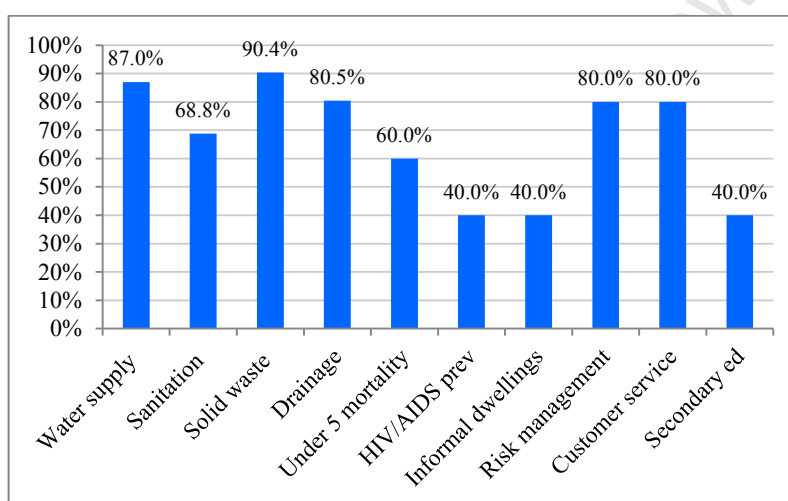


Figure G4.2: Social component variable scores – eThekweni

Good scores were received for the variables concerning risk management and customer service; and the municipality has been particularly proactive at building partnerships between the three different spheres of government (national, provincial and municipal) and civil society. The ‘Raising Citizens Voice’ initiative aims at helping to empower citizens to hold local government accountable for the provision of services in a positive manner and Community Health Clubs provide training to residents on a wide range of issues concerning water supply and sanitation. Also worth mentioning is the fact that the new Customer Services building which is currently being constructed, will be a fully sustainable building together with green roof and energy saving / water recycling features.

G4.3.2 Economic component

eThekwini received its lowest score (42%) for the economic component. Whilst none of the variables in this component scored particularly well (Figure G4.3), this low performance is largely due to the very high levels of inequality in the city and the extremely high percentage (about 40%) of non-revenue water (NRW). The city is developing water demand management and other strategies to reduce losses, and the NRW figures are slowly improving. The financial performance levels of the WSA, as measured through the RPMS, could also be improved.

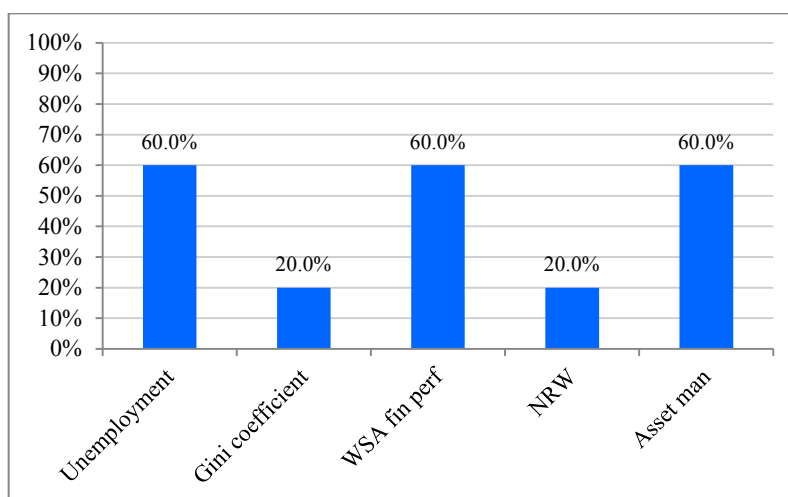


Figure G4.3: Economic component variable scores – eThekwini

G4.3.3 Environmental component

ET scored 55% in the environmental component. The main issues with environmental management concern the low availability of water, groundwater and surface water quality, and the issue of balanced resource use and distribution (Figure G4.4).

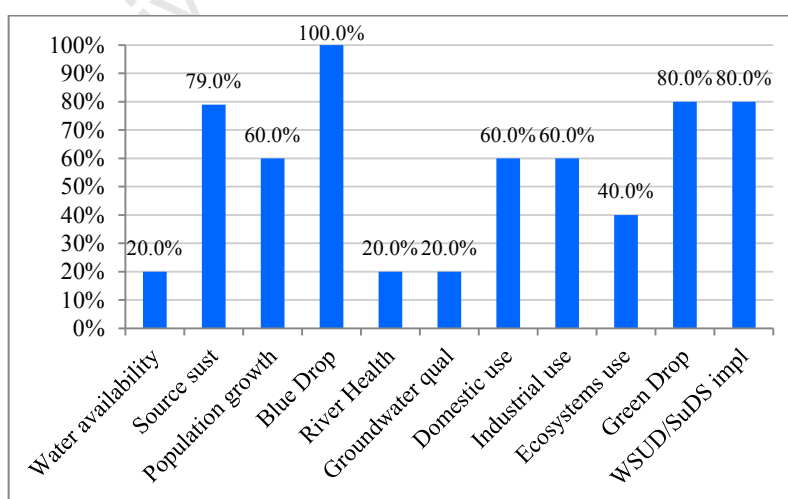


Figure G4.4: Environmental component variable scores – eThekwini

The city is currently exceeding the sustainable yield of its water resources, and will continue to do so until at least 2013 when the next impoundment system (Springfield Dam) comes on line. Even then, there are concerns that poor planning will result in ongoing difficulties with water supply. The recently-implemented Green Rivers Programme is aimed at highlighting problem areas in the 19 rivers in the municipal area, such as those resulting from e.g. maintenance / overflow issues at sewage pump stations and polluted stormwater from under- and un-serviced areas. The results are displayed as river quality maps on the eThekweni website and also feed into the national River Health monitoring programme.

G4.3.4 Institutional component

The institutional component received the highest score of 77%, reflecting eThekweni's real strengths in terms of their approach towards innovative and efficient business practices. The only mediocre scores for this component were those dealing with meeting MDG water and sanitation targets, as measured through the RPMS, as well as some issues with departmental integration (Figure G4.5). Harrison (2010) noted in particular the problems experienced with getting Environmental Impact Assessment (EIA) and procurement processes approved, highlighting connectivity issues between critical departments.

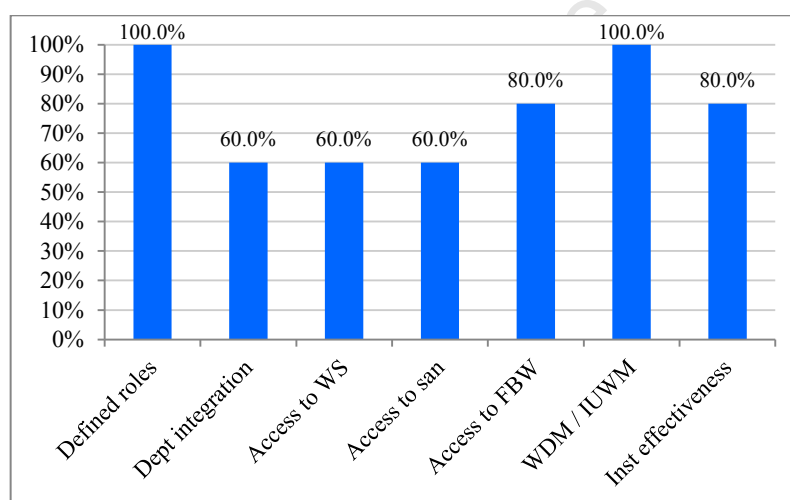


Figure G4.5: Institutional component variable scores – eThekweni

The city appears thus to have a strong legislative and policy-oriented water environment, but there are deficiencies in the numbers of technically-qualified staff, particularly at management level, and this has impacts on the functioning of the Water & Sanitation department, as well as with other related business areas in the municipality, e.g. Housing, Stormwater & Roads etc.

G5 City of Johannesburg Metropolitan Municipality

With about 3.8 million residents, Johannesburg is the largest city in South Africa by population and the provincial capital of Gauteng, the wealthiest province in South Africa. It generates 16% of South Africa's GDP and employs 12% of the national workforce. The city is one of the 40

largest metropolitan areas in the world and is also the world's largest city not situated on a river, lake, or coastline. Mining was the foundation of the city's economy, but its importance is gradually declining due to dwindling reserves and service and manufacturing industries have become more significant. The City of Johannesburg Metropolitan Municipality (JHB) is the entity responsible for local government delivery, and they are achieving this by way of a 'corporatised' structure in which the city has divided up responsibilities into several key departments mandated to deliver quality services (Eagle, 2011). The management structure is based on a 'client / contractor' model in that there is a top (Council) level providing the policy / regulatory function which develops and monitors the entities set up to deliver the services – 13 core municipal departments and 16 municipal entities, of which the following are of relevance to urban water management: infrastructure and services (including the entity tasked with the provision of water supply and sanitation services, Joburg Water), development planning and urban management, transportation (including stormwater management), corporate strategy, and environmental planning.

Johannesburg does not have its own substantial natural water source close by and is dependent on inter-basin water transfers. As with the two other SACN cities in the Gauteng Province, JHB is supplied with its bulk water by the water board, Rand Water who in turn draws water from the Vaal dam, which is fed by the Lesotho Highland Water Scheme. Water resources planning scenarios have highlighted that new augmentation schemes will be necessary to meet demand by 2020. Whilst much of the historical water services backlog has been eradicated, the population in the city keeps growing as a result of natural population growth and of in-migration (Van Rooyen *et al.*, 2009). This continued increase in population and growth in informal settlements (estimated at 7%) make addressing backlogs a huge challenge (City of Johannesburg, 2008). Reducing unaccounted-for-water has been a priority for the city since 2003 when Joburg Water was technically bankrupt. One of the programmes that was initiated, Operation Gcin'amanzi was introduced because of acute water losses experienced in Soweto coupled with the fact that the City was not recovering payment for water in the area, and resulted in a Constitutional Court judgement regarding the lawfulness of pre-paid meters and the right to free basic water (Box 2.8, Section 2.8.5.2).

G5.1 Component analysis

Table G5.1 details the SIUWM percentage scores for the City of Johannesburg Metropolitan Municipality (JHB). JHB attained an overall SIUWM score of 55% which puts it into the category 'low potential for sustainability'. JHB scored highest for the environmental component (64%) and lowest for the economic component (42%). The social and institutional components scored 63% and 54% respectively.

Table G51.1: SIUWM scores for City of Johannesburg Metropolitan Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	63	Levels of Service (LOS)	88.7	Water supply	86.9
				Sanitation	87.3
				Solid waste	93.3
				Drainage	87.6
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	56.6	Population living in informal dwellings	40.0	
			Risk management and disaster mitigation	80.0	
	Skills and awareness levels	63.2	Customer service standards - RPMS 7	100.0	
			% people with secondary education	40.0	
Economic	42	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
	Cost Recovery / funding	34.6	WSA financial performance - RPMS 9	60.0	
			Water use efficiency / NRW - RPMS 11	20.0	
	Asset management	60.0	Strategic asset management - RPMS 10	60.0	
Environmental	64	Resource sustainability / feasibility (quantity)	66.0	Per capita water availability (m ³)	60.0
				Sustainability of source	80.0
				Average annual population growth rate	60.0
	Sustainability of water resources (quality)	43.1	Potable water quality / Blue Drop	100.0	
			River Health	20.0	
			Groundwater quality	40.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	57.7	Domestic	60.0	
			Industrial	80.0	
			Maintenance of ecosystems	40.0	
Wastewater management	80.0	Wastewater quality / Green Drop	80.0		
Stormwater management	80.0	WSUD / SuDS policy and implementation	80.0		
Institutional	54	Governance model	56.6	Defined roles and responsibilities	80.0
				Departmental integration	40.0
	Progress with meeting targets (MDGs and others)	45.8	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	20.0	
			Access to FBW - RPMS 3	80.0	
	Institutional capacity and policy dictates	60.0	WDM policy / IUWM implementation	60.0	
Institutional effectiveness - RPMS 8			60.0		

nc = not calculated

G5.2 Indicator analysis

Figure G5.1 shows a breakdown of the indicator scores for Johannesburg and highlights the specific variables which contribute to unsustainability in the water sector as ‘Capacity to pay’, ‘Cost Recovery’, Resource quality’ and ‘Meeting targets’.

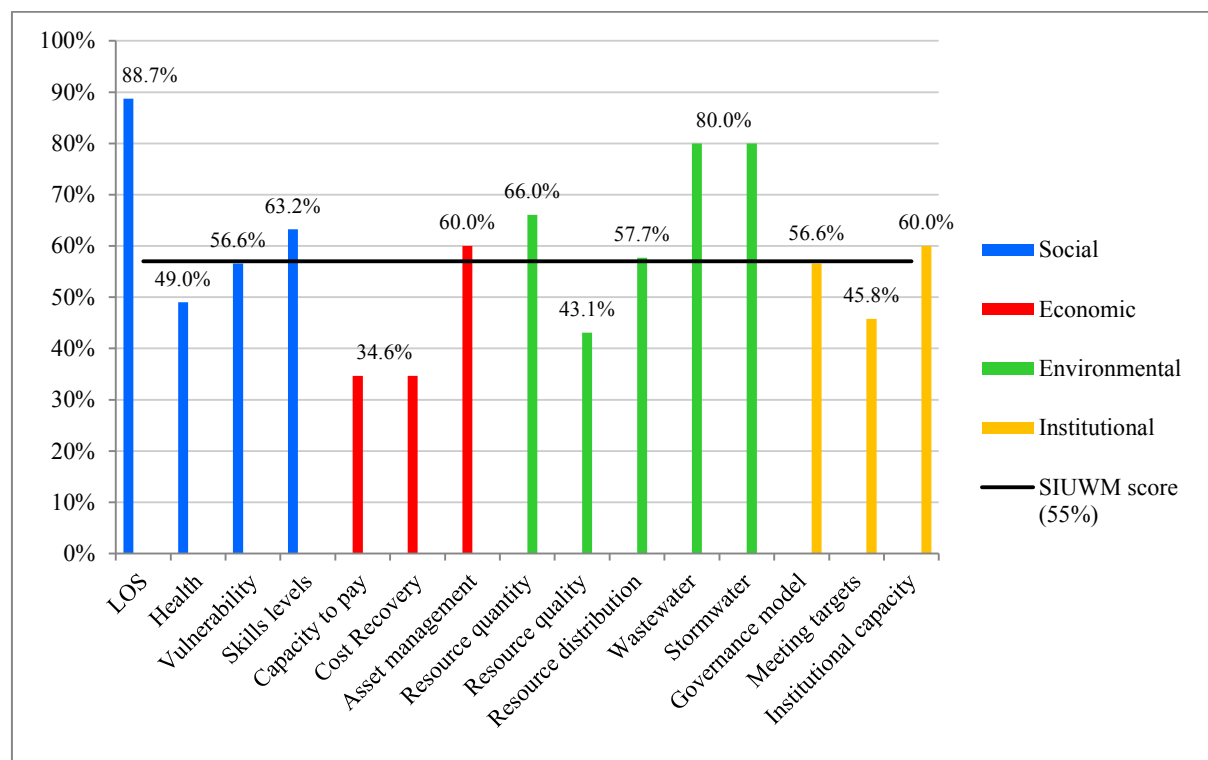


Figure G5.1: SIUWM indicator scores – Johannesburg

G5.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G5.3.1 Social component

JHB attained a score of 63% for the social component and, similarly to many of the other SACN cities, this was mainly as a result of poor scores for the variables ‘HIV/AIDS prevalence’, ‘Informal dwellings’ and ‘Secondary education’ (Figure G5.2). The scores for access to services are relatively good for all four categories of water services, but the negative social impacts arising from large numbers of people living in informal settlements cannot be ignored. JHB’s vision is to be a world-class African city, but high levels of poverty and inequalities prevail, with continuation of social and economic spatial divisions based on race and class (Van Rooyen *et al.*, 2009). It is estimated that over a quarter of Johannesburg’s households earn below the national minimum of R1600 per month while less than a third have completed their secondary education (City of Johannesburg, 2008).

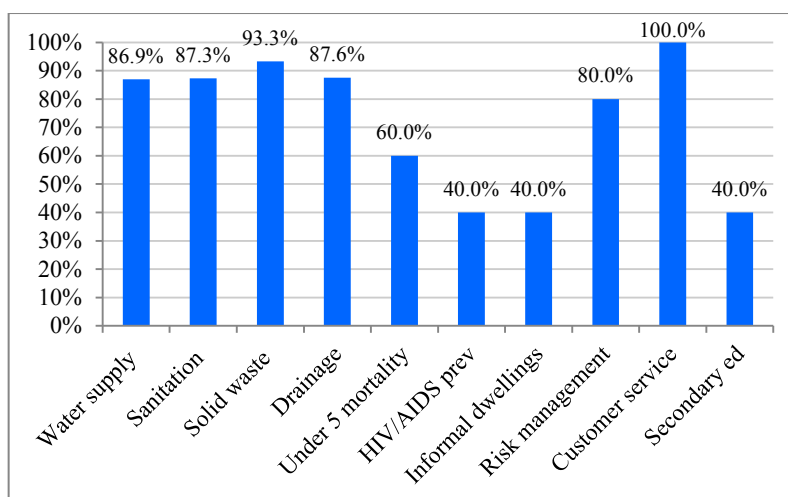


Figure G5.2: Social component variable scores – Johannesburg

G5.3.2 Economic component

JHB received its lowest score of 42% for the economic component, again mainly as a result of the fact that it is an extremely unequal society as measured by the Gini coefficient and it currently has high levels of NRW (Figure G5.3). Both of these indicators point towards difficulties with city residents being able to pay for the services that they require, and this is unlikely to change given current rates of population growth and urbanisation. Financial performance appears to have improved with the corporatisation model that was inherently set up to drive efficiency. However it appears that the delivery of public services may have been at the cost of equity issues, and alternative means are required to marry redistribution concerns with efficiency gains (Van Rooyen *et al.*, 2009).

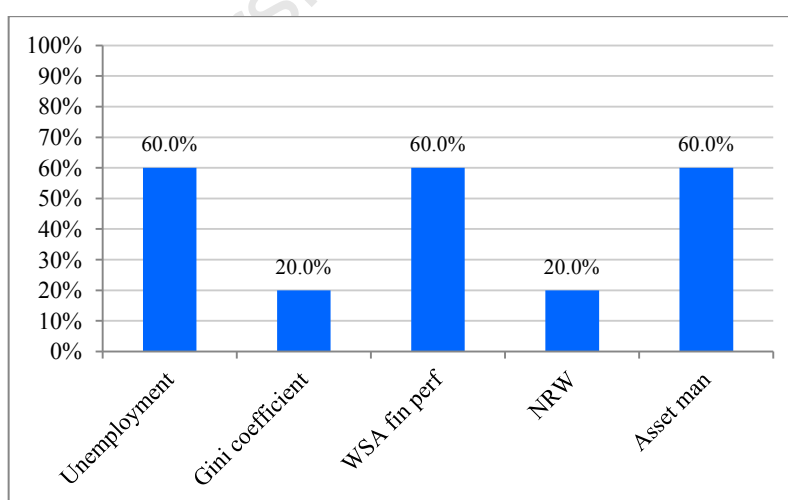


Figure G5.3: Economic component variable scores – Johannesburg

G5.3.3 Environmental component

JHB scored 64% in the environmental component. The main issues with environmental management concern pollution of rivers, groundwater quality and the balanced use and protection of water resources. River health is currently very poor throughout the metropolitan area as a result of both point and non-point source pollution (Figure G5.4). Whilst there appears to be good commitment towards policy development and implementation of WSUD and SuDS initiatives, stormwater management is still a major concern and is one of the main contributing factors to poor surface and groundwater quality. Capacity issues at wastewater treatment works and local sub-catchment reticulation problems also result in blockages, overflows and poor effluent quality at times (Eagle, 2011).

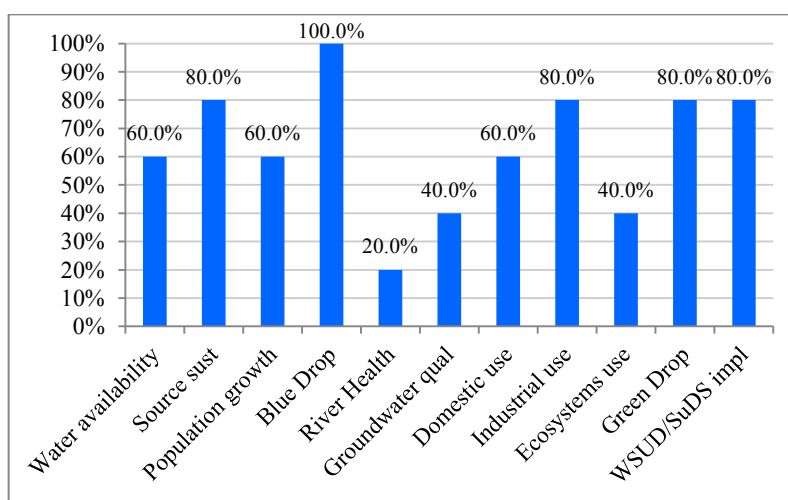


Figure G5.4: Environmental component variable scores – Johannesburg

G5.3.4 Institutional component

The institutional component received a score of 54%, mainly as a result of the variables ‘Departmental integration’ and ‘Meeting targets’ (Figure G5.5). Eagle (2011) reported that there are major issues implementing IUWM in the city stemming from a lack of integration between departments. Water services are seldom linked to other affiliated services in an integrated manner, and very often have different policy oversight departments. The JHB corporatized governance model is also very complicated and over-reliant on building personal relationships and/or strategic alliances with members of other departments in order to keep pace with eth service delivery requirements (Eagle, 2011).

The MDG sanitation targets in the city have not yet been met, and specific attention is required in the informal settlement areas. In many of these areas the sanitation level of service provided is VIP latrines, an intermediate level of service which was introduced to try and balance efficiency and equity interests (Van Rooyen *et al.*, 2009).

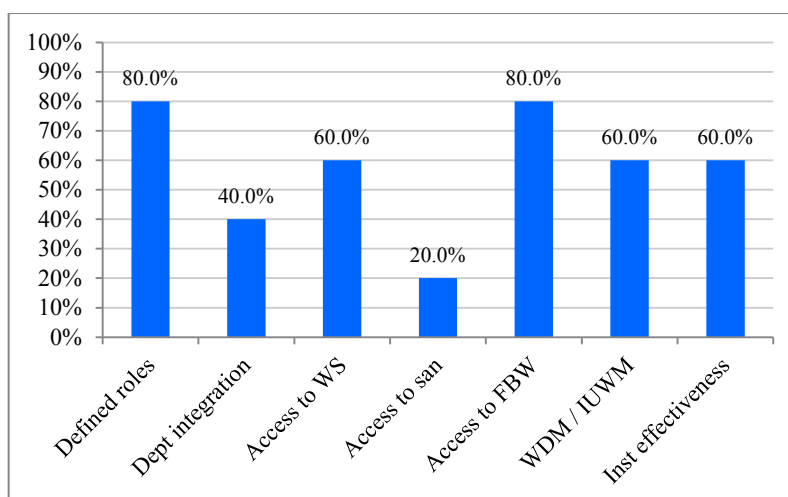


Figure G5.5: Institutional component variable scores – Johannesburg

G6 Mangaung Local Municipality

Mangaung Local Municipality (MN) includes the city of Bloemfontein which is the judicial capital of South Africa, as well as the towns of Botshabelo and Thaba Nchu and a large rural area. Situated in the centre of South Africa in the Free State province, MN is home to about 800 000 people and continuing to grow in size as a result of in-migration from surrounding areas. While community services contribute to over a third of Mangaung's economy, other prominent sectors include finance, retail and trade, transport, and manufacturing. The remaining sectors such as agriculture and mining are very small and make a minor contribution to the local economy. Primary development objectives of the municipality are: well-maintained and efficient infrastructure services; economic growth; improved housing; reduced impact of HIV/AIDS; high quality learning and literacy levels; and clean, well-kept natural open spaces, parks and well-maintained built environment. BloemWater and MN together are responsible for treating water to potable standards and distributing it to the metropolitan area which includes Bloemfontein, Thaba Nchu and Botshabelo. MN purchases 70% of its water from BloemWater and the remainder is sourced from rivers in the area. The Modder River flows into the Mockes dam which feeds the municipal water treatment plant at Maselspoort. The Welbedacht dam on the Caledon River feeds water to the BloemWater treatment plant near Wepener. The areas supplying the dams consist mainly of rural and agricultural land with very little industry so that inflows are of good quality (Mangaung Local Municipality, 2009).

G6.1 Component analysis

Table G6.1 details the SIUWM percentage scores for Mangaung Local Municipality (MN). MN was the lowest scoring of the SACN cities with an overall SIUWM score of 50% which puts it into the category 'low potential for sustainability'. MN scored particularly poorly in the environmental component (40%) and economic components (41%). The social and institutional components scored 58% and 68% respectively.

Table G6.1: SIUWM scores for Mangaung Local Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	58	Levels of Service (LOS)	86.0	Water supply	90.0
				Sanitation	83.3
				Solid waste	85.0
				Drainage	85.8
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	49.0	Population living in informal dwellings	40.0	
			Risk management and disaster mitigation	60.0	
	Skills and awareness levels	56.6	Customer service standards - RPMS 7	80.0	
			% people with secondary education	40.0	
Economic	41	Capacity (to pay / access services)	40.0	Unemployment rate	80.0
				Gini coefficient	20.0
	Cost Recovery / funding	28.3	WSA financial performance - RPMS 9	40.0	
			Water use efficiency / NRW - RPMS 11	20.0	
Asset management	60.0	Strategic asset management - RPMS 10	60.0		
Environmental	40	Resource sustainability / feasibility (quantity)	57.9	Per capita water availability (m ³)	40.0
				Sustainability of source	81.0
				Average annual population growth rate	60.0
	Sustainability of water resources (quality)	31.7	Potable water quality / Blue Drop	80.0	
			River Health	20.0	
			Groundwater quality	20.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	66.0	Domestic	60.0	
			Industrial	80.0	
Maintenance of ecosystems			60.0		
Wastewater management	20.0	Wastewater quality / Green Drop	20.0		
Stormwater management	40.0	WSUD / SuDS policy and implementation	40.0		
Institutional	68	Governance model	69.3	Defined roles and responsibilities	80.0
				Departmental integration	60.0
	Progress with meeting targets (MDGs and others)	66.0	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	60.0	
			Access to FBW - RPMS 3	80.0	
	Institutional capacity and policy dictates	69.3	WDM policy / IUWM implementation	80.0	
Institutional effectiveness - RPMS 8			60.0		

nc = not calculated

G6.2 Indicator analysis

Figure G6.1 shows a breakdown of the indicator scores for Mangaung and highlights the specific areas of concern as cost recovery, resource quality and wastewater treatment and management.

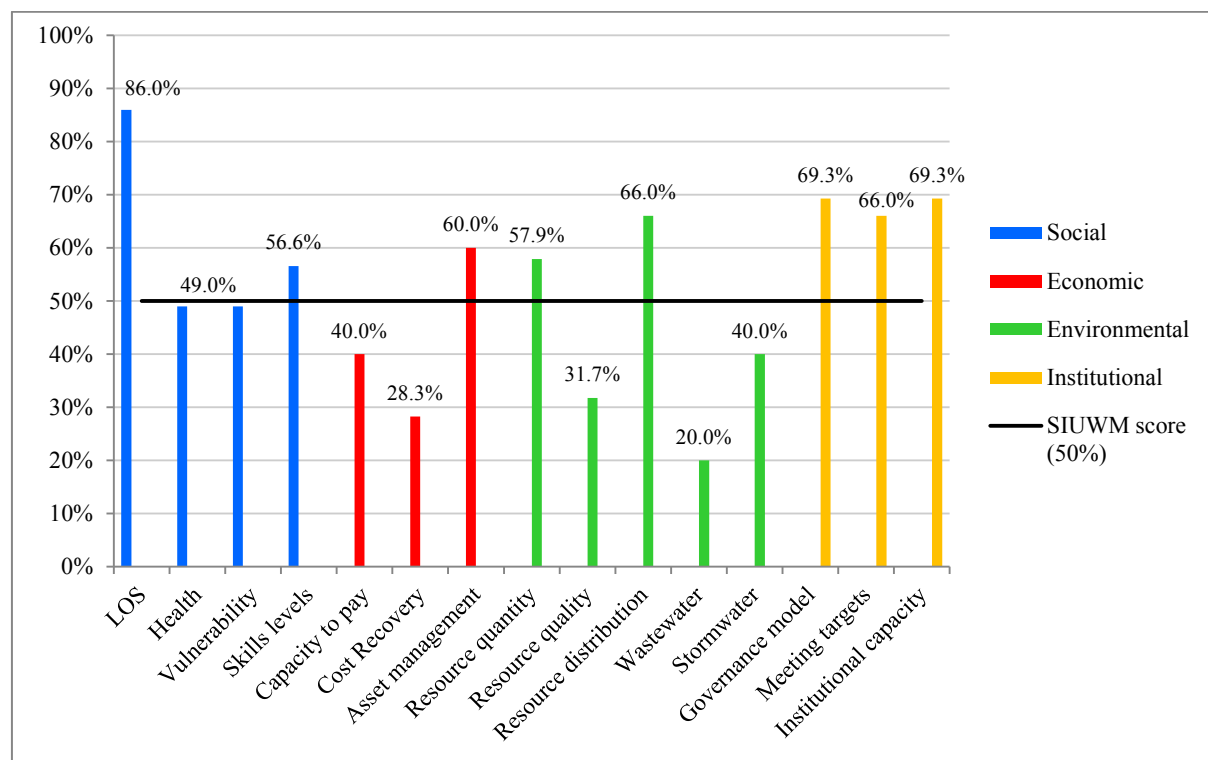


Figure G6.1: SIUWM indicator scores – Mangaung

G6.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G6.3.1 Social component

MN attained a score of 58% for the social component and similarly to many of the other SACN cities, fared badly in the indicators ‘HIV/AIDS prevalence’, ‘Informal dwellings’ and ‘Secondary education’ (Figure G6.2). Published and/or verifiable data on many of the variables (except for the RPMS variables) for the SIUWM was difficult to obtain for MN, and the author was not successful in securing appointments to interview the required officials, either on a face-to-face basis or by electronic communication, even after repeated attempts. As a result many of the scores are subjective interpretations and could improve with better data. It should be noted however that the absence of information is of itself an indication of a less than sustainable system.

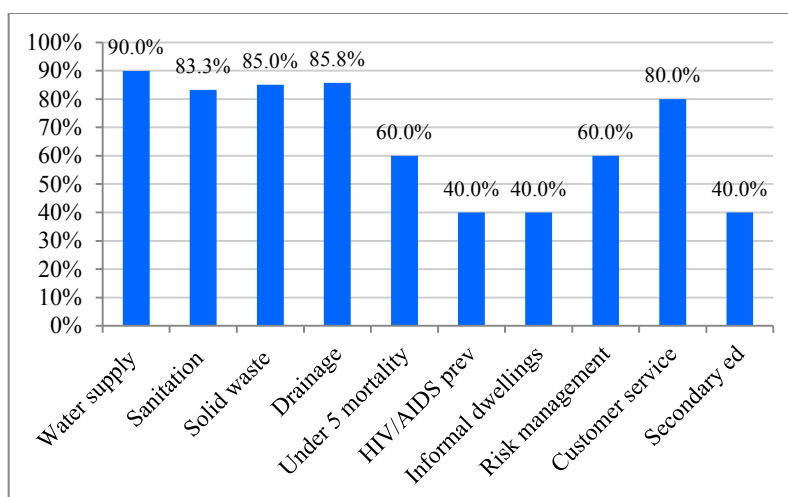


Figure G6.2: Social component variable scores – Mangaung

G6.3.2 Economic component

MN received a score of 41% for the economic component, with significant issues in all variables except for unemployment levels which appear to have steadily improved recently. NRW is particularly problematic, as is the level of inequality in the city. The WSA is also currently performing very poorly financially, as measured through the RPMS.

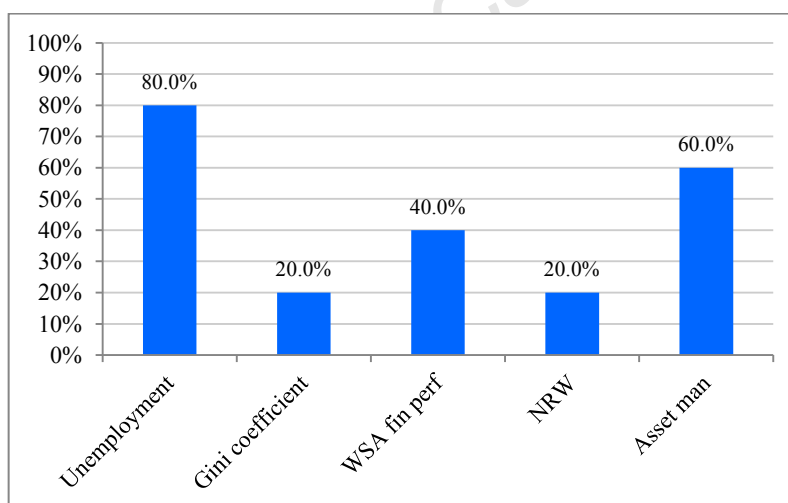


Figure G6.3: Economic component variable scores – Mangaung

G6.3.3 Environmental component

MN received its lowest score (40%) for the environmental component, particularly in the areas of water availability, river health, groundwater quality and wastewater treatment – although as discussed previously, not all of these variable scores could be verified. The Green Drop score as measured through the RPMS was particularly low and is likely to have significant impacts on the other environmental variables from poor quality sewage effluent flows into surface and

groundwater resources. The last River Health Programme report (RHP, 2003) suggests that only 25% of the rivers in the metropolitan area are in a satisfactory state.

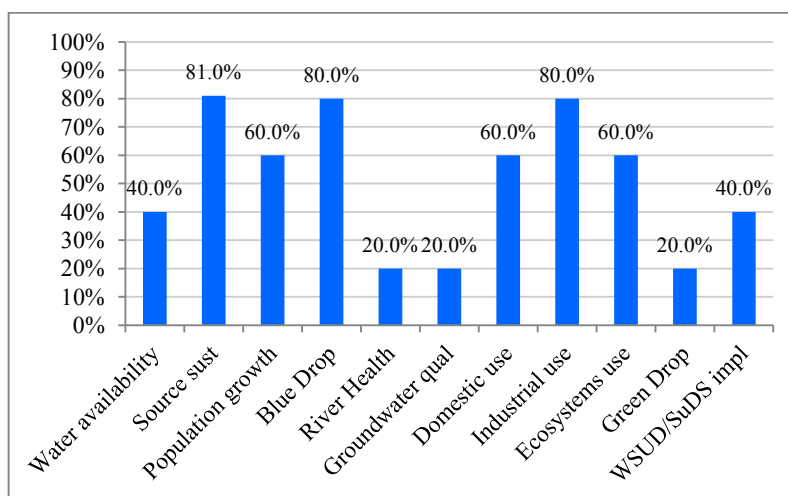


Figure G6.4: Environmental component variable scores – Mangaung

G6.3.4 Institutional component

The institutional component received the highest score of 68%, with no specific variables scoring particularly badly. It would have been useful to have had more comprehensive information on governance structures at the municipality, however, to give a clearer picture of the state of urban water management in the city.

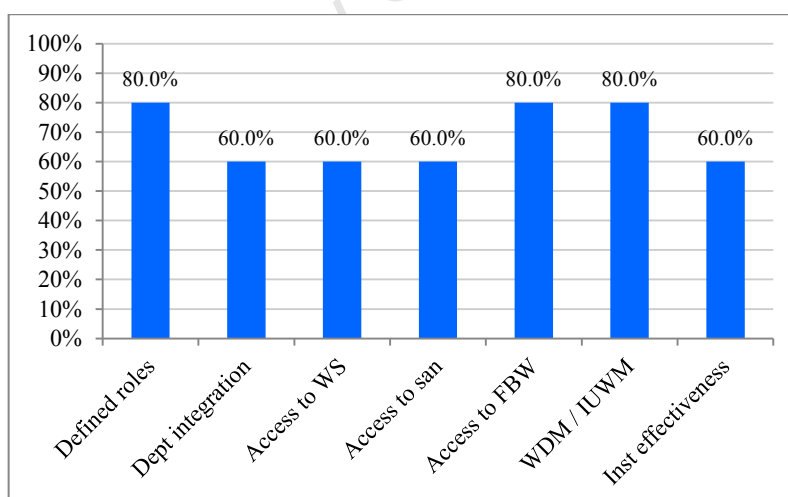


Figure G6.5: Institutional component variable scores – Mangaung

G7 The Msunduzi Local Municipality

Msunduzi (MS) is a Local Municipality in the Umgungundlovu District with a population of about 650,000. It encompasses the city of Pietermaritzburg which is the capital of the

KwaZulu-Natal Province and the main economic hub of Umgungundlovu District Municipality. In terms of national and provincial policies, Pietermaritzburg has been identified as a focus area for development and economic growth. This, in turn, will create greater urbanization and economic development pressures on Msunduzi, as is evident in the uneven development between the suburbs and city centre, and the poorly developed townships and surrounding rural settlements (SRK, 2009). Urbanisation has manifested itself in informal settlements in the southern and northern areas of the Municipality. While the city serves as the provincial capital, much more is required to provide the economic opportunities needed to ensure employment and adequate livelihoods for all.

Water quality in the uMsunduzi catchment varies significantly. The system is fairly healthy in its upper reaches but surface water quality declines as it passes through Pietermaritzburg. With the incorporation of the Greater Edendale area in 1996, followed by the Vulindlela area in 2000, MS has inherited a number of different levels of service in water and sanitation and extensive backlogs exist. The Umgeni River system is the main source of potable water and it includes a number of storage dams, treatment works and inter-basin transfer schemes. Bulk water supply to MS is the responsibility of Umgeni Water. Water for potable purposes is purified at the Midmar and DV Harris treatment works.

The majority of Msunduzi is fully reticulated with bulk supply of potable water, but some areas are supplied water by means of tankers and boreholes. The Vulindlela area is in critical need of sanitation infrastructure with a backlog of approximately 31 000 VIPs (SRK, 2009). This is as a result of informal settlement of areas that have not been identified for service provision. Anticipated increases in high density housing in MS means that a new sewage treatment facility will need to be developed.

G7.1 Component analysis

Table G7.1 details the SIUWM percentage scores for Msunduzi Local Municipality (MS). MS attained an overall SIUWM score of 53% which puts it into the category ‘low potential for sustainability’. MS scored highest in the social and institutional components (65% and 63% respectively) and lowest in the economic components (38%). The environmental component scored 52%.

G7.2 Indicator analysis

Figure G7.1 shows a breakdown of the indicator scores for Msunduzi and shows that the main areas of concern are in the economic component (‘Capacity to pay’, ‘Cost recovery’ and ‘Asset management’. Resource quality has also been identified as being problematic. As with Mangaung Local Municipality, published and/or verifiable data on many of the variables (except for the RPMS variables) for the SIUWM was difficult to obtain, and the author was not successful in securing appointments to interview the required officials, either on a face-to-face basis or by electronic communication, even after repeated attempts. As a result many of the scores are subjective interpretations and could improve (or worsen) with better data.

Table G7.1: SIUWM scores for Msunduzi Local Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	65	Levels of Service (LOS)	82.5	Water supply	91.3
				Sanitation	79.5
				Solid waste	77.6
				Drainage	82.4
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	69.3	Population living in informal dwellings	80.0	
			Risk management and disaster mitigation	60.0	
	Skills and awareness levels	63.2	Customer service standards - RPMS 7	100.0	
			% people with secondary education	40.0	
Economic	38	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
	Cost Recovery / funding	40.0	WSA financial performance - RPMS 9	80.0	
			Water use efficiency / NRW - RPMS 11	20.0	
Asset management	40.0	Strategic asset management - RPMS 10	40.0		
Environmental	52	Resource sustainability / feasibility (quantity)	50.4	Per capita water availability (m ³)	20.0
				Sustainability of source	80.0
				Average annual population growth rate	80.0
	Sustainability of water resources (quality)	40.0	Potable water quality / Blue Drop	80.0	
			River Health	40.0	
			Groundwater quality	20.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	52.4	Domestic	60.0	
			Industrial	60.0	
Maintenance of ecosystems			40.0		
Wastewater management	60.0	Wastewater quality / Green Drop	60.0		
Stormwater management	60.0	WSUD / SuDS policy and implementation	60.0		
Institutional	63	Governance model	69.3	Defined roles and responsibilities	80.0
				Departmental integration	60.0
	Progress with meeting targets (MDGs and others)	60.0	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	60.0	
			Access to FBW - RPMS 3	60.0	
	Institutional capacity and policy dictates	60.0	WDM policy / IUWM implementation	60.0	
Institutional effectiveness - RPMS 8			60.0		

nc = not calculated

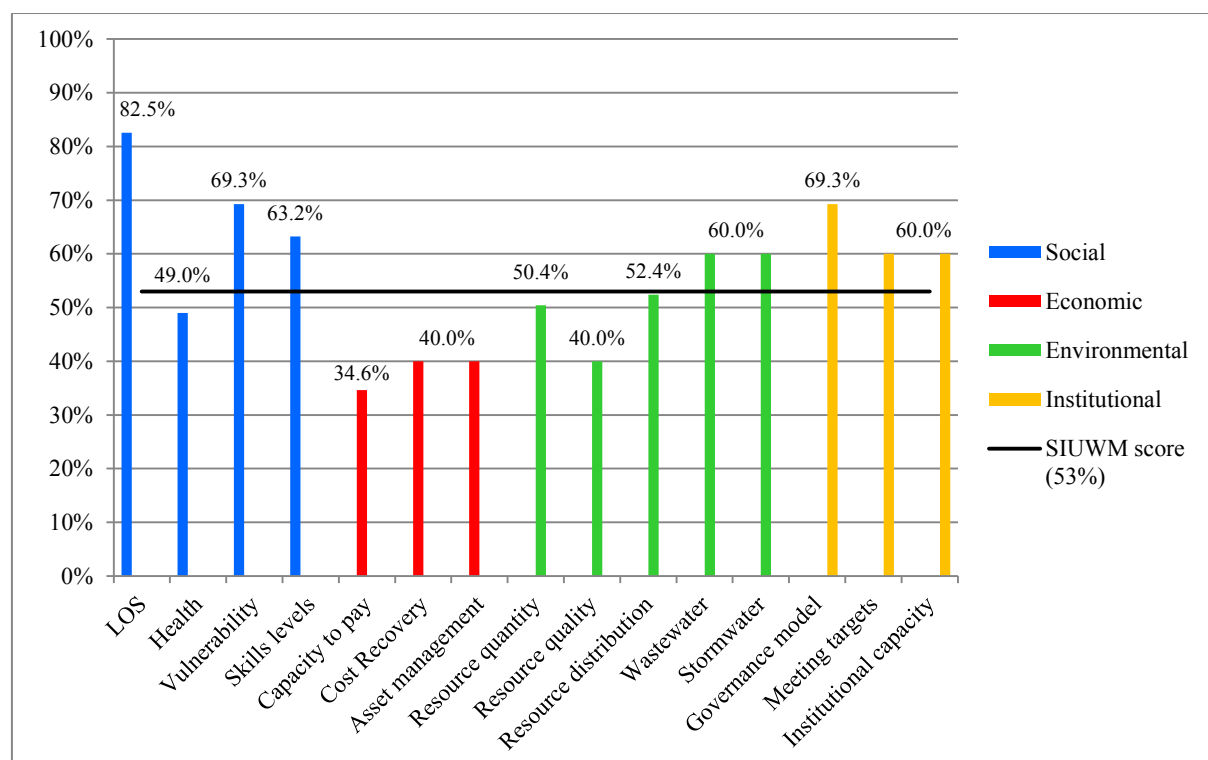


Figure G7.1: SIUWM indicator scores – Msunduzi

G7.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G7.3.1 Social component

MS attained its highest score (65%) for the social component and fared reasonably well in all variables except for ‘HIV/AIDS prevalence’ and ‘Secondary education’ (Figure G7.2). Some issues are obvious with the scores for access to services, particularly with respect to sanitation and solid waste, and this will clearly have knock-on social and environmental impacts. Problems with service delivery also put pressure on health and disaster response systems, as is evident in the scores for the related variables (‘Under 5 mortality’ and ‘Risk management’). SRK (2009) reports that the rapidly increasing density of settlement, including housing, industrial and commercial development, is resulting in increased storm water run-off which has significantly increased the risk of flooding.

The observed HIV/AIDS prevalence rates are particularly problematic in that the provision of health facilities in the municipality is reported as being unevenly distributed and insufficient to deal with the issue. Whilst literacy rates appear to be increasing, the number of adults who have completed secondary education is still extremely low.

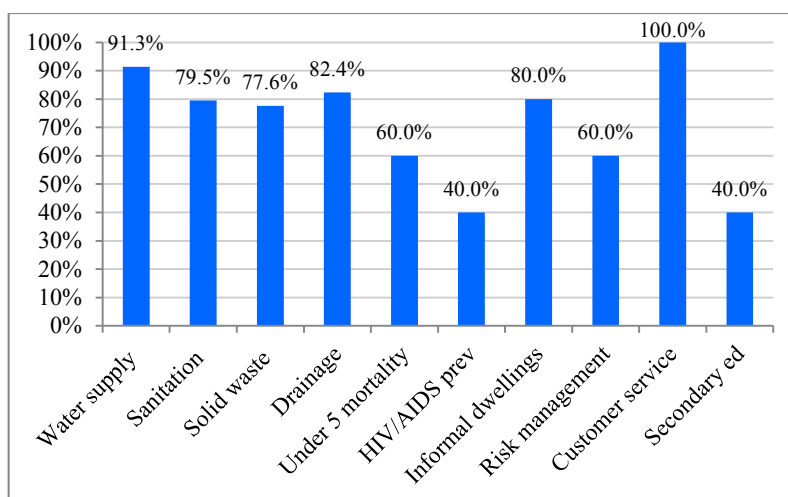


Figure G7.2: Social component variable scores – Msunduzi

G7.3.2 Economic component

MS's score of 38% for the economic component reflects serious obstacles for the city with regard to moving to a sustainable state. Surprisingly, MS appears to have scored reasonably well for the RPMS variable concerning WSA financial performance, but all other variables for this component scored poorly (Figure G7.3). Very low scores were achieved for 'Gini coefficient' and 'NRW'. The very high levels of inequality in the city are similar to those being experienced in almost every South African city. The high percentage of non-revenue water (estimated to be over 60% during the 2009/10 financial year) (NRW) is cause for real concern. Half of this figure was the result of physical water leaks and bursts, while the rest was attributed to illegal connections and unmetered or unregistered connections. The municipality intends to reduce total NRW to 32% by the end of 2013.

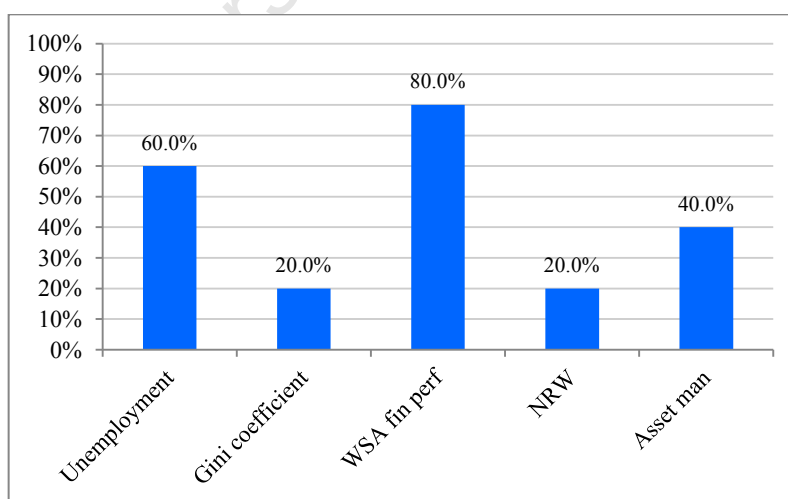


Figure G7.3: Economic component variable scores – Msunduzi

G7.3.3 Environmental component

MS scored 52% in the environmental component. The main issues with environmental management concern the low availability of fresh water resources, pollution of rivers, groundwater quality and protection of resources (Figure G7.4). Current demand for water exceeds the capacity of the Umgeni system and augmentation from other river systems will be required in future. Transfer schemes from the Mooi River and the Umkomaas River are already in advanced stages of planning and design, however the implementation of these schemes may not be achieved in time to reduce the risk of shortfalls (SRK, 2009). River health in the municipal area varies significantly, but most of the rivers that run through the city are described as ‘seriously modified’ (SRK, 2009). Groundwater quality is largely unknown.

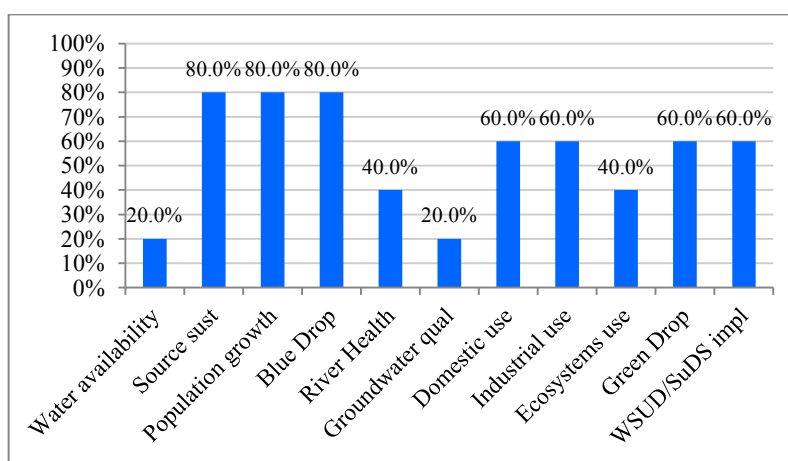


Figure G7.4: Environmental component variable scores – Msunduzi

G7.3.4 Institutional component

The institutional component received a score of 63%, with no particularly poor performances in any of the variables (Figure G7.5).

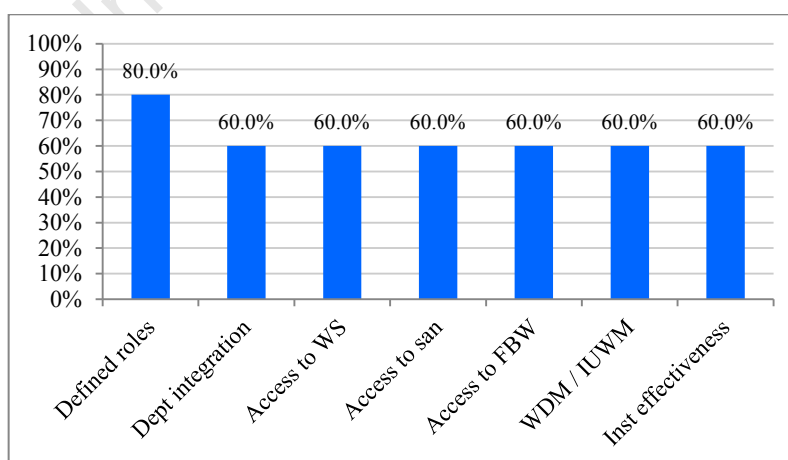


Figure G7.5: Institutional component variable scores – Msunduzi

G8 Nelson Mandela Bay Metropolitan Municipality

The Nelson Mandela Bay Metropolitan Municipality (NMM) includes the city of Port Elizabeth as well as the neighbouring towns of Uitenhage and Despatch, with a population of some 1.5 million (SACN, 2006). This major seaport on the south-eastern coast of Africa midway between the ports of Durban and Cape Town is located in the Eastern Cape Province and is considered the economic capital of the region. The city is an important centre for the automobile industry and is a major transport hub with its well equipped airport, harbour and port. The unemployment rate among the economically active sector of the community is however still high at approximately 35% (NMM, 2008). Although this has shown a steady decline since 1994, it remains higher than the national average for South Africa. A key challenge for the city of Port Elizabeth is balancing short-term job creation with laying the platform for industries which will provide economic sustainability. The Municipality continues to provide relief to impoverished households through its 'Assistance to the Poor Scheme' under the Indigent Policy, and increased its monthly free supply from 6 kℓ of water to 8 kℓ of water and free basic electricity from 50 kWh of electricity to 75 kWh per household respectively in 2007 (Mureverwi, 2009). Approximately 93 000 households receive free basic water, sanitation and refuse removal services, while almost 95 000 households receive free electricity every month (NMM, 2008).

NMM acts as the Water Services Authority (WSA) for Port Elizabeth and is responsible for bulk water supply, water treatment and distribution, as well as sanitation services provision. Water is sourced from a complex system of surface water sources, including reservoirs in the catchments of the Krom, Kouga and Gamtoos rivers, and via long-distance transfer from the Orange River system.

The formal residential areas of Port Elizabeth are well serviced with respect to water and sanitation infrastructure, but many of the informal settlements lack basic infrastructure. The terrain in these areas renders the provision of services problematic with most informal settlements located on slopes or flood plains.

G8.1 Component analysis

Table G8.1 details the SIUWM percentage scores for Nelson Mandela Bay Metropolitan Municipality (NMM). NMM attained an overall SIUWM score of 59% which puts it into the category 'low potential for sustainability'. NMM scored highest in the institutional components (72%) and lowest in the economic components (46%). The social and environmental components both scored 61%.

G8.2 Indicator analysis

Figure G8.1 shows a breakdown of the indicator scores for NMM and highlights the specific areas of concern as those related to the economic component, i.e. 'Capacity to pay' and 'Cost recovery'. Poor scores were also achieved in the indicators assessing health and vulnerability, as well as those related to stormwater management.

Table G8.1: SIUWM scores for Nelson Mandela Bay Metropolitan Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	61	Levels of Service (LOS)	88.6	Water supply	98.0
				Sanitation	94.0
				Solid waste	81.0
				Drainage	82.0
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	49.0	Population living in informal dwellings	40.0	
			Risk management and disaster mitigation	60.0	
	Skills and awareness levels	63.2	Customer service standards - RPMS 7	100.0	
			% people with secondary education	40.0	
Economic	46	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
	Cost Recovery / funding	34.6	WSA financial performance - RPMS 9	60.0	
			Water use efficiency / NRW - RPMS 11	20.0	
	Asset management	80.0	Strategic asset management - RPMS 10	80.0	
Environmental	61	Resource sustainability / feasibility (quantity)	73.0	Per capita water availability (m ³)	60.0
				Sustainability of source	81.0
				Average annual population growth rate	80.0
	Sustainability of water resources (quality)	57.7	Potable water quality / Blue Drop	80.0	
			River Health	40.0	
			Groundwater quality	60.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	62.1	Domestic	100.0	
			Industrial	60.0	
			Maintenance of ecosystems	40.0	
Wastewater management	80.0	Wastewater quality / Green Drop	80.0		
Stormwater management	40.0	WSUD / SuDS policy and implementation	40.0		
Institutional	72	Governance model	89.4	Defined roles and responsibilities	100.0
				Departmental integration	80.0
	Progress with meeting targets (MDGs and others)	60.0	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	60.0	
			Access to FBW - RPMS 3	60.0	
	Institutional capacity and policy dictates	69.3	WDM policy / IUWM implementation	80.0	
Institutional effectiveness - RPMS 8			60.0		

nc = not calculated

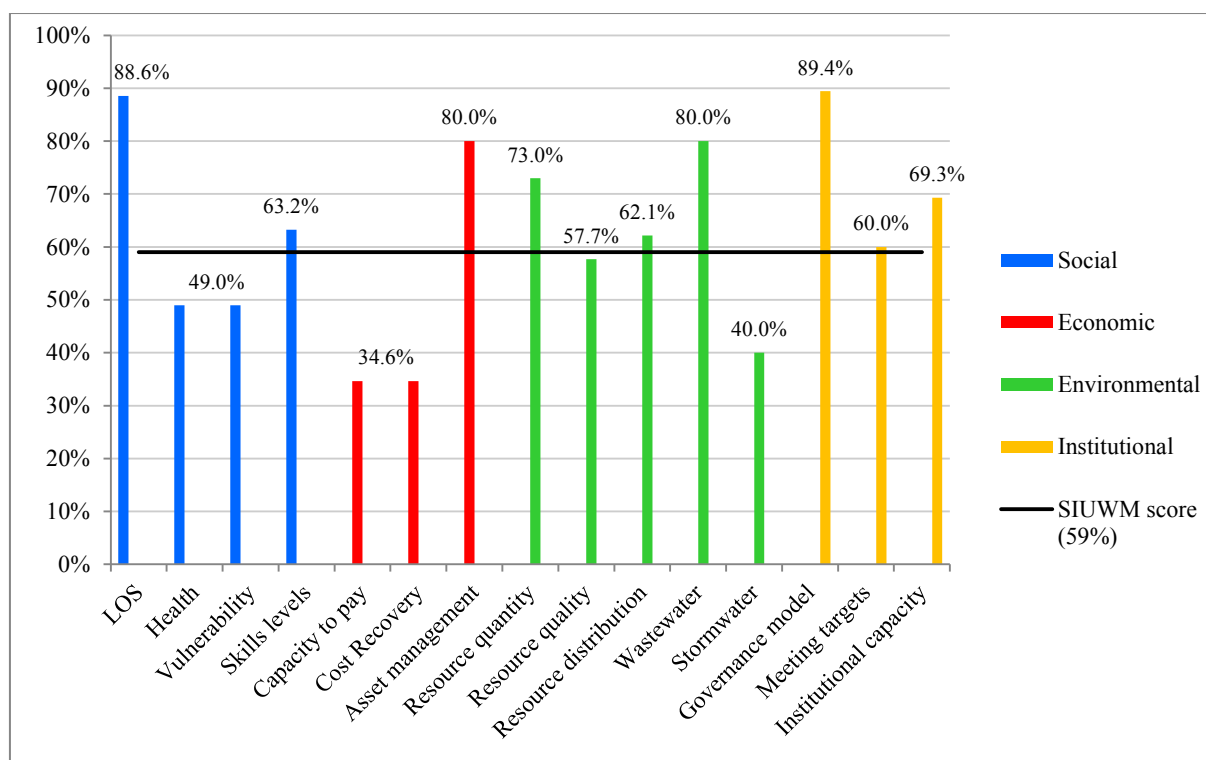


Figure G8.1: SIUWM indicator scores – Nelson Mandela Bay

G8.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G8.3.1 Social component

NMM obtained a score of 61% for its social component. The ‘level of service’ indicator scored well with all formal areas in the city having adequate service delivery. The lowest performing variables were those concerning HIV/AIDS prevalence, numbers of people living in informal settlements and education levels (Figure G8.2). The variables ‘Risk management’ and ‘Under 5 mortality’ achieved modest scores. Disaster management is mostly related to floods and fires which occur mainly in the informal settlements. In the formal settlement areas, well-planned engineering design has reduced the risk of significant damage due to floods and fires. The infant mortality rates are mainly as a result of poor living conditions in low-income and informal settlements.

Poor scores were obtained for the variable ‘Secondary education’ which points to another aspect of vulnerability and weaknesses in the social fabric of the city. On the other hand, the variable ‘Customer service’ scored very high, showing that the municipality is making concerted efforts to provide a good service to all their residents, and have put in place the necessary institutional arrangements to support this.

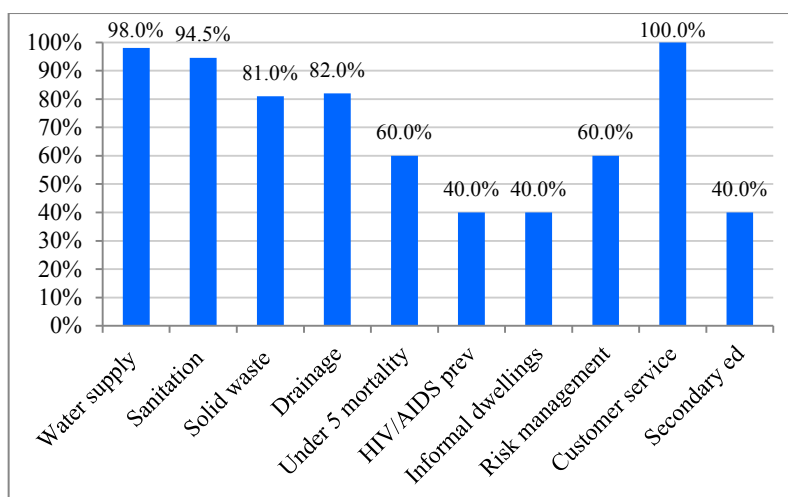


Figure G8.2: Social component variable scores – Nelson Mandela Bay

G8.3.2 Economic component

NMM received its lowest score of 46% for the economic component and as a whole, the sustainability of Port Elizabeth's economic systems with regard to urban water management needs improvement. The lowest performing variables are 'Gini coefficient' and 'NRW' (Figure G8.3). The unemployment rate in NMM is also problematic at over 28%, as is the modest scoring for WSA financial performance as measured through the RPMS. Despite this, the average household income level is relatively high at R5700, indicating that the majority of households should have the capacity to pay for water services. The amount of non-revenue water is a major concern when it comes to cost recovery as current levels are estimated at 35%. Most of this water is assumed to be lost due to leaks in the supply reservoirs and pipe network, as well as errors in the meter readings.

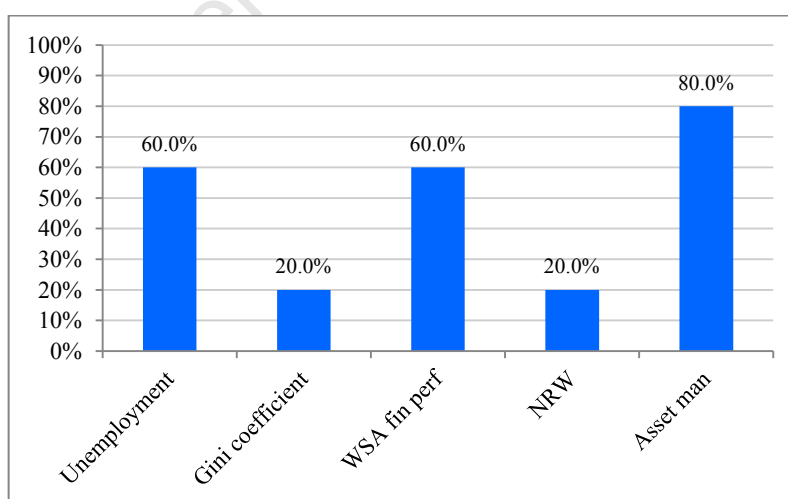


Figure G8.3: Economic component variable scores – Nelson Mandela Bay

G8.3.3 Environmental component

NMM scored 61% in the environmental component and although this is a reasonable score there are a number of concerns. The lowest scoring variables were ‘River health’, ‘Ecosystems use’ and ‘WSUD/SuDS implementation’ (Figure G8.4). The quality of the rivers flowing in the urban areas of the city was below NEMA regulations and NMM performed poorly in the River Health Programme assessment (RHP, 2004). With regard to ‘use’ of the resource, only 10% is used for maintaining the ecosystem; this is likely to have serious consequences for future water resource planning. There has also been poor progress towards the implementation of WSUD and SuDS policy by the municipality. On the other hand, there appears to have been reasonable control by the municipality over issues such as domestic water use and the treatment of both potable water and sewage effluent.

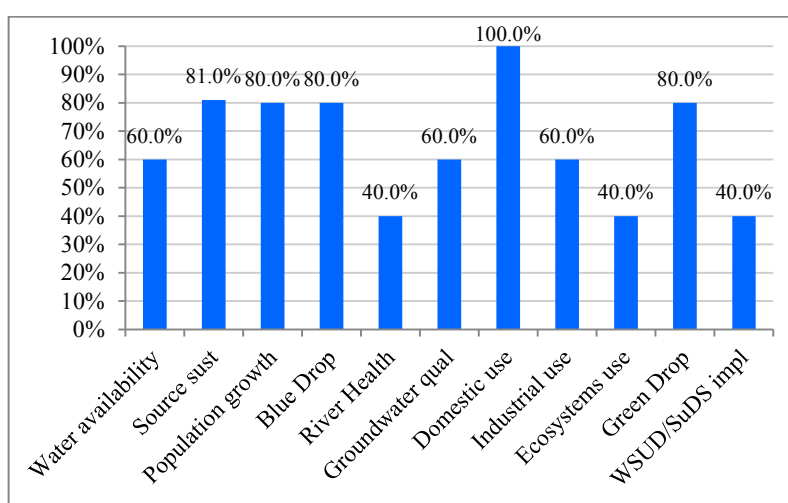


Figure G8.4: Environmental component variable scores – Nelson Mandela Metro

G8.3.4 Institutional component

The result obtained for NMM’s institutional component is the highest of the four components with a score of 72% and there are no particularly problematic areas (Figure G8.5). The governance structure results in a good understanding of the various authorities’ roles and responsibilities from the mayor down to the ward representatives. NMM has a reasonable record when it comes to progress towards achieving the MDG targets, although it appears that some improvements could be made with respect to the numbers of people with access to Free Basic Water (FBW), as measured through the RPMS.

The score for ‘Institutional effectiveness’ could be enhanced by improving the monitoring capability of the municipality and the data recording systems that are in place.

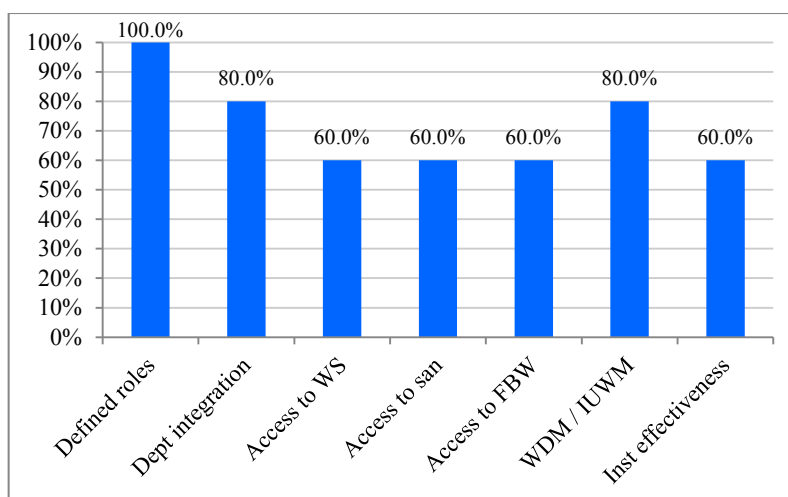


Figure G8.5: Institutional component variable scores – Nelson Mandela Bay

G9 City of Tshwane Metropolitan Municipality

The City of Tshwane Metropolitan Municipality (TS) is the fifth largest municipality by population in the country, comprising approximately 2.4 million people and 687 000 households (DWA, 2010f). The city was formed in 2000 as an amalgamation of 13 separate municipal authorities; this number increased to 15 after the local government elections in 2011 resulted in the inclusion of two more areas. Pretoria is the administrative capital of South Africa and is home to the Union Buildings with government-related business playing an important role in Tshwane's economy. The growth of the city has been focused largely around the central core whilst growing radically along the major movement lines. The continuous processes of outward urban expansion provide constant pressures on the municipality's capacity to provide service and infrastructure. Almost 380 000 people fall below the poverty line (income of R3000 per household per month), most of whom are registered as indigent in order that they can qualify for free basic services and rebates. TS acts as both the WSA and the Water Services Provider (WSP) to most, but not all, city areas – a municipal entity and a water board (Magalies Water) provide water distribution services to the northern / Temba areas. Rand Water provides most of the bulk water supply, while TS themselves also sells water to other municipalities (DWA, 2010f). Virtually all households in the metro have access to an adequate water supply, although the 180 000 households in informal settlements mainly access water through communal standpipes. Sanitation mostly comprises chemical toilets and pit latrines.

G9.1 Component analysis

Table G9.1 details the SIUWM percentage scores for City of Tshwane Metropolitan Municipality (TS). TS attained an overall SIUWM score of 53% which puts it into the category 'low potential for sustainability'. TS scored lowest in the economic components (44%). The social, environmental and institutional components scored 53%, 59% and 56% respectively.

Table G9.1: SIUWM scores for City of Tshwane Metropolitan Municipality

Comp	Score (%)	Indicator	Score (%)	Variable	Score (%)
Social	53	Levels of Service (LOS)	82.1	Water supply	88.2
				Sanitation	78.3
				Solid waste	80.7
				Drainage	81.6
	Health	49.0	Under 5 mortality rate	60.0	
			HIV/AIDS prevalence	40.0	
	Vulnerability	40.0	Population living in informal dwellings	20.0	
			Risk management and disaster mitigation	80.0	
	Skills and awareness levels	49.0	Customer service standards - RPMS 7	60.0	
			% people with secondary education	40.0	
Economic	44	Capacity (to pay / access services)	34.6	Unemployment rate	60.0
				Gini coefficient	20.0
	Cost Recovery / funding	40.0	WSA financial performance - RPMS 9	80.0	
			Water use efficiency / NRW - RPMS 11	20.0	
Asset management	60.0	Strategic asset management - RPMS 10	60.0		
Environmental	59	Resource sustainability / feasibility (quantity)	66.5	Per capita water availability (m ³)	60.0
				Sustainability of source	81.7
				Average annual population growth rate	60.0
	Sustainability of water resources (quality)	43.1	Potable water quality / Blue Drop	100.0	
			River Health	20.0	
			Groundwater quality	40.0	
	Ability to respond to climate change impacts	nc	Energy consumption by water sector	nc	
			Climate change strategy	nc	
	Use (resource distribution per sector)	52.4	Domestic	60.0	
			Industrial	60.0	
Maintenance of ecosystems			40.0		
Wastewater management	60.0	Wastewater quality / Green Drop	60.0		
Stormwater management	80.0	WSUD / SuDS policy and implementation	80.0		
Institutional	56	Governance model	69.3	Defined roles and responsibilities	80.0
				Departmental integration	60.0
	Progress with meeting targets (MDGs and others)	41.6	Access to water supply - RPMS 1	60.0	
			Access to sanitation - RPMS 2	20.0	
			Access to FBW - RPMS 3	60.0	
	Institutional capacity and policy dictates	60.0	WDM policy / IUWM implementation	60.0	
Institutional effectiveness - RPMS 8			60.0		

nc = not calculated

G9.2 Indicator analysis

Figure G9.1 shows a breakdown of the indicator scores for TS and highlights the specific areas of concern as those related to the economic component, i.e. ‘Capacity to pay’ and ‘Cost recovery’. Poor scores were also achieved in the indicators assessing vulnerability, as well as those related to water resource quality and meeting MDG targets.

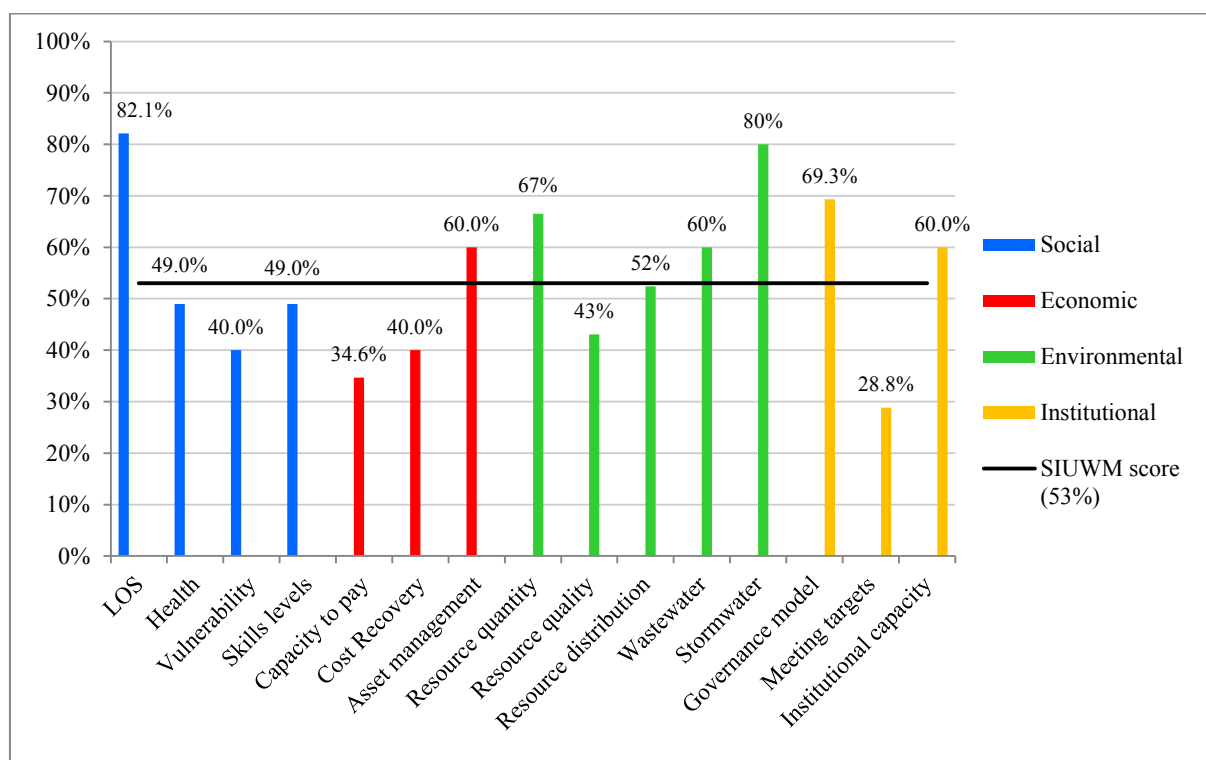


Figure G9.2: SIUWM indicator scores – Tshwane

G9.3 Variable analysis

Analysis of the variable scores provides further detail for the sustainability analysis, and highlights some of the linkages between the components and their indicators.

G9.3.1 Social component

TS attained a score of 53% for the social component and, as with many of the other SACN cities this was mainly as a result of the impacts resulting from large numbers of people living in informal settlements without access to the majority of social services (Figure G9.2). As already discussed a large proportion of the Tshwane population (about 25%) resides in informal areas with only limited access to basic water and sanitation services. Backlogs are being attended to, however, with waterborne sanitation systems being installed in the semi-formal areas and UD toilets being implemented in the outer, more rural areas (Mouton, 2011).

With regard to health, the ‘Under 5 mortality rate’ could be improved and the observed HIV/AIDS prevalence rates are unacceptably high. Poor scores were obtained for the variable

‘Secondary education’ and ‘Customer service’ as measured through the RPMS is also worthy of attention. Skills levels at the municipality are a particular problem in this regard – Mouton (2011) reported that only about 1000 of the 1669 approved posts at the city have been filled, and because many of the positions are unfunded, it is difficult to motivate for filling them.

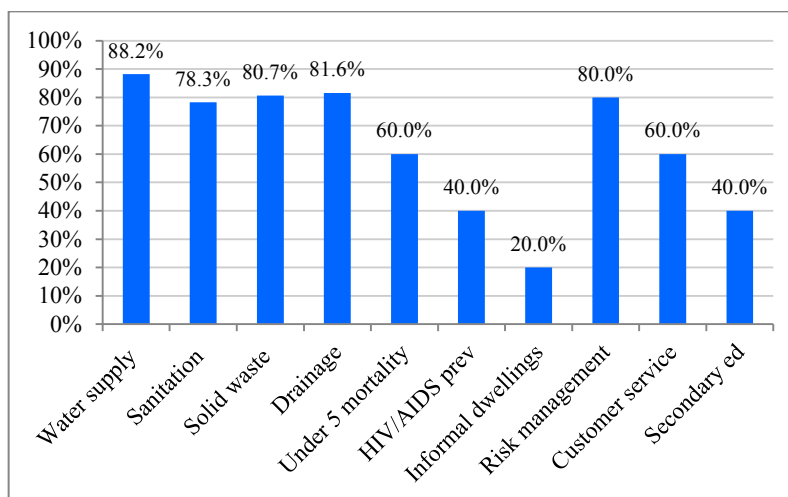


Figure G9.2: Social component variable scores – Tshwane

G9.3.2 Economic component

TS received its lowest score of 44% for the economic component and whilst a recent DWA report has shown that the municipality is financially viable (DWA, 2010f), there are still issues with respect to cost recovery by the city and people’s capacity to pay for services – as seen in the low scores for the variables ‘Unemployment’, ‘Gini coefficient’ and ‘NRW’ (Figure G9.3).

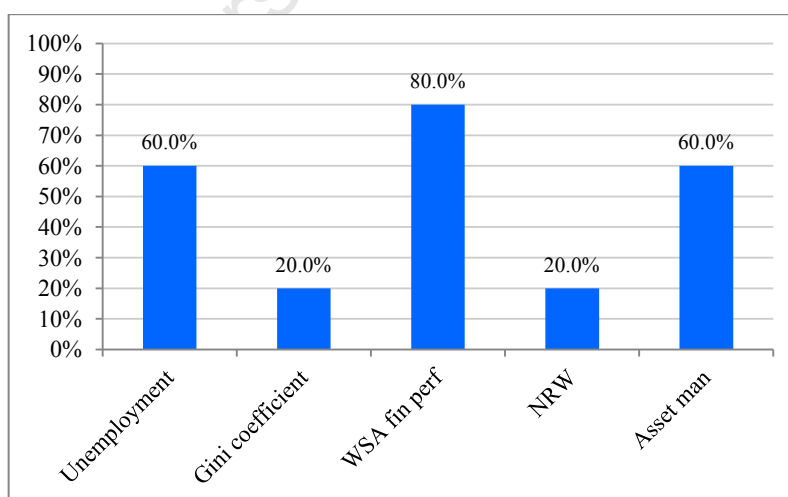


Figure G9.3: Economic component variable scores – Tshwane

Asset Management is being addressed but there are significant problems with O&M activities – e.g. many of the old AC pipes in the city need replacing, but insufficient budgetary allowances

are being made for this. Physical water losses, including theft, result in NRW figures of around 25 to 28%; the city is however developing strategies (such as pressure management systems) to reduce losses from these contributing factors.

G9.3.3 Environmental component

TS scored 59% in the environmental component. There is significant variation in the scores for this variable, although the main areas of concern are pollution of rivers, groundwater quality and the issue of balanced resource use and distribution (Figure G9.4). Groundwater pollution as a result of poor sanitation services (e.g. pit latrines) is a major concern in areas where there is sandy gravel with shallow impermeable granite layers (Janse van Vuuren, 2011). Stormwater pollution from informal settlement areas impacts significantly on surface water resources, and river health throughout the city is consequently very poor. There are also serious problems with the quality of treated effluent discharging to river systems – of the 10 sewage treatment works in the city, only 2 were awarded Green Drop status in the 2009/10 assessment period (Mouton, 2011).

TS has shown good commitment towards establishing policy in terms of WSUD and SuDS, but implementation has been challenging owing to issues of poor funding in the stormwater division, and to institutional structures impeding progress in this regard.

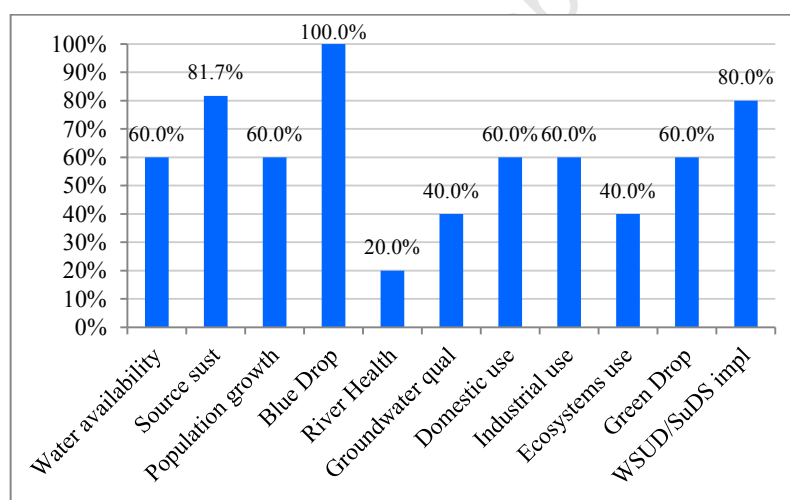


Figure G9.4: Environmental component variable scores – Tshwane

G9.3.4 Institutional component

The institutional component received a score of 56%, and would have been higher if it was not for the very poor scoring for the variable concerned with meeting MDG sanitation targets, as measured through the RPMS (Figure G9.5). Most of the other variable scores in this component were mediocre, reflecting the fact that institutional structures could be improved in almost all areas of the urban water management system – particularly in terms of institutional effectiveness, through improvements to procurement and planning processes. Departmental integration could also be improved; the separation of service delivery functions makes

integration particularly difficult, and joint projects are dependent on personal relationships being forged. This is particularly problematic when it comes to obtaining the required environmental authorisations for projects (Janse van Vuuren, 2011).

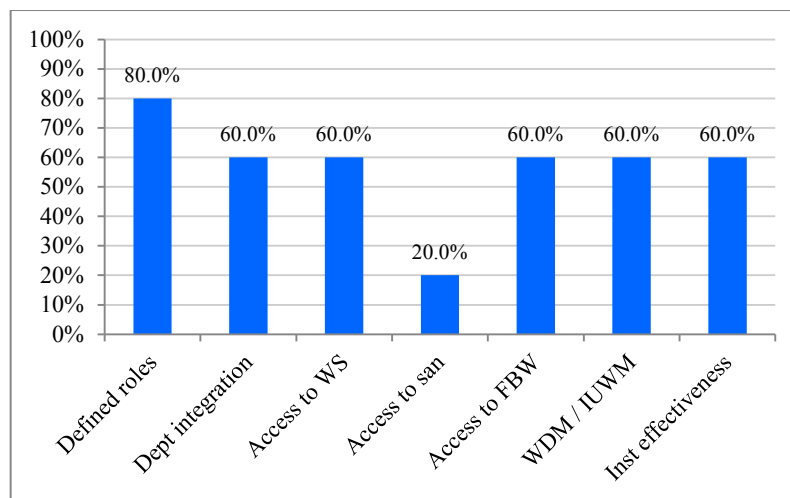


Figure G9.5: Institutional component variable scores – Tshwane

Appendix H

Research ethics

University of Cape Town

