‘What is to be sustained for whom?’: Equity as a key to sustainable sanitation in South African informal settlements

Thesis presented for the degree of Doctor of Philosophy (PhD)

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‘Ensuring access to water and sanitation for all, which is safe, affordable, acceptable and sufficient, requires multiple interventions from different stakeholders, leadership, an enabling environment for interventions to be effective and sustainable, and an engaged population willing and able to claim their rights.’

Catarina de Albuquerque, statement to the 18th session of the United Nations Human Rights Council, 15 September 2011 (de Albequerque, 2012)

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Some of the literature for Appendix C relating to sanitation technologies used in South Africa is based on the literature review and fieldwork completed as part of my master's dissertation entitled *Improving water and sanitation services in informal settlements in Cape Town: Finding the balance between "hard" and "soft" approaches* (Pan, 2011).

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Glossary of Abbreviations and Acronyms

AMCOW – African Ministers' Council on Water

ANC – African National Congress

ANCYL – African National Congress Youth League

BSF – Black soldier fly

CAB –Communal Ablution Block

CBO – community based organization

CCT – City of Cape Town

CDS – City Development Strategy

CJ – City of Johannesburg

COGTA – Department of Cooperative Governance and Traditional Affairs

CORC – Community Organisation Resource Centre

DA – Democratic Alliance

DEWATS – Decentralized Wastewater Treatment Systems

DHS – Department of Human Settlements

DPLG – Department of Provincial and Local Government (renamed to CoGTA)

DWAF – Department of Water Affairs and Forestry (now split into DWAS and the Department of Environmental Affairs)

DWS – Department of Water and Sanitation

EHP – Environmental Health Practitioner

EISD – Environment and Infrastructure Services Directorate

EM – eThekwini Municipality

EPWP – Expanded Public Works Programme

EWS – eThekwini Water and Sanitation department

FBSan – Free Basic Sanitation

FBW – Free Basic Water

GEAR – Growth, Employment and Redistribution Programme

GIS – Geographical Information System

ha – hectares

HH – Household

HSIS – Human Settlements Informal Settlements

IDP – Integrated Development Plan

ISN – Informal Settlement Network

JMP – Joint Monitoring Programme

JW – Johannesburg Water

kℓ – kilolitres

km – kilometers

KPI – Key Performance Indicator

ℓ – litres

LCA – Life Cycle Assessment

LoS – Level(s) of Service

MDG – Millennium Development Goals

M&E – monitoring and evaluation

MHM – menstrual hygiene management

MIG – Municipal Infrastructure Grant

MOE – Municipal Owned Entities

MoU- Memorand(um)a of Understanding

MTREF – Medium Term Revenue and Expenditure Framework

NGO – non-governmental organisation

O&M – operations and maintenance

PFT – portable flush toilet

PPE – personal protective equipment

PPP – public private partnership

PRG – Pollution Research Group

RDP – Reconstruction and Development Programme

RHIG – Rural Household Infrastructure Grant

SALGA – South African Local Government Association

SDF – Spatial Development Framework

SDG – Sustainable Development Goal

SDI – Slum Dwellers International

SIUWM – Sustainability Index for Urban Water Management

SJC – Social Justice Coalition

TAF – Technology Assessment Framework

UDDT – Urine Diversion Dry Toilet

UDL – Urban Development Line

UISP – Upgrading of Informal Settlements Programme

UKZN – University of Kwa-Zulu Natal

USDG – Urban Settlements Development Grant

VIP – Ventilated Improved Pit latrine

WASH – Water, sanitation and hygiene

WHO – World Health Organization

WRC – Water Research Commission

WSA – Water Service Authority

WSP – Water Service Provider

WSDP – Water Service Development Plan

WSISU – Water and Sanitation Informal Settlements Unit

WWTW – Wastewater treatment works

Glossary of Terms

Adaptive management: Adaptive management is a systematic multi-disciplinary approach for improving decision-making under uncertain conditions by learning from the outcomes of management decisions and policies (Holling, 1978). It 'involves the design and implementation of management programs that offer the possibility to experiment with and compare selected policies and practices' (Medema et al., 2008:) through evaluation of alternative hypotheses and assumptions, which is repeated to support continuous improvement and organisational learning (Pahl-Wostl, 2007; Medema et al., 2008).

Backlog: The number of households who do not have access to a basic sanitation service level. Calculations can vary depending on how a basic sanitation service level is defined in addition to the unit used for counting, *e.g.* eThekwini uses consumer units whereas other municipalities use households. There can also be 'second generation' backlogs, which are households that previously had access to a sanitation service who no longer have access, typically due to a breakdown in the sanitation system.

Backyarders: Are people who live in structures built informally in the yard of a formally titled household or rental property.

Basic sanitation facility: 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).

Blackwater: Is the mixture of urine, faeces, flush water (and anal cleansing water if used instead of dry cleansing materials like toilet paper). It contains pathogens from faeces and nutrients from urine that are diluted with the flush water (Tilley et al., 2014).

Brown agenda: Relates primarily to development required to address issues related to environmental health such as improving water supply, sanitation or drainage systems and access to housing, or reducing adverse health conditions created by rapid industrialisation with particular sensitivity to the needs of low-income groups (Williams, 1997; Bolnick et al., 2006).

Bucket system: The 'official' bucket system is a dry container based system that requires regular emptying consisting of a toilet seat over a 25ℓ plastic bucket that is dosed with chemicals to assist with sanitisation and odour reduction and is associated with the Apartheid government and considered an inadequate 'undignified' form of sanitation. A National Bucket Eradication programme was initiated by then President Thabo Mbeki in 2006 with target dates for eradication continuously pushed back due to various constraints (Mjoli, 2012).

Co-production: 'refers to the joint production of public services between citizen and state, with… one or more elements of the production process being shared' (Mitlin, 2008).

Cost of revenue: The total cost of manufacturing and delivering a product or service. Cost of revenue information is found in a company's income statement, and is designed to represent the direct costs associated with the goods and services the company provides. Indirect costs, such as salaries, are not included (Investopedia, 2016).

Demand-driven: In this approach, the push for sanitation services is supposed to reflect user needs and is associated with a stronger role for non-governmental stakeholders in sanitation service delivery and the promotion of participatory processes.

Enabling environment: There are six elements of an enabling environment that are necessary to support successful WASH interventions identified by Lüthi, et al. (2011a): government support, legal and regulatory framework, institutional arrangements, skills and capacity, financial arrangements and socio-cultural acceptance.

Environmental health: Is the branch of public health that is concerned with all aspects of the natural (air, water and soil) and built environment that may affect human health and disease control.

Environmental justice: This can be related to social justice, but with a specific emphasis on the intersection with environmental and public health issues. It 'embraces the principle that all people and communities [regardless of race, class, ethnicity or religion] are entitled to equal protection of environmental and public health laws and regulations' (Bullard, 1996).

Environmental sanitation: Environmental sanitation is defined by the Water Supply and Sanitation Collaborative Council as: 'Interventions to reduce peoples' exposure to disease by providing a clean environment in which to live, with measures to break the cycle of disease. This usually includes hygienic management of human and animal excreta, refuse, wastewater, stormwater, the control of disease vectors, and the provision of washing facilities for personal and domestic hygiene. ES involves both behaviours and facilities which work together to form a hygienic environment' (EAWAG & SANDEC, 2000).

Green agenda: Relates mainly to preventing natural resource degradation and the loss of or deterioration of natural life support systems (Bolnick et al*.,* 2006), and an emphasis on the sustainability of natural ecosystems.

Greywater: Is the total volume of water generated from washing food, clothes and dishware, as well as from bathing, but not from toilets. It may contain traces of excreta, *e.g.* from washing diapers and, therefore, may also have pathogens. Greywater accounts for approximately 65% of the wastewater produced by households with a flush toilet (Tilley et al., 2014).

Homeland: Homelands (also known as Bantustans) under the Apartheid government were areas designated for black South Africans, and were part of the government's strategy to remove black South Africans from urban areas starting in the1950s. They were designated as separate administrative regions to the rest of the country or 'white South Africa' and reinforced segregationist policies.

Inclusive design: The British Design Council has described the aim of inclusive design as 'to remove the barriers that create undue effort and separation. It enables everyone to participate equally, confidently and independently in everyday activities' (Design Council, 2016).

Incremental upgrading: This is a method of upgrading that relates to the gradual improvement in human settlements in stages, and in the South African context usually refers to different models applied to the upgrading of informal settlements with progressively increasing levels of service and improved housing over time. Some models include: re-blocking or the site and service model.

Informal settlement: Are residential areas which do not meet local authority requirements for conventional townships, often characterised by inadequate infrastructure, makeshift dwellings, and poor access to health and education facilities (PGWC, 2003).

Level of service: This term is closely associated to an incremental approach to service delivery where each level is characterised by the benefits that a user can receive. Typically, in the South African context of sanitation services, this is associated with a different sanitation technology provided to households on an individual or shared basis.

Monitoring and evaluation: Monitoring refers to tracking the progress of a process over regular intervals. Evaluation is used to assess the outcome of a project or process, and the situation should be assessed at a minimum at the beginning and end of a project or process using performance indicators (Cotton, 2000).

Municipal Infrastructure Grant: It is a conditional ring-fenced grant transferred from national to local government and is intended to be linked with municipal integrated development plans (IDPs) (DPLG, 2004). The MIG was one of the major sources of funding for sanitation projects in South Africa, but from 2011 onwards, the MIG was replaced by the Urban Settlements Development Grant (USDG) for metropolitan municipalities (DWA, 2012b).

Operations and maintenance: Operation refers to the procedures and activities involved in the delivery of services, *e.g.* conveyance, pumping, treatment of wastewater. Maintenance refers to activities aimed at keeping existing capital assets in serviceable condition, *e.g.* repairing sewage pipes, pumps and public taps (Cotton, 2000). Commonly lumped together and referred to as O&M.

Peri-urban: These areas can be described as a transition or interaction zone where activities associated with both urban and rural areas coincide. Iaquinta & Drescher (2000) describe the need to acknowledge 'the spectrum of change from rural to urban [as] discontinuous, "lumpy", and multidimensional' and developed a typology based on proximity to the city and various sociological factors.

Reblocking: A method for upgrading settlements whereby the spatial configuration of the settlement is changed to enable improved access routes and service upgrades. It is a participatory process where informal settlement residents assist with designing a new layout and with re-building their own shacks.

Sanitation service chain: The management of human excreta from collection/storage, conveyance (transport), to treatment and disposal or reuse.

Service delivery: Refers to the provision of a service including the support system, facilities, infrastructure and performance of required operations and maintenance activities. In South Africa, service delivery often relates to the provision of services to meet basic needs, *e.g.* water supply, sanitation, electricity and housing.

Sanitation ladder: This framework was developed as a tool to measure progress towards sanitation coverage and promoted by global monitoring programmes such as the Joint Monitoring Programme run by the WHO and UNICEF (2014), which is conventionally associated with increasing benefits to users as they 'climb' up each rung associated with various technologies, typically represented from the lowest to highest as: 1) open defecation (no facilities), 2) unimproved (facilities may be present but do not ensure that excreta is separated from human contact), e.g. pit latrines without a slab or platform or bucket latrines, 3) shared (facilities which may otherwise be acceptable, shared between two or more households including public toilet facilities), 4) improved (facilities that hygienically separate users from contact with human excreta), e.g. flush/pour flush toilets connected to sewer systems, septic tanks or pit latrines, VIPs, pit latrines with slabs, composting toilets.

Sanitation software: Refers to various planning/management approaches, which are primarily participatory in nature that promote health and hygiene and capacity building, and is considered complementary to 'hardware', i.e. infrastructure and facilities or 'taps and toilets'.

Section 24(a): From the Bill of Rights states that 'everyone has a right to an environment that is not harmful to their health or well-being' (RSA, 1996a), and is often invoked as the legal basis for the right to access basic sanitation in South Africa given sanitation's impact on the environmental and human health.

Site and service: Site and service developments usually provide only what households cannot easily provide or afford for themselves, e.g. a plot of land with basic utilities (water, sanitation, flood protection, security lighting, etc.), municipal services (schools, refuse collection, clinics, etc.*)* and financing (Gattoni, 2009).

Slippage: The term refers to unsustainable service delivery resulting in deteriorating levels of service or fluctuating coverage of water, sanitation and hygiene (WASH) services (Reddy et al., 2010; Improve International, 2015). In South Africa, the term 'second generation backlogs' is also used.

Soakaway: A pit designed for wastewater drainage designed to drain slowly into surrounding soil, typically filled with various sized gravel or rubble.

Social justice: In this thesis it refers to a movement towards a society that enables the realisation of human rights and equality of access to benefits and opportunities regardless of background, which enables participation from all social groups (Adams et al., 2016).

Stakeholder: Individuals, organisations and institutions that have a vested interest in and can directly affect or be affected by a particular project, policy or programme.

Supply driven: In the context of sanitation usually refers to a subsidised government-driven approach to sanitation service delivery focusing on infrastructure rather than health and hygiene promotion and a user-led demand for sanitation services incorporating participatory processes (Tissington, 2011).

Abstract

Universal access to sustainable and equitable sanitation is a Sustainable Development Goal on the 2030 Agenda for Sustainable Development. The South African government has taken strides to try and meet both international and domestic development goals with its Free Basic Sanitation policy, for which a national implementation strategy was developed in 2008. Although the policy was formulated at a national level, municipal governments are delegated the authority to ensure service delivery at the local level. Municipalities have adapted and interpreted the policy to suit their own contexts. In particular, they have attempted to address the challenge of providing sanitation services to informal settlements using different approaches with varying degrees of success and often without explicit consideration or guidance for how to incorporate sustainability and equity principles.

The aims of this thesis are thus to explore how the concepts of sustainability and equity can be applied to improve municipal sanitation services in South African informal settlements and to explore how various dimensions of sanitation and equity relate to sanitation. A comparative case study method using the lens of sustainability and equity was used to critique the approaches to providing sanitation services to informal settlements in three of South Africa's largest municipalities: eThekwini (Durban), Johannesburg and Cape Town. Each municipal case study incorporated an embedded case study that was used to examine sanitation services in selected informal settlements at a programme, project or settlement level. Primary data was collected using interviews and field visits. Secondary data was obtained from national and municipal records such as water and sanitation department reports, census data from Statistics South Africa, and municipal geographical information system databases.

Findings from the thesis indicate that there is a need to better incorporate multiple stakeholders' perspectives on what sustainable and equitable sanitation services should be like. Strengths and weaknesses of each municipality's approach to sanitation service provision were compared and used to identify factors relating to sustainability and equity. A major conceptual gap identified in sanitation service delivery approaches is the need to emphasise equity as a core tenet of sustainability, especially in a socio-economic context of extreme inequality. This thesis makes a contribution towards knowledge by highlighting the importance of equity to support sustainable sanitation service delivery in South African informal settlements, adding new perspective into different dimensions of equity in sanitation and a suggested framework for how they could be incorporated into M&E practices.

Keywords: informal settlements; urban; South Africa; sanitation; sustainability; equity

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1 Introduction

1.1 Background to the study

Millennium Development Goal (MDG) 7, Target 7(c) was to 'halve, by 2015, the proportion of people without sustainable access to safe drinking-water and basic sanitation'. According to the Joint Monitoring Programme (JMP) of the World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF), the majority of countries in Sub-Saharan Africa did not meet the MDG for sanitation (WHO & UNICEF, 2015). Goal 6 of the post-2015 Sustainable Development Goals (SDGs) is to push for universal adequate and *equitable* access to water and sanitation by 2030 to 'finish the job of the MDGs' (UNDP, 2015). Sustainable sanitation has been defined by the Sustainable Sanitation Alliance as a sanitation system designed to manage human excreta and domestic wastewater that is 'economically viable, socially acceptable, and technically and institutionally appropriate; it should also protect the environment and the natural resources' (SuSanA, 2013). Equity is an 'ethical concept' relating to notions of 'social justice, fairness, and human rights' based on need as a foundation for the allocation of resources (Scott et al., 2012). It relates most strongly to economic and social aspects of sustainability with an emphasis on universal access in the context of water and sanitation services.

Although over 1.8 billion people gained access to improved sanitation facilities between 1990 and 2010, approximately 2.4 billion people, or ~32% of the global population, still lack access to improved sanitation (WHO & UNICEF, 2015) due to rapid population growth (WHO & UNICEF, 2012). Given the rapid increase in the urban population, the number of urban dwellers without access to improved sanitation increased by 139 million from 1990 to 2012 (WHO & UNICEF, 2014). While the majority of people lacking access to sanitation still reside in rural areas, the high population density of cities magnifies the negative impacts of inadequate services. According to United Nations (UN) estimates, the numbers and sizes of cities are increasing at a much higher rate in developing countries than in developed countries with 91% of the estimated urban population increase taking place in developing countries (UN-HABITAT, 2012). Urban slums (including informal settlements) are prevalent in Sub-Saharan Africa, with 62% of the urban population living in slums that often lack access to basic services such as water and sanitation (UN-HABITAT, 2012). According to the 2015 Joint Monitoring Programme (JMP) report, Sub-Saharan Africa has experienced a population growth of 169% since the monitoring programme started in 1990. Population growth, particularly in urban areas, has outpaced the rate of water and sanitation delivery in the region, leading to a decline in the percentage of the population with sanitation access in several African cities (WHO & UNICEF, 2015).

Sanitation access is higher in South Africa than most other Sub-Saharan African countries (~79.5%[1]) (Stats SA, 2014a), but overall coverage statistics mask inter- and intra-

[1] N.B. There is a discrepancy between the South African government's national basic sanitation coverage statistics and improved sanitation statistics stated in the JMP[1] report, which are stated as 66% (WHO & UNICEF, 2015). This is likely due to the inclusion of shared services in the South African government's count; whereas the JMP differentiates between improved and shared services.

urban access inequalities. South Africa still faces many of the same developmental challenges as many other African countries in areas such as water scarcity, rapid urbanisation and a demand for services that outpaces the rate at which they are delivered[2]. Given that universal sanitation access in South Africa has been made a national development priority (National Planning Commission, 2012), there is a unique opportunity for setting regional precedents due to South Africa's influential position as one of the wealthiest countries in Africa (Briceño-garmendia et al., 2008; World Bank, 2010b). But, achieving universal access is also a major challenge as South Africa is one of the world's most unequal countries in terms of income distribution and access to services (Van der Berg, 2010; UN-HABITAT, 2012). South Africa's apartheid history of racially segregated cities has particular ramifications for equity in infrastructure development (Huchzermeyer, 2009). In South Africa, a Level of Service (LoS) framework describes an incremental approach to service delivery where each level is characterised by the benefits that a user can receive. Each level is associated with a different type of sanitation system provided to households on an individual or shared basis with the highest LoS typically an individual household flush toilet connected to the municipal sewer system. The use of a LoS framework to provide different services to different areas of the city is pragmatic, but it may reinforce inequities in infrastructure and service provision if promoting equity is not an explicit objective of service delivery programmes. Furthermore, there is a public perception that 'alternative' sanitation systems (to conventional waterborne systems) are inferior (Robins, 2014) given that they are associated primarily with low-income housing developments and informal settlements. Thus, addressing equity concerns related to perceptions, access and resource allocation needs to be a significant part of the planning and provision of sanitation services for low-income urban areas, especially in informal settlements that lack access to basic services.

There are also concerns to address in relation to the general sustainability of sanitation services. Although there are increasing numbers of households gaining access in South Africa, up to 26% of household sanitation services in formal areas 'are at risk of service failure and/or are experiencing service delivery breakdowns' (DWA, 2012b). The risk of failure of existing services is compounded by the need to extend services to the 22% of households who have never had access to basic sanitation[3], a large proportion of whom live in informal settlements[4] or backyard dwellings (Stats SA, 2014a); where basic sanitation is defined as:

> the infrastructure necessary to provide a sanitation facility 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

[2] Service delivery refers to the provision of a service including the support system, facilities, infrastructure and performance of required operations and maintenance activities. In South Africa, service delivery often relates to the provision of services to meet basic needs, e.g. water supply, sanitation, electricity and housing.

[3] See Glossary of Terms for definition. Note that the definition for basic sanitation differs slightly from that of improved sanitation, which is the term used by the JMP run by the WHO and UNICEF.

[4] See Glossary of Terms for definition. Many informal settlements are located in areas designated for non-residential usage, which relates to the legal/technical challenges associated with providing sanitation services in these areas.

> carrying flies and pests, [which is easily accessible to a household and sustainably operated], and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner[5] (DWAF, 2003).

The figures for service areas at risk of failure or already experiencing breakdown are in line with international accounts of high rates of 'slippage', i.e. unsustainable service delivery resulting in deteriorating levels of service or fluctuating coverage of water, sanitation and hygiene (WASH) services (Reddy et al., 2010; Improve International, 2015). Therefore, one can conclude that attaining universal sanitation coverage will remain an elusive goal if services cannot be sustained or extended at a rate that keeps pace with urbanisation.

1.2 Need for research, development of research aims and contributions to knowledge

There is a great need for sanitation in the informal settlements of South Africa that constitute the majority of the household sanitation backlog[6]. There is however a high risk of trying to meet the backlog with unsustainable and inequitable sanitation services given the slippage rates and existing infrastructural inequity mentioned previously. Sustainability and equity in sanitation services are generally stated as desirable outcomes to support improvements in health and environmental conditions (RSA, 1996b; EAWAG & SANDEC, 2000; UNDP, 2015). There is, however, still ambiguity around what these concepts should entail and how to apply them given their multidimensional and complex nature. While a number of assessment frameworks have been developed to evaluate the sustainability of sanitation systems (Olschewski, 2013), especially for wastewater treatment (Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004), and sanitation projects (McConville & Mihelcic, 2007), equity principles are not explicitly incorporated although they may be implied within socio-cultural or institutional dimensions. While equity can be viewed as a part of the social and economic dimensions of sustainability and an important principle of sustainable development (Kates et al., 2005; Dempsey et al., 2011), it is not well-defined and requires greater emphasis in relation to sustainability (Oden, 2010; Campbell, 2013) and how these principles can be operationalised to improve sanitation services to informal settlements. Furthermore, internal conflicts within dimensions of sustainability (Campbell, 1996) in relation to equitable sanitation services need further exploration to identify potential conflicts and trade-offs. The aims of this thesis were thus to:

i) explore how the principles of sustainability and equity can be applied to assess and inform improvements to municipal sanitation services in South African informal settlements, and

ii) examine dimensions of sustainability and equity in relation to sanitation service delivery and potential sources of conflicts or trade-offs.

[5] Combining the definition of a 'basic sanitation facility' and 'basic sanitation service'.

[6] The sanitation backlog consists of households who do not have access to at least a basic LoS in the municipalities that will be examined in this thesis.

During the initial phases of research, the primary research objective was to develop a strategy for shifting from a 'basic level' of sanitation service (containing and disposing of human waste) in South African informal settlements to a system of resource recovery. After further literature review and data collection began, however, it became clear that in the South African context the challenge of providing universal access to sanitation at even the most rudimentary or 'basic level' of service still needs to be overcome. Under these circumstances, focusing on promoting resource recovery as a 'higher' level of service seemed inappropriate. Furthermore, while resource recovery is a desirable outcome, it is not the primary objective or problem with urban sanitation services in informal settlements. A more fundamental challenge highlighted in the Sustainable Development Goals (UNDP, 2015), is to ensure that *everyone* has safe and reliable access to some form of sanitation facility that continues to operate as intended. The primary research objective thus shifted towards how to emphasise the need for sustainability with equity highlighted as a critical contributor to the sustainability of sanitation services for South African urban and peri-urban informal settlements. This was achieved through a critique of the different approaches to sanitation service delivery in informal settlements in the three largest (by population size) metropolitan municipalities in South Africa (Johannesburg, Cape Town and eThekwini) using the lens of sustainability with special attention given to equity.

The three municipalities selected are the three largest by population in South Africa. Each has distinctive environmental, institutional and social characteristics, but they are all facing similar challenges with regards to the need to provide sanitation services rapidly and on a large scale in informal settlements. The critique was based on a comparative case study analysis of a subsidised LoS approach, which is closely associated to an incremental approach to service delivery where each level is characterised by the benefits that a user can receive[7]. Sanitation service delivery programmes to informal settlements in the context of these three highly fragmented, unequal and heterogeneous municipalities were examined. The case studies were used to:

i) investigate the rationale behind the different levels of service provided,

ii) assess dimensions of sustainability and equity of existing projects and programmes in selected embedded case studies,

iii) identify factors in each municipality's approach that contribute to or detract from sustainability and equity, and

iv) provide perspectives from multiple stakeholders that inform how they view dimensions of sustainability and equity as they apply to sanitation services.

As mentioned previously, each of the case study municipalities need to address large sanitation service delivery backlogs, but face unique contextual challenges. National and provincial government play significant roles in terms of setting standards and regulations, providing policy guidelines, monitoring progress, and allocating resources for the provision

[7] See Glossary of Terms for more detail.

of sanitation services. However, municipalities are seen as the implementers of actual service delivery (DPLG, 2008). Given different contextual challenges and institutional arrangements, each municipality has developed its own localised approaches and municipal policies for providing services to residents of informal settlements and other un-served populations such as 'backyarders[8]'.

Primary data for the case studies was collected through interviews with key stakeholders in municipal, provincial and national government departments, non-governmental stakeholders in NGOs and private companies and group discussions with residents of informal settlements. Field visits were also made to selected informal settlements in each municipality. It should be noted that although the study compared municipal approaches, the purpose was neither to rank their performance nor to give an extensive history on the development of each municipality and the growth of informal settlements. Rather, the overall intention of the critique was to provide an assessment of practices to infer elements of sustainability and equity that still need to be incorporated into informal settlement sanitation service delivery in each municipality. The case studies should be viewed as exploratory studies to identify practices that may support or hinder sustainability and equity, and to prompt recommendations for ways to improve household service delivery programmes in accordance with principles of sustainability and equity.

The author makes an original contribution to knowledge by:

i) identifying three dimensions of equity to consider in relation to sanitation service delivery in informal settlements, and

ii) adding insight into the need to emphasise equity as a core tenet of sustainability using multiple stakeholders' perspectives in a context of extreme socio-economic inequality and differentiated levels of service.

There are limitations to the research in relation to the generalisations that can be drawn from only three case studies and context specific issues. However, the insights arising from the research expand the global discourse on sustainability and equity as applied to sanitation. They also add perspective to the tension between some of the environmental and economic objectives of sustainability and social equity that are exacerbated in a context of urban inequality.

1.3 Thesis outline

The thesis comprises six chapters, 23 appendices and a list of references. Chapter 1 began with a background to the problem relating to insufficient sanitation services globally and nationally, and the need to incorporate sustainability with special attention given to equity as principles for service delivery. The particular challenge faced in urban areas is also

[8] See Glossary of Terms. Backyard dwellings are usually also categorised as informal, but since they are usually attached to formal titled households, they are handled differently than informal settlements.

highlighted, followed by an explanation of the need for this research and research aims. Chapter 2 begins with a review of general sustainability and equity principles followed by sanitation-related sustainability and equity literature organised by different dimensions in relation to sanitation service provision with an emphasis on the South African context. Dimensions of sustainability that are explored in Section 2.3 include: environmental, economic, technical, health and hygiene, socio-cultural and institutional sustainability. In Section 2.4 the importance of social equity in sanitation service delivery, its relation to sustainable development and the need to consider equity at different scales and in relation to three dimensions of equity: resource allocation, access and perceptions are described.

A description of the research process including: the literature review, how data was collected, the methods used for analysing the data and an overview of the method used for assessing sustainability and equity in the case studies is given in Chapter 3. Chapter 4 consists of the three municipal case studies of sanitation services. Each municipal case study includes an assessment of the sustainability and equity of a specific programme or project pertaining to sanitation services in informal settlements in each municipality. In eThekwini (Section 4.1) the Urine Diversion Dry Toilet (UDDT) and Communal Ablution Block (CAB) programmes are examined. In Section 4.2, a pilot project in Johannesburg using a CAB that uses recycled wastewater for flushing is presented, and in Section 4.3, the use of an upgrading method in Cape Town known as reblocking is investigated. Chapter 5 includes: a critique of the levels of service approach, a comparison of sustainability and equity issues relating to sanitation services in each case study municipality, service delivery gaps and trade-offs between aspects of sustainability and equity. Finally, the contribution to knowledge, conclusions and recommendations for improvements to sanitation services and areas for further research are presented in Chapter 6.

The appendices contain documents that support the research including inter alia case study related data such as organisational diagrams, an example of field notes and an interview transcript, municipally defined levels of service and water and sanitation tariffs.

2 Literature review

This chapter begins with a brief discussion on general principles of sustainability and equity and potential conflicts between these principles in relation to Campbell's 'planner's triangle' model. The emphasis of the chapter, however, will be on sustainability and equity as applied specifically to sanitation services with a discussion on which dimensions of sustainability and equity are considered as most relevant to evaluate sanitation services followed by a more detailed discussion of each dimension discussed. The chapter then concludes with a critical discussion of various sustainability and equity assessment tools for sanitation systems, a summary of the justification for the chosen dimensions of sustainability and equity, their meaning in this thesis and their relevance in the South African context.

2.1 Discussion on general sustainability and equity principles

There is no uniform definition for sustainability, although it is mentioned frequently in academic literature, policies and even popular culture. In its most basic 'conservative' definition, sustainability is usually considered the capacity of a system to endure over time (Kappauf, 2011:9). A commonly cited definition relating sustainability to development from *Our Common Future*, also referred to as the 'Brundtland Report', is sustainable development as a 'paradigm [that] seeks to satisfy the survival and prosperity needs of present and future human populations' (WCED, 1987), with special attention to the needs of the world's poorest within the limitations of the environment's ability to meet present and future needs for everyone (WCED, 1987; Carden, 2013). A more recent vision put forward by the European Union is the theme of "Living well, within the limits of our planet" (EU, 2013) which places greater emphasis on living using ecological limits or environmental boundaries as guidelines for resource use, consumption and production (Hoff, Nykvist & Carson, 2014). Sustainability as part of a development agenda can, however, be viewed as a 'normative construct' that has become 'value-laden and political' (Movik & Mehta, 2010:4). For example, while the Brundtland Commission's view that economic growth is essential to social development has gained widespread political support (Haughton, 1999) it has also been criticised for supporting a form of market-driven economic growth that leads to environmental degradation (Lélé, 1991; O'Connor, 1993). These conflicting views highlight the way that sustainability in relation to development is understood differently depending on the context and the particular goals that are prioritised (Scoones et al. 2007), e.g. some individuals may prescribe greater value to economic sustainability than environmental sustainability or vice versa.

Sustainability should therefore be understood as dynamic, politicised and a subject for debate with multiple and 'diverse pathways to different futures' (Scoones et al., 2007:34). Thompson (2010) describes the debate between advocates of 'strong sustainability, who insist that natural capital must not decline over time', and advocates of 'weak sustainability' who want to ensure that 'human well-being does not decline over time'. It can be argued that some dimensions should be considered as more important than others, e.g. the 'green' (using less)

versus 'brown' (providing more) agenda[9], but a more productive approach is to try and integrate the two agenda and to consider where there may be synergies and trade-offs (McGranahan *et al*., 2001; Allen *et al*., 2002). As Haughton (1999) points out, one of the characteristics that distinguishes sustainable development from general environmental planning concerns relates to equity principles which include[10]: intergenerational equity ('principle of futurity'), intragenerational equity (contemporary social justice), geographical equity (connecting local and global concerns) and procedural equity (regulatory and participatory systems that are open and fair). Haughton (1999) argues that sustainable development will be undermined if equity principles are not addressed 'singly and collectively'. Given the complex and mutable nature of sustainability, however, there are potential conflicts between different goals of sustainable development and principles of equity that need to be considered.

Campbell (1996) developed the 'planner's triangle' model (Figure 2.1) to describe sustainable development supported by three pillars: economy, environment and equity. He notes, however, that there are conflicts between the three priorities of economic development, equity and environmental protection that planners face, primarily relating to conflicts between economic growth and social equity, or property conflict; between economic development and environmental protection, or resource conflict; and between environmental protection and social equity, or development conflict (Campbell, 1996).

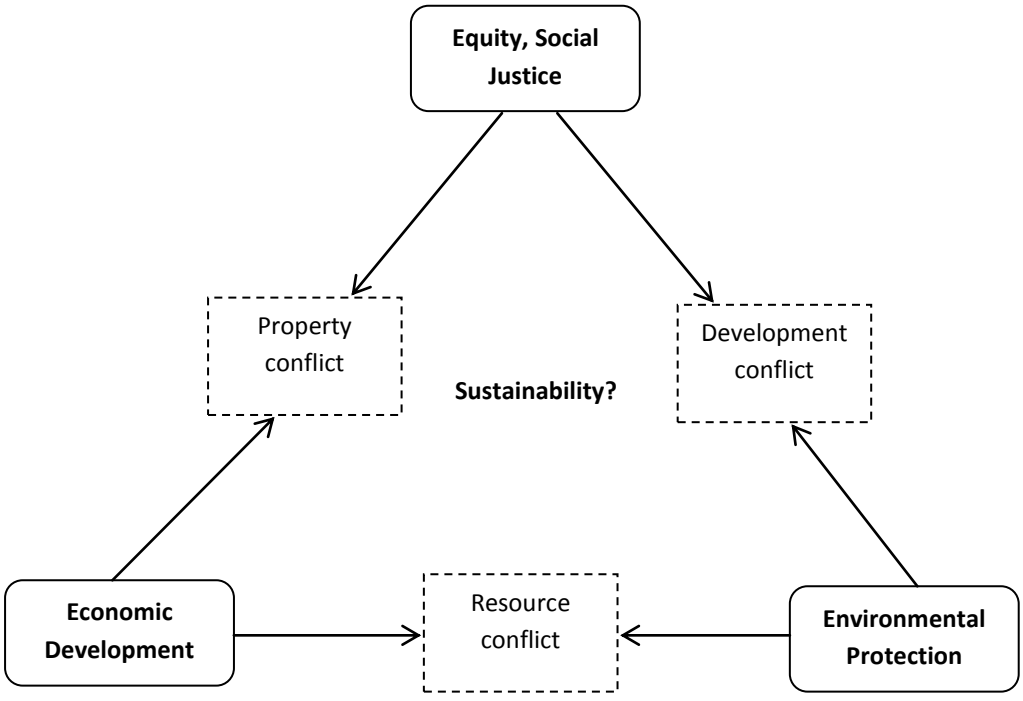

Figure 2.1: Planner's triangle for sustainable development (Campbell, 1996)

[9] See the Glossary of terms for more detailed definitions of the brown and green agenda.
[10] Inter-species equity is briefly discussed by Haughton, but as it has less relevance to the sanitation specific equity discussion than the other principles it will not be discussed in this thesis.

In relation to sanitation service provision, all three conflicts can arise, but the focus of the discussion in Section 2.2 will be on equity concerns in relation to sanitation provision. In particular, as Campbell (2013) succinctly frames the question, '*what* is to be sustained, and for *whom*?' can be used as an underlying question when making sanitation service development decisions, and the focus of this research.

2.2 Introduction and background to discussion on sustainability and equity in sanitation

Prior to moving into the discussion on specific dimensions of sustainability and equity in relation to sanitation, it is useful to clarify what sanitation is and some of the principles underpinning sustainable sanitation. Sanitation refers to the systems and services designed to manage human excreta and domestic wastewater safely through the sanitation service chain depicted in Figure 2.2, and to facilitate hygienic behaviours such as hand washing. (N.B. For the remainder of the thesis, sanitation services will be used in reference to all of its relevant components.)

Figure 2.2: Generic sanitation service chain (Gates Foundation, 2010; Tilley et al., 2014; WSP, 2014)

Some of the key principles that have influenced the movement towards universal sanitation access that is sustainable and equitable include the Bellagio Principles, the eThekwini Declaration and the SDGs (the successor of the MDGs). The Bellagio Principles promoted the linkage between sustainability (primarily environmental sustainability) and social equity. The four principles were developed as part of a workshop involving multiple international organisations and experts to promote a new approach to household-centred environmental sanitation[11], which usually includes: hygienic management of human and animal excreta, refuse, wastewater, stormwater, the control of disease vectors, and the provision of washing facilities for personal and domestic hygiene. One of the key components is to consider waste as a resource that should be managed as close as possible to the source (EAWAG & SANDEC, 2000).

The four principles are:

i) Human dignity, quality of life and environmental security at household level should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local and national setting.

[11] See the Glossary of Terms for more details.

ii) In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services.

iii) Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flows and waste management processes.

iv) The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, community, town, district, catchment, city) and wastes diluted as little as possible. (EAWAG & SANDEC, 2000)

Although not explicitly discussing sustainability and equity, principles such as a focus on human dignity, the promotion of holistic waste management and responsiveness to needs at both a local and national setting speak to environmental sustainability and geographical equity concerns mentioned in Section 2.1.

The eThekwini Declaration was endorsed by international organisations like the African Ministers' Council on Water (AMCOW[12]) to improve monitoring on progress and commitment by African governments to fund sanitation service delivery. Eleven commitments were made with Commitments 7 and 9 making specific reference to sustainability and equity principles such as 'caring for the environment' and recognising gender and youth aspects of sanitation (AMCOW, 2008).

Of the three documents mentioned, the SDGs are the most overarching and make the most explicit link between equity and the sustainable development agenda. This is emphasised in the international post-2015 SDG Goal 6 to 'Ensure availability and sustainable management of water and sanitation for all' (Osborn, Cutter & Ullah, 2015). The sub-point Goal 6.2 makes an even more explicit reference to equity with the aim to 'achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations' by 2030 (Osborn, Cutter & Ullah, 2015).

The Bellagio Principles, eThekwini Declaration and SDGs reflect several aspects of sustainability and equity and provide a background for defining sustainability and equity using a multi-dimensional approach which will be discussed in the subsequent sections of this chapter. Although equity is discussed separately from 'general' sustainability to highlight the particular need to incorporate equity principles into sanitation service delivery, equity should be considered as one of the 'pillars' of social and economic sustainability. While it is encouraging that there is an explicit acknowledgment of the need to promote equity in sanitation, specific criteria for assessing equity are less well-established than those for general sustainability. Furthermore, as noted in Section 2.1, sustainability and equity represent conceptual ideals. Therefore, different stakeholders often prioritise different objectives resulting in tension between certain aspects of sustainability and equity, which will be discussed in this chapter and Chapter 5.

[12] AMCOW is supported by the World Bank Water and Sanitation Program for Africa.

How do conflicts over different goals in sustainable development relate specifically to sustainability and equity in sanitation services for South African informal settlements? One example is the underlying issue of land ownership and tenure that has a significant effect on public investment in sanitation services. Where informal settlements are located, who owns the land and how it should be used has a major impact on the type of service that is provided by the government as will be discussed in the case studies (Chapter 4). How to provide services to informal settlements on privately owned land using public funds has been presented as a financial and legal challenge for many South African municipalities. Should the land be purchased by municipalities for housing development? Even if there are sufficient funds available or land can be purchased, there is a concern from municipal officials that providing services to informal settlements will encourage more illegal occupation of properties (Taing et al., 2013) and be considered an 'unofficial granting of tenure rights' (Graham, 2005:63). Although the 2016 draft update to the national sanitation policy takes the stance that municipalities need to provide services on private land (DWS, 2016), municipal level policies still need to be developed in detail.

In addition to property conflicts, there are development conflicts to consider such as whether or not to use dry or wet sanitation systems (which can also be viewed as a resource conflict) or decentralised versus centralised systems to promote economic development and protect the environment and human health. Although a wide variety of sanitation systems are used in South Africa, the majority of formal households have individual household wet sanitation systems connected to centralised sewerage and treatment systems, which are considered to be the highest level of service. The majority of informal households use communal sewered or shared on-site sanitation, which are considered as emergency, basic or interim levels of service depending on the sanitation type and local authority definition. These interim levels of service may be considered as 'backward' (Matsebe & Osman, 2012) and lacking privacy in comparison to the private household sewered connections in formal areas. Guidance in the Strategic Framework for Water Services (DWAF, 2003) suggests that informal settlements be provided with an interim basic level of water and sanitation services that are 'appropriate, affordable and practical'; however, further guidance on how to meet those criteria is not given. 'Interim services' inherently imply that they are not long-term and potentially could reinforce inequalities for already socio-economically disadvantaged residents of informal settlements. Thus, deeper issues around what interim sanitation services should be, what should come afterwards and who should be making these decisions to promote sustainability and equity remain unaddressed.

Conflicts highlighted in the planner's triangle over property, resources and development can easily arise over sanitation service delivery in informal settlements given their precarious position. Therefore, therefore there is a need for multi-dimensional sustainability and equity criteria to assess sanitation service planning decisions. In this section, dimensions of sustainability and equity that relate to sanitation systems will be discussed in relation to Campbell's underlying question linking sustainability and equity concerns. Each dimension will be presented separately with six dimensions of sustainability and three dimensions of equity described. Sustainability as a concept applied to systems typically includes the integration and overlap of the environmental, social, health and

hygiene[13], technical, economic, and institutional (including political), dimensions (SACN, 2011; Carden, 2013). Principles of equity (Haughton, 1999) were introduced in Section 2.1 and will be related to resource allocation, access and perception as dimensions of equity.

2.3 Sustainability in sanitation

As mentioned in the introduction, sustainable sanitation as defined by the Sustainable Sanitation Alliance (SuSanA) is a sanitation system that is 'economically viable, socially acceptable, and technically and institutionally appropriate; it should also protect the environment and the natural resources' (SuSanA, 2013). Linked to the concept of sustainability is the concept of resilience as an important characteristic of dynamic systems, which implies a system's 'ability to tolerate disturbances while retaining its structure and function' (Fiksel, 2003). Thus a sustainable and resilient sanitation system should be able to operate over a long period of time despite varying conditions.

According to Mara et al. (2007), there are four criteria which qualify a sanitation system as sustainable which reflect elements of the Bellagio Principles (EAWAG & SANDEC, 2000) and the SuSanA definition, but apply more specifically to the selection of a sanitation system. They are (paraphrased from Mara et al., 2007):

i) *Human health*: Sanitation arrangements should improve human health and not create conditions harmful to it.

ii) *Affordability*: Sanitation must be affordable for households using them with particular consideration for the affordability of sanitation arrangements for poor and very poor households.

iii) *Environmental sustainability*: Sanitation should not result in any adverse environmental impact. Water, nutrients and organic solids in excreta and domestic wastewater and organic wastes should be treated to an appropriate level, then safely used in aquaculture and/or agriculture or fit for purpose function depending on the treatment standards. Where possible, biogas should be produced by anaerobic digestion of organic solids and collected for beneficial use.

iv) *Institutional appropriateness*: Sanitation arrangements should be managed at the lowest appropriate level, recognising the household as a major actor in sustaining human health and the environment. Beneficiary communities must be partners in the planning, implementation and, where appropriate, O&M of sanitation systems or upgrades to the system, especially when they are charged for using the services. Different roles and needs of men and women in a process must be recognised and facilitated.

Combining the principles mentioned previously, and after a review of several sustainable sanitation assessment criteria developed by multiple authors (Hellström et al., 2000; Balkema et al., 2002; Kvarnström et al., 2004; McConville & Mihelcic, 2007), six

[13] Health and hygiene often would fall under the social dimension for more general sustainability criteria, but given their central importance to sanitation services they are considered separately in this thesis.

dimensions for evaluating sustainable sanitation were identified: environmental, economic, technical, institutional (which includes political considerations), socio-cultural and health and hygiene. Although health and hygiene could be considered under the umbrella of the socio-cultural dimension, given their central importance to sanitation, it made more sense to highlight them as a separate but related category.

To identify the most suitable criteria for measuring the sustainability of sanitation systems requires 'agreement on a shared vision of sustainability' (Carden, 2013); however, the vision may change over time, and furthermore, may go beyond the scope of a single sanitation project. Therefore, developing and measuring specific sustainability criteria should be utilised as a means to an end, which is to ensure that general principles of sustainability can be used as a framework for establishing different levels of responsibility and goals to improve the quality and functioning of sanitation services in relation to: households, wards (or neighbourhood), the city (municipality) and beyond (EAWAG & SANDEC, 2000). Some general sustainability principles such as the Bellagio Principles and those promoted by Mara et al. (2007) were mentioned previously. The following sections will discuss in greater depth the various dimensions that sustainability criteria can be categorised under: environmental, economic, technical, institutional, socio-cultural and health and hygiene.

2.3.1 Environmental sustainability

One of the most easily recognised dimensions of sustainability is environmental sustainability. Environmental sustainability in this thesis relates to the desire to mitigate negative effects on the natural environment related to a lack of or inadequate sanitation, and how the sanitation service chain can fit into ecological cycles. A key environmental sustainability objective is to reduce the amount of resources required (land, water, energy, construction materials) to provide sanitation. A second objective is to minimise negative impacts on water quality. Some typical water quality measures include: faecal coliform counts; biochemical oxygen demand (BOD); chemical oxygen demand (COD); nitrogen in the form of nitrates; and phosphorus in the form of phosphates, which together contribute to eutrophication of surface water. Contaminants such as heavy metals like lead, mercury and arsenic and pharmaceutical products should also be monitored if there is a potential risk of contamination to water resources given their potential toxicity and negative impacts on ecosystems and human health in high enough concentrations and over prolonged periods of exposure (Järup, 2003; Odendaal et al., 2015). Another aspect of environmental sustainability to consider is the potential for resource recovery of water, energy and nutrients. Some potential indicators for various environmental sustainability criteria are shown in Table 2.1. A few will be highlighted for further discussion of how the indicators could be used and potential trade-offs with other sustainability or equity criteria.

Table 2.1: Environmental sustainability assessment criteria from collection to treatment and reuse and/or disposal (after Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004)

Criteria	Indicator
Environmental	
1. Land use	m²/person
2. Energy	MJ/person
3. Construction material	Type and volume
4. Chemicals	Type and volume
5. Fresh water used (O&M)	kℓ/person/year
6. BOD/COD discharged	g/person/year
7. Impact on eutrophication	g/person/year of N and P
8. Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	mg/person/year
9. Contribution to global warming	kg of CO_2 equivalent/year
10. Odour	Qualitative
11. Nutrients recovered	% of incoming
12. Organic material recovered	% of incoming
13. Energy recovered	% of system consumption
14. Water recovered	% of system consumption

Land use relates to the amount of land required for the entire system which could be measured in square meters per person served. Communal systems would score better than private systems in this criterion, but would rank lower when assessed against socio-cultural, health and hygiene and equity criteria. The energy used for sanitation services relates primarily to the transport and treatment stages of the sanitation service chain. Ideally, energy usage could be minimised, which is one of the trade-offs to consider between different types of sanitation systems. For example, an on-site dry sanitation system would use less energy than an off-site wet sanitation system; however, it could increase the risk of groundwater contamination and release more odours than a waterborne system. In practice, some of the proposed indicators may be impractical or difficult to assess for sanitation projects in informal areas, e.g. the contribution to global warming or eutrophication, but they at least allude to some of the environmental impacts of sanitation services and would require decision-makers to link a local sanitation project to a global context, which is one of the equity principles promoted by Haughton (1999).

2.3.1.1 Ecological sanitation

Although ecological sanitation is not explicitly a criterion for environmental sustainability, it strongly promotes the objectives to reduce the amount of resources required to provide sanitation and the potential for resource recovery (Criteria 11-14 in Table 2.1). Thus, it will

be discussed as one potential pathway to promote environmentally sustainable sanitation in addition to some of the examples of ecological sanitation identified in South Africa.

Ecosan (ecological sanitation) is one model for resource recovery with an underlying philosophy of recycling nutrients: nitrogen (N), phosphorus (P), and potassium (K), which are essential nutrients for agriculture, and are found in urine and faeces (Winblad et al., 2004; Langergraber & Muellegger, 2005). Separation of wastewater and excreta streams at source is encouraged to facilitate nutrient and water reuse (Meinzinger et al., 2009). Because each stream varies in volume, nutrient and pathogen loading (Mara et. al, 2007), if urine can be separated from faeces for example it is advantageous for reuse since faeces contains the majority of pathogens (Meinzinger et al., 2009). An additional advantage of separating urine from faeces is that odour is reduced (Drangert, 1998; Meinzinger et al., 2009). An Ecosan model for domestic sanitation is shown in Figure 2.3.

Mara et al. (2007), however, argue that 'ecological sanitation' can also apply to other sanitation system models that mix waste streams, *e.g.* a conventional or low-cost sewerage where all streams (yellow, brown and grey water) are conveyed together to a wastewater treatment plant to produce biogas and a microbiologically safe effluent which can be reused for aquaculture and/or agriculture. The main qualification to be 'ecological sanitation', according to the broader definition proposed by Mara (2007), is a sanitation system that supports reuse of different waste streams whether in a decentralised, centralised system or intermittently emptied system (pit latrines, septic tanks, pour flush and conservancy tank). The relationship of ecological cycles to sanitation as an aspect of environmental sustainability is likely to be violated or ignored if there is 'a lack of interest in or strong socio-cultural objections to reusing human wastes' (Mara et al., 2007:311). Therefore, it is important to assess reuse demand from 'front-end' and 'back-end'[14] users (Murray & Ray, 2010), to get political buy-in (Matsebe & Osman, 2012) and to consider the most effective way to market ecological sanitation to users (Holden et al., 2003).

Tilley et al. (2014) identify different 'products' that are generated directly by humans such as excreta (urine and faeces) or 'products' that are added to help with cleansing or composting. In waterborne systems flushwater and either anal cleansing water or dry cleansing material mix with excreta to become blackwater. Greywater is wastewater generated from everything other than toilets, although traces of excreta, and therefore pathogens may be found in it, e.g. from washing diapers. Faecal sludge comes from on-site sanitation systems, which differs from sewage sludge that originates from sewer-based wastewater collection and centralised treatment processes (Tilley et al., 2014).

[14] 'Front-end' users are those who are producing the waste and using sanitation systems, typically household members; whereas 'back-end' users are not involved with the sanitation system directly but are potential 'customers' for waste. They can include entrepreneurs who intend to sell reuse products, farmers who use wastewater for irrigation or sludge for fertilising, *etc.*

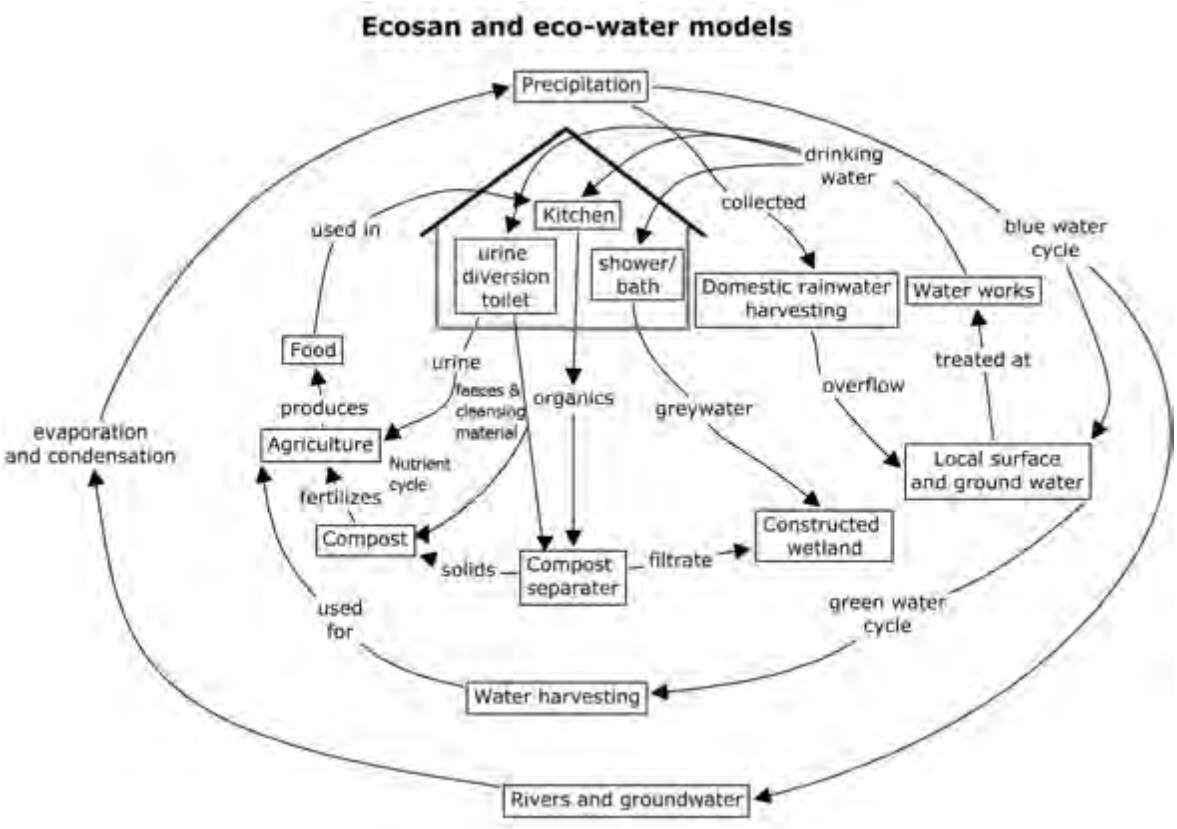

Figure 2.3: Ecosan and eco-water models for closing the nutrient and water cycles (after Rosemarin et al., 2008)

Different sanitation systems result in different products, which require different treatment and disposal methods, and potentially offer different reuse opportunities. One of the opportunities being pursued in eThekwini municipality is nutrient recovery from urine diversion dry toilets (UDDTs). A pilot research project was conducted to collect urine from 700 households to test in a laboratory scale struvite reactor to capture phosphorus from the urine. Soluble magnesium was added to the urine inside the reactor to form struvite ($MgNH4PO4{\cdot}6H2O$) as a precipitate, which can be used as a fertilizer (Rhoton et al., 2014). Further investigation was underway as of 2014 on how to optimise operating parameters for the reactor, as well as the logistics and economics of scaling up urine collection and struvite production from the ~75,000 rural and peri-urban households using UDDTs in eThekwini (Etter et al., 2014).

Another resource recovery pilot project in eThekwini is the conversion of faecal sludge from VIPs into pelletized fertilizer through the LaDePa (latrine dehydration and pasteurisation) system. The LaDePa machine is a containerised mobile faecal sludge treatment system, which separates detritus (non-biodegradable material) from the rest of the sludge that is then dried and pasteurised to remove pathogens. Greater detail on how the system works was described in Harrison & Wilson (2012). In addition to the technological innovation, a new contractual model had to be developed and is still undergoing approval within the municipality, which highlights some of the management challenges of converting

waste products into resources and transitioning from a pilot project to a large-scale programme. The main concept was to outsource the servicing of VIPs through a public-private-partnership, whereby the municipality leases the LaDePa units from a private company (Particle Separation Solutions) who owns and operates the system for the lease period, and who can outsource portions of the contract, such as the VIP sludge collection to sub-contractors who may be based in the communities whom they serve (Harrison & Wilson, 2012).

In Cape Town, a pilot project involving the use of black soldier fly larvae to digest faecal sludge from an informal settlement was attempted as a form of low-cost treatment and resource recovery system. A non-profit organisation, BioCycle, which is linked to the private company, Agriprotein, set up a pilot facility in a peri-urban settlement to test the feasibility of using black soldier fly larvae to essentially convert faecal sludge, which was combined with food scraps, into an insect protein which could be used as an animal feed (Kotze, 2013, pers. comm., 26 June). A business model was proposed to set up a small-scale decentralised treatment facility, which could treat ~250-500kg per day, serving a population of ~3500 people. Similar to the LaDePa contract model in eThekwini, small-scale entrepreneurs could be sub-contracted to collect and transport faecal sludge from households to the facility, and the municipality could pay the owners of the facility at a rate equivalent or higher to what it would cost to transport and treat the same volume of waste at a centralised wastewater treatment facility. In addition to treating the faecal sludge, the proposed business model included selling black soldier fly larvae as animal feed directly and/or using the larvae to feed egg laying chickens. Then the eggs could be sold to bring in additional profit for users who could set up a committee to manage the funds. Facility operators were hired by BioCycle from the local residents being served by the pilot facility and eggs were sold on a small scale (Kotze, 2013, pers. comm., 26 June), but ultimately, the pilot in Cape Town was unsuccessful[15] and funding for the project was cut in 2015. As of 2015, however, there were plans underway for Agriprotein to develop a larger scale black soldier fly facility in conjunction with eThekwini municipality to assist with processing faecal sludge from UDDTs which will be described further in Chapter 4.

Decentralised treatment and resource recovery systems for on-site sanitation facilities are considered mainly for rural areas and urban and peri-urban informal settlements in South Africa. There are, however, examples of centralised systems converting wastewater to energy, such as Johannesburg's Northern Wastewater Treatment Works, which was designed to convert biogas to thermal and electrical energy to cover ~12% of the works' energy requirements, with plans to increase biogas production if the pilot is successful (Deacon & Louw, 2013).

Notwithstanding the examples given, reuse for waste products is still only practiced for a fraction of the faecal sludge and wastewater generated in South Africa (Adewumi et al..

[15] The proposed business model to CCT was never adopted by the municipality. There were also issues with scaling up the operation and getting a consistent power supply to the facility to assist with treatment. Eventually, funding was cut by Agriprotein, which was funding the pilot project as part of its non-profit BioCycle initiative. Instead, they decided to shift focus to the eThekwini project.

2010). There is significant potential to increase the reuse of waste products, such as faecal sludge and wastewater for irrigation purposes given water scarcity problems in much of South Africa, but there are still many considerations that need to be evaluated prior to implementing reuse projects (Adewumi et al., 2010). eThekwini is researching faecal sludge reuse on a larger scale than any other South African municipality as of 2016, and lessons learned there can serve as a useful case study as more sludge reuse programmes are implemented. Environmental impacts were considered difficult to assess, but an estimate of the cost of rehabilitating land that was contaminated by inadequately treated sludge disposal was used as a proxy, implying that if sludge is safely reused these costs would not be incurred and there may be reduced contamination of land and groundwater resources (Van der Waal, 2008).

In summary, while there are many potential positive impacts of resource recovery from wastewater and faecal sludge, the main challenges would be to ensure that there are adequate resources and capacity available to manage treatment and recycling facilities, and to have adequate policies in place to ensure that benefits are distributed and reinvested where they are most needed such as to improve sanitation services in informal settlements. Furthermore, given that most of the resource recovery projects identified in South Africa have been in relation to low-cost on-site sanitation systems (with the exception of the wastewater to energy project), the equity of primarily promoting decentralised Ecosan models in low-income areas needs to be carefully reconsidered by municipalities. The broader definition supported by Mara (2007) is more inclusive and reflects the reality that the majority of households in metropolitan areas already have or aspire to sewered sanitation systems.

2.3.2 Economic sustainability

Economic sustainability relates to consideration for the financial and economic costs required to keep a sanitation system running at an acceptable standard, the potential benefits derived from economic investment in sanitation and demand for the service. The economic sustainability of a sanitation service needs to be assessed prior to selecting a particular type of system, and is often one of the most heavily weighted criteria for sustainability, e.g. the *Strategic Framework for Water Services* (DWAF, 2003) refers to sustainability mainly in the context of affordability. Access to water and sanitation has been recognised as a human right, but it is necessary to do so while still acknowledging the need to cover the costs of delivering the services. Table 2.2 includes potential economic sustainability assessment criteria drawn from literature.

Table 2.2: Economic sustainability assessment criteria (after Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004).

Criteria	Indicator
Economic	
1. Annual costs (use life cycle cost approach)	Cost/person/year
2. Capacity to pay - user (% of available income)	Disposable income/person
3. Local development potential	Qualitative
4. Time required by users to access or maintain facilities	Hours/person/year
5. Willingness to pay (% of available income)	Cost/person/year

The cost of a system (Criteria 1) is one of the most important economic sustainability criteria to consider, and as mentioned, is one of the most frequently cited criterion by government officials for deciding on which sanitation system to choose. There are various costs that need to be recovered such as:

- financial costs (O&M costs, capital costs, cost of servicing capital, support costs) – arising directly from the construction, maintenance and use of sanitation facilities;
- economic costs (environmental costs, opportunity costs, externalities dealing with public health and/or environmental impacts) – are more useful for priority setting although they are more difficult to measure and translate into monetary value than financial costs (adapted from Cardone & Fonseca, 2003 and World Bank, 2010).

One of the methods to promote costing for sustainable services being promoted by the International Water and Sanitation Centre (IRC) is the life-cycle costs approach (LCCA) to look at the costs of providing water, sanitation and hygiene services over the entire life-cycle of a service. Costs are estimated for all elements of service provision from initial construction, through repairs, replacements and expansion (IRC, 2012b). Costs are broadly categorised as recurrent and one-time expenditure. One-time expenditure includes capital expenditure on the initial costs to develop or extend a service for either 'hardware' such as pumps and pipes, or once-off 'software' like community training and consultation (IRC, 2012a). Recurrent expenditures include (IRC, 2012a):

- cost of capital, e.g. cost of interest payments on loans;
- operating, i.e. 'running costs', and minor maintenance expenditure;
- capital maintenance expenditure such as asset renewal and replacement cost;
- direct support costs[16] relating to expenditure on post-construction structured support to service providers or users related to O&M such as monitoring, technical, legal and/or administrative support; and

[16] N.B. This is usually included under operating expenditure in urban utilities departments.

- indirect support costs relating to creating and supporting an enabling environment for water, sanitation and hygiene (WASH) services, which includes macro-level planning, policy making and capacity support at national level or to decentralised service authorities or local government.

Financial costs represent the costs actually paid for the service by users, or the cost of providing the service paid by local or central government or the water service authority (WSA). Economic costs, however, need to consider broader impacts beyond a specific project or programme such as the opportunity costs for resources used. Shadow prices[17] for various sanitation options can be estimated using the discount rate and 'shadow factors' to convert market prices to shadow prices for labour, water, land, equipment and materials (Kalbermatten et al., 1982; Ridgley, 1989; Werner & Malz, 2008).

Although comparing economic costs gives a better estimation of the 'real' cost to a country's economy for a particular sanitation option as compared to only financial costs, economic evaluation can be a subjective process, particularly when trying to assign monetary values to environmental or health costs or benefits (Brikké & Rojas, 2003; Werner & Malz, 2008), and some benefits may be prioritised over others as mentioned previously, requiring some type of weighting system to assess.

The costs of conventional waterborne sanitation, which includes water provision, sewer maintenance, sewage treatment, user education, personnel, vehicle maintenance, revenue collection and extension of service coverage, are often not fully accounted for in many municipalities (Martin & Pansegrouw, 2009; Mjoli et al., 2009). Costs for alternative systems are even less well documented. Costs for sanitation systems are usually presented as unit costs based on the price paid to vendors for particular items, but as Fonseca et al. (2011) indicate prices are often confused with costs since the true cost to society of providing the service, or not providing the service (e.g. negative health consequences) is often not considered. Estimates ranging from GDP losses of 0.9% to 2.4% in 18 African countries assessed (WSP, 2012) (not including South Africa) have been made relating to the significant economic consequences of inadequate sanitation associated with: adverse health effects associated with poor water supply and sanitation, the direct costs of treating sanitation-related illnesses (diarrhoeal diseases are the most common), lost-income due to reduced or lost productivity of both those sick and those caretakers, mortality costs, and time spent to access facilities (Van Minh & Nguyen-Viet, 2011; SWA, 2012). A conservative estimate of the socio-economic cost in South Africa of diarrhoeal diseases alone was 1% of the GDP (Pegram et al., 1998). There are also other costs related to poor water quality impacting industrial and agricultural products, reduced income from tourism, and clean-up costs, which are hard to measure and not accounted for in the economic impact estimates (SWA, 2012).

[17] A shadow price represents the estimated value of a good or service for which there is no ready market from which to derive a price. Hutton *et al.* (2009)

Notwithstanding the importance of cost considerations, there are also other criteria that need to be considered. Access to basic services is legally supported as a human right and it is also considered a prerequisite for income generation, poverty alleviation and a willingness to pay (Cardone & Fonseca, 2003). An important caveat of delivering water and sanitation services to those unable or unwilling to meet the costs is the likelihood that systems will not be properly maintained and services will not be able to be extended to meet the demands of future generations (Cardone & Fonseca, 2003), which links to the intergenerational principle of equity.

There are, however, arguments that support the use of subsidies for sanitation and ways to design subsidies effectively to target those most in need (Cardone & Fonseca, 2003; Evans et al., 2009). As shown in Table 2.2, an alternative or complementary economic sustainability measure to 'willingness to pay' (Criterion 5) is the user's 'capacity to pay' (Criterion 2) as a percentage of available income. The 'capacity to pay' is a more relevant criterion in the South African context given the national Free Basic Sanitation policy which promotes subsidies to provide a basic level of sanitation for indigent households. South Africa's Free Basic Sanitation policy is designed to support subsidised sanitation services for indigent households and will be discussed further in Section 2.3.2.1.

The benefits of improving sanitation provide another side of the argument for investment in sanitation as opposed to the cost of unimproved sanitation. Some estimates on the economic benefits of improved sanitation have been conducted, most notably by the WHO, which estimated that globally the economic return on sanitation spending is USD5.5 per US dollar invested, and USD2.8 for Sub-Saharan Africa (Hutton, 2012). The WHO estimates may even underestimate the long-term economic benefits of improved access to sanitation, as Schmidt (2014:525) argues that '...the educational, developmental and gender-related benefits of water and sanitation access are large enough to merit investment' (in support of Criterion 3). In summary, while it is important to consider the costs of sanitation with regards to economic sustainability, it is also important to weigh them against the potential benefits. Considering the ethical argument for investment in sanitation over and above economic cost recovery is an area where there may be tension between equity objectives and economic sustainability, which is one of the development conflicts that is frequently referenced in relation to subsidised services (Muller, 2008).

Another element to consider in relation to the economic sustainability of sanitation services is a demand amongst users for sanitation services. As mentioned by Mjoli et al. (2009: 55), with respect to the Free Basic Sanitation policy in South Africa, an amendment is needed to recognise that sustainable service provision is 'not simply a question of adequate funds, but rather of adequate demand'. In the context of Free Basic Sanitation, where recipients do not pay for the service, assessing willingness to pay becomes a less useful measure of demand. Instead, according to the Free Basic Sanitation implementation policy, demand responsiveness should place greater emphasis on 'the views of communities as to what sanitation service they require' (DWAF, 2008:3), which relates to socio-cultural sustainability. There may however be a mismatch between community views on their sanitation requirements and available resources for providing services. For example, what

some community members may view as 'proper' or 'dignified' sanitation such as conventional flush toilets (Robins, 2014) may not be economically or technically feasible to provide to every household. The challenge of reconciling multiple demands within resource constraints and also incorporating sustainability and equity principles is discussed further in Sections 2.4 and 5.5.

2.3.2.1 Funds used for Free Basic Sanitation services

South Africa has implemented a policy known as Free Basic Sanitation (FBSan), which supports the provision of subsidised sanitation services to indigent households. There is a debate in the international water, sanitation and hygiene sector as to whether or not subsidies for the construction of sanitation facilities are effective or not (Evans et al., 2009); however, the South African government has taken the stance that subsidies for utilities such as water (Free Basic Water) and sanitation are justifiable and necessary to support social equity (Muller, 2008). More on the development of FBSan and related policies is discussed in Section 2.3.4.2. There are five main sources of public funding for FBSan services outlined in Table 2.3.

Table 2.3: Public funding sources for FBSan (Tissington, 2011)

Funding source	Description	Administrator
Equitable Share (ES)	An unconditional grant meant to be used by municipalities for O&M of water/sanitation services. The sanitation subsidy for operations is proportional to the number of indigent household in each municipality's jurisdiction.	Department of Cooperative Governance and Traditional Affairs
Municipal Infrastructure Grant (MIG)	A ring-fenced, conditional grant, intended for capital costs of infrastructure development.	Department of Cooperative Governance and Traditional Affairs
Urban Settlement Development Grant (USDG)	Intended to assist metropolitan municipalities to conduct planning in an integrated manner, especially with respect to bulk water and sanitation services in well-located areas.	Department of Human Settlements
Rural Household Infrastructure Grant (RHIG)	Targeted at reducing the backlog for water and sanitation services in rural areas.	Department of Human Settlements
Municipal revenue	Provided through cross-subsidisation usually. N.B. Cross-subsidisation is only possible in richer municipalities with a sufficient revenue base.	Each municipality

Different municipalities rely on different proportions of each funding source. The Division of Revenue Act, which is related to Section 214(1) of the Constitution pertaining to equitable division of revenue between the three spheres of government, determines the amount of the Equitable Share (ES) grant available to each municipality. The sanitation operation subsidy is supposed to be proportional to the number of indigent households in each municipality's jurisdiction (Tissington, 2011), and is reviewed annually along with other ES allocations. The National Treasury determines the amount of grant money that each province and municipality

should receive, and different national departments help administer the funds, except for municipal revenue which is directly managed by the municipalities.

The largest source of funding used for sanitation projects according to the July 2012 Ministerial Sanitation Task Team (MSTT) is the Municipal Infrastructure Grant (MIG), which is a conditional grant intended to support the capital costs of infrastructure development. The MSTT (2012) noted in their report, however, that since the MIG is intended mainly for infrastructure development and capital expenditure, funding for operations and maintenance faces a significant shortfall. Furthermore, the ES, which is intended to help fund O&M, is often misappropriated to fill other budgetary gaps (MSTT, 2012). (N.B. The second largest source of funding used for sanitation projects is the Urban Settlements Development Grant (USDG), which only applies to metropolitan municipalities.)

In all of the case study municipalities, all households regardless of income level benefit from the Free Basic Water (FBW) and FBSan policies. Tariffs are charged on a rising block scheme where the first 6kℓ of water are free[18]. As usage levels rise, the cost increases within each consumption block, *e.g.* 0-6 kℓ is free, 6-10.5kℓ costs 'x' amount per kℓ, etc. The sanitation tariff for sewered systems is implemented differently in each municipality, e.g. in Cape Town the quantity is deemed to be 70% of water used and a rising block tariff is applied; whereas Johannesburg and eThekwini correlate sewerage charges directly to water usage. The tariff structure is designed to help cross-subsidise the FBW and FBSan services, as there is a strong correlation between domestic water use and household income level, with high income households using more water than middle and low-income households (van Zyl et al., 2008:382). According to a study by Mjoli et al. (2009) that modelled operating expenditure and anticipated revenue, the largest metropolitan municipalities would continue to be able to generate enough funds to cover O&M costs for FBSan through a combination of their own revenue and grants over a 10 year period, unless the revenue base growth rate did not keep pace with the growth in the number of indigent households, or grants were significantly reduced. As noted by Tissington (2011), however, not all municipalities are able to generate enough revenue to cover operating costs due to high levels of poverty resulting in a smaller revenue base than their wealthier counterparts.

One of the concerns with the economic sustainability of FBSan is that eventually operating costs may exceed revenues, which is already occurring in some municipalities who rely more heavily on national grants than the larger wealthier metropolitan municipalities (Mjoli et al., 2009). Since sanitation tariffs are based on sewer systems and calculated based on a percentage of water consumption, dry on-site sanitation is not considered as a revenue generating service for municipalities since most of them are not charging collection and disposal fees. Therefore, municipalities with a large number of households using on-site sanitation systems would likely have to earmark a significant portion of the ES to the O&M of on-site dry sanitation systems serviced as part of FBSan to make up for any revenue shortfalls (Mjoli et al., 2009:23).

[18] The volume varies by municipality, with 6kℓ recommended as the minimum to provide for free, *e.g.* Johannesburg has proposed increasing FBW allocations based on indigent categories with up to 15kℓl free for those in the poorest category.

2.3.2.2 Alternative funding mechanisms and capturing value

South Africa's implementation of a free basic water and sanitation policy is an example of the implementation of the right to water and sanitation based on large-scale government subsidised services, stemming primarily from political drivers (Muller, 2008). There are, however, risks to the economic sustainability of FBSan which are dependent on a combination of public funding sources described in Table 2.3. Financial models suggest that wealthy municipalities such as the three metropolitan municipalities examined in this thesis can afford to provide FBSan services if they continue to have a strong revenue base and a sufficient portion of the national Equitable Share grant is allocated towards sanitation (Mjoli et al., 2009). Nevertheless, given the risk of continued sluggish national economic growth and the large number of households still lacking sanitation services, alternative funding mechanisms need to be explored.

As mentioned previously, there are significant benefits to improving sanitation services and increasing access, but there are also significant costs. The Department of Water Affairs in South Africa estimated that approximately R50 billion ($5.5 billion) would be required to provide services to the 1.2 million households without sanitation services for infrastructure expansion, upgrades, and operations and maintenance requirements (presumably rehabilitation costs) of existing services, with the majority of funds being required for operations and maintenance (DWA, 2012b). Given the high costs for not only extending, but also maintaining sanitation services, the report released by the DHS Ministerial Sanitation Task Team (MSTT) recommended better enforcement of a separate budget for O&M to essentially ring-fence the O&M budget (DHS, 2012). Additionally, in recognition of the financial challenges of maintaining sanitation services, the MSTT recommended charging a minimum service fee for basic sanitation, e.g. per private toilet, if the community being served is economically capable of paying (DHS, 2012:90). (N.B. It is unclear whether or not this recommendation applies to informal areas.)

A slightly different approach to the cross-subsidisation already occurring in water and sanitation services in South African cities, is to look at the benefits to non-users ('non poor' households) of providing water supply and sanitation services to under or un-served areas. A study of households in Kampala, Uganda and Cape Town, South Africa indicated that surveyed households were sensitive to public health impacts of inadequate water and sanitation services, and were willing to pay up to USD2.83 (Kampala) and USD11.21 (Cape Town) (for shared services) per household per month (in 2011 USD values) to improve services in informal settlements (Kobel & Del Mistro, 2012; Kobel & Del Mistro, 2013). In Uganda, survey respondents preferred for the funds to be managed through a special purpose vehicle rather than through taxes collected into the central government or instituting body's coffers (Kobel & Del Mistro, 2012), whereas in Cape Town, respondents' did not show as much distrust for government institutions (Kobel & Del Mistro, 2013).

Capturing value from waste is another potential funding mechanism for sanitation services to at least offset the O&M costs. Some methods for waste resource recovery mentioned in Section 2.3.1 include: biogas production, nutrient recovery through composting and fertilizer production and animal feed (e.g. conversion to protein using BSF). Anaerobic

digesters linked to public toilets have been used in several informal settlements in Kenya and India. Users paid to use the toilet facilities in three cases reviewed, but only paid for biogas use in two of the cases, and as remuneration for a caretaker in one of the cases. The biogas was used in several different ways, for heating water, cooking food, or in one case to assist with effluent disinfection from the anaerobic digesters (Abraham et al., 2013). While results were mixed, e.g. underutilization of biogas, safety concerns, and other challenges, there was evidence that biogas as an energy source could add value to sanitation services and potentially be used to offset O&M costs, as mentioned in Section 2.3.1.

Fertilizer production is another potential opportunity to derive value from sanitation services. Using human excreta for fertilizer is an old practice, but since the introduction of chemical fertilizers and urbanization, use of human excreta as a fertilizer has decreased; although this may change as global demand for fertilizer is expected to increase (Rosemarin et al., 2008). Adequate treatment before use as a fertilizer is important, and consideration for how to carry-out large scale production also needs further research. As mentioned in Section 2.3.1, eThekwini municipality is experimenting with the production of fertilizers in the form of pellets produced from VIP sludge and struvite from urine collected from UDDTs, although a cost benefit analysis still needed to be conducted (Grau et al., 2012). Wastewater for irrigation and use in aquaculture are also potential reuse opportunities, but as they tend not to apply as much with respect to urban informal settlement sanitation options in South Africa[19], they will not be discussed in detail.

2.3.3 Technical sustainability

Technical sustainability refers primarily to consideration of the physical conditions, facilities and infrastructure required to support ongoing sanitation services (Table 2.4). One of the major critiques of sanitation programmes in low and middle-income (developing) countries is the use of inappropriate technologies, which are too expensive (linking to economic sustainability) or when there is inadequate management capacity (Franceys et al., 1992; OECD, 2006; Lawless, 2007), which relates to Criteria 3-7 in Table 2.4. Instead, alternative design guidelines and an incremental or levels of service approach to sanitation improvement may be required (Allen & Hoffman, 2008; Kvarnström et al., 2011) to facilitate sanitation service provision in urban informal settlements given their frequently dense housing configuration, location on marginal land and low-income levels of residents. Design guidelines in South Africa were generally developed for the formal construction sector, and by definition, informal settlements do not adhere to formal design criteria; however, even low-cost sanitation systems need to adhere to certain minimum safety standards and design criteria[20].

[19] In most urban/peri-urban informal settlements in South Africa, agriculture is not practiced on a sufficient scale to warrant irrigation. Conditions are also not conducive to aquaculture given insufficient space and relative lack of experience with aquaculture compared to Asian countries.

[20] Although, dated, the *Red Book* (CSIR, 2000) is often used as a reference for human settlements design standards in South Africa, and it is set to be updated in 2017.

Table 2.4: Technical sustainability assessment criteria (after Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004).

Criteria	Indicator
Technical	
1. System robustness: risk of failure, effect of failure, structural stability, robustness against extreme conditions	Qualitative
2. Robustness of use: sensitivity to shock loads, abuse of system	Qualitative
3. Flexibility/adaptability (to different conditions/user groups)	Qualitative
4. Possibility to use local skills and materials for construction and O&M	Qualitative
5. Complexity of construction and O&M	Qualitative
6. Compatibility with existing systems	Qualitative
7. Ease of system monitoring	Qualitative
8. Durability/lifetime	Qualitative

An important technical criterion is the robustness of the sanitation system (Criterion 1 in Table 2.4). Toilets often become receptacles for solid waste in informal settlements, and toilet paper is often not used for anal cleansing. Instead, newspaper and telephone book paper are often used in poor communities in South Africa (Eslick & Harrison, 2004) given the relatively high cost of toilet paper as a proportion of household income, which needs to be taken into consideration during the planning and design stages of projects especially for the design of waterborne systems that are prone to pipe blockages if bulky anal cleansing material is used or general waste is flushed into the system. Either the system must be robust enough to handle bulky cleansing material or toilet paper should be provided to poor households.

Another key criterion which affects the technical sustainability of a sanitation service is the complexity of construction and subsequent O&M required (Criterion 5). While a more technologically sophisticated system may offer benefits such as social acceptability, energy production or reuse potential for nutrients and water (Section 2.3.1), these benefits should be weighed against the potential risk of failure introduced by more complicated systems. There are numerous examples of unsuccessful pilot projects in South Africa and other developing countries which introduced relatively sophisticated sanitation technologies to low-income urban areas without taking into account the capacity of the local management capacity to continue operating a system once the initial pilot phase was complete (Taing et al., 2011). Looking at the entire sanitation chain ‘the combination of technologies and management arrangements required to manage excreta safely from where it is produced to the point of disposal or reuse’ (Parkinson et al., 2014b) can uncover potential weaknesses in a particular technological approach, e.g. if parts need to be imported from another country potentially causing delays in repairs.

All of the criteria mentioned link to the notion of technical 'appropriateness', which is a relative concept that is dependent on the context in which it is applied. An operational definition adopted by Kalbermatten et al. (1982:5), which relates to the process of determining an appropriate technology on a case by case basis, is 'a method or technique that provides a socially and environmentally acceptable level of service or quality of product with full health benefits and at the least economic cost.'

2.3.4 Institutional sustainability

Institutional sustainability is linked to the policies, 'institutional culture' and management arrangements conducive to supporting sanitation service delivery. Behaviour and attitudinal change at an institutional level as well as amongst individuals may also be required to accommodate approaches that differ from conventional 'supply driven'[21] or 'top-down' approaches to sanitation service provision, which rely on generalised assumptions about beneficiaries and 'blue print' solutions. In contrast, participatory approaches to sanitation service planning rely on multiple stakeholders' participation at various stages of sanitation service provision to try and respond to project or site specific demands to increase sustainability potential, and to build capacity amongst different stakeholder groups and are often referred to as 'bottom up' or 'demand driven' in contrast to conventional approaches. A caveat of participatory approaches, however, is that participation can come in many forms and may be more appropriate for different stages of sanitation service delivery than others (Nance & Ortolano, 2007). Furthermore participation in itself is not necessarily a guarantee of institutional sustainability, but rather represents a way of managing institutional arrangements. Nevertheless, given the growth and promotion of participatory approaches to deliver water and sanitation services to the rural and urban poor over the last few decades, they will be discussed in further detail in Section 2.3.4.1.

In most cases, regardless of the participation level of users, government agencies will need to be involved at some stage to support institutional sustainability (Nance & Ortolano, 2007; Allen, Hoffman & Griffiths, 2008), particularly for urban sanitation systems. One of the challenges however relating to institutional arrangements for sanitation service delivery is the confusion around which government department should be responsible for it. As George (2008:73) points out, while sanitation is one of the best investments that a country can make, benefiting health, education and tourism (and other sectors), 'Excreta disposal is a political football, kicked between departments'. This observation of shifting responsibility for sanitation holds true in South Africa and will be touched on in Section 2.3.4.2.

Table 2.5 shows potential institutional assessment criteria which are qualitative in nature. As Criteria 1 and 3 indicate, a sustainable sanitation system should be able to meet existing legal and institutional requirements, and if not, modifications to either the system or the legal and institutional regulations will need to be made. Institutional arrangements for

[21] 'Supply driven' in the context of sanitation usually refers to a subsidised government-driven approach to sanitation service delivery focusing more on infrastructure than health and hygiene promotion and in contrast to a user-led demand for sanitation services incorporating participatory processes (Tissington, 2011).

who is responsible for managing sanitation services (Criterion 2), such as informal cleaning agreements between households sharing communal sanitation facilities, also have a bearing on the sustainability of services. Different management configurations for O&M of water and sanitation systems are briefly summarised in Table 2.6. Many different institutions are involved with sanitation service provision in informal areas; therefore it is important to ensure that roles and responsibilities are clear and commensurate with the capacity of each institution to perform the assigned responsibility. Suggested roles and responsibilities during different stages of sanitation service delivery are described in Appendix 1D.

Table 2.5: Institutional sustainability assessment criteria (after Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004)

Criteria	Indicator
Institutional	
1. Institutional requirements met	Qualitative
2. Responsibility distribution is clear	Definition of level of organisation (household, settlement, municipality)
3. Legal acceptability	Qualitative

Table 2.6: O&M management systems (after Cotton, 2000)

Management system	Examples	Implications
Centrally managed Private service connections to individual plots which require supporting external infrastructure	• Piped water supply • Sewerage	Public institutions have statutory responsibility for service delivery and O&M
***Community-managed** Non-private facilities which are shared by members of a community or user groups; depending on the technology adopted, these may or may not require supporting external infrastructure	*With external support infrastructure* • Piped water to public standposts • Sewered communal or shared latrines • Communal handpumps or wells • Communal latrines linked to pits or septic tanks	A group of users is responsible for O&M; if there is external support infrastructure, the roles and responsibilities need to be carefully defined between the community and the external agencies. In some cases, *e.g.* rural piped water, user groups may be responsible for the whole system including external infrastructure
***Household managed** Private on-plot services which do not require supporting external infrastructure	• On-plot wells, handpumps • Latrines linked to on-plot pits or septic tanks	Responsibility for O&M of privately owned on-plot facilities rests with the owner or plot-holder

*These management models tend to be more widely applied in rural than urban areas and require a high level of social cohesion.

The allocation of responsibilities needs to be discussed during the design and planning stage of a project (Mara et al., 2007), and re-evaluated during the implementation and O&M phases. For example, some of the environmental and technical criteria in Table 2.1 and Table

2.4 relate most to the treatment aspects of a sanitation system, thus, would be of greatest interest to stakeholders who are involved in regulating effluent quality such as WWTW operators; whereas other criteria such as many of the socio-cultural criteria, such as convenience, would be of greatest interest to users (IWA, 2006). As Mara et al. (2007) mention, there are also likely to be different roles and needs for different user groups, which also need to be addressed in sanitation planning. While individual needs should be considered, there also needs to be 'a coherent city-wide approach to sanitation' (Mara et al., 2007:307), which is able to incorporate different sanitation systems and levels of service[22] sustainably and for collective benefit.

2.3.4.1 Processes and tools to support user participation in sanitation planning and service delivery

There are several approaches and tools that can be utilised and adapted as necessary to incorporate users into planning processes, which will be presented in this section. How well selected sanitation 'software'[23] address sustainability and equity considerations are also evaluated. Community-Led Total Sanitation (CLTS), Community-Led Urban Environmental Sanitation (CLUES), SaniFOAM and Sanitation 21 are examples of holistic participatory sanitation planning frameworks developed over the last 15 years. All four incorporate elements of participatory approaches and have evolved out of the shift towards more demand-responsive approaches to sanitation following the International Drinking Water Supply and Sanitation Decade (1981-1990), although they all have different areas of focus. They can be considered as more holistic approaches to traditional infrastructure 'hardware'[24] focused sanitation planning because they explicitly incorporate 'software' (hygiene promotion, capacity building, management frameworks, etc.) into the process of planning and implementing sanitation improvements. Furthermore, there is a clear emphasis on including many different stakeholders in the process. Another common feature is that implicitly each approach relies on interdisciplinarity to address multidimensional challenges of sanitation development. Each approach however has different strengths and weaknesses and needs to be adjusted to the context.

The main components of the various planning approaches and frameworks mentioned are summarised in Table 2.7. McConville et al. (2011) make the argument that the use of planning theory can assist engineers responsible for sanitation service provision in incorporating 'context-appropriate processes', particularly if participation in planning is going to be effective and meaningful. The participatory planning frameworks in Table 2.7 were designed primarily for use in developing countries, and shift away from infrastructure driven planning approaches. They each contain varying degrees of emphasis on participatory

[22] See the Glossary of terms for a definition and the case studies in Chapter 4 for a description of levels of service as applied in each case study municipality.
[23] 'Software' refers to various planning approaches, which are primarily participatory in nature, that support improvements in health and hygiene, and is considered complementary to 'hardware', *i.e.* infrastructure and facilities or 'taps and toilets'.
[24] The physical infrastructure required to provide sanitation services, simplistically referred to as 'taps and toilets'.

approaches. There is a general trend as of the late-1990s and 2000s in international sanitation development practice leaning towards 'community-led' or 'demand-driven' approaches to promote social sustainability (Kar & Chambers, 2008; Lagardien et al., 2010; Movik & Mehta, 2010; Lüthi et al., 2011a; Whaley & Webster, 2011; McGranahan, 2015), particularly for provision in low-income areas, but there are some criticisms and potential caveats.

As mentioned, participation can come in many forms (Arnstein, 1969; Abbott, 1996; Nance & Ortolano, 2007). In a study of the impacts of participation on condominial sewerage projects in two Brazilian states, Nance & Ortolano (2007) found that participation was most effective for mobilizing and decision-making in planning stages rather than in construction and maintenance operations. Something to be very wary of is that 'government neglect and even manipulation can parade as a purposeful devolution of control to communities', particularly when it comes to service provision in low-income areas (McGranahan et al., 2001:109-110). In addition, local collective action can address many, but not all public goods and externalities associated with sanitation, e.g. 'drainage districts' which do not fall into the same boundary as socially identifiable communities (McGranahan et al., 2001:108). Broader impacts beyond a single local project need to be taken into account when trying to plan for sanitation programmatically as opposed to a project-based approach.

In the CLUES framework, one of the conditions for an 'enabling environment'[25] is a cohesive community (Lüthi, et al., 2011a**)**. In urban areas with heterogeneous populations and complex social dynamics, power struggles between different factions in a community, transient populations, etc. can hinder or even prevent community participation based planning approaches from being effective without a great deal of external support and facilitation. Tomlinson (2015) emphasises the importance of 'overlapping' champions, *i.e.* individuals who are willing and committed to sanitation improvements drawn from organised communities, CBOs, NGOs and city governments willing to work together. Planning approaches that are based on, or heavily rely on, community participation need to be aware of the form of participation, who is involved and how and when to utilise it most effectively. To summarise, different stakeholders should be 'involved in ways that are appropriate to their interests, capabilities and responsibilities' (Tayler et al., 2003:19), which will have a significant bearing on the sustainability and equity of the sanitation services provided or co-produced[26].

Each of the four approaches reviewed in Table 2.7 has a slightly different focus, which may suit different contexts better than others. Each approach is summarised with respect to the target audience, main focus or objective, where the approach has been implemented, potential challenges to application in South African urban informal settlements, and incorporation of sustainability and equity principles. Of the four approaches, the framework proposed by Sanitation 21 seems to be the most viable to application in the South African context, if used in conjunction with existing M&E tools (Appendix 1V), institutions

[25] There are six elements of an enabling environment, which are necessary to support successful WASH interventions identified by Lüthi, *et al.* (2011): government support, legal and regulatory framework, institutional arrangements, skills and capacity, financial arrangements and socio-cultural acceptance.

[26] Co-production 'refers to the joint production of public services between citizen and state, with… one or more elements of the production process being shared' (Mitlin, 2008).

and policies (Section 2.3.4.2), although it still needs to be tested in South Africa. Guidelines for how CLTS can be adapted and applied to the South African context where subsidies are provided have been developed (Lagardien et al., 2014), although the guidelines still need to be tested on a larger scale beyond the pilot study from which they are derived.

Table 2.7: Summary of key components of CLTS, SaniFOAM, CLUES and Sanitation 21 (Kar & Chambers, 2008; Devine, 2009; Evans et al., 2009; Lüthi, et al., 2011a; Parkinson et al., 2014a)

Summary	CLTS	SaniFOAM	CLUES	Sanitation 21
Target audience	Government and NGO field staff, facilitators and community trainers	Sanitation program managers and implementers	Local authorities, donor agencies, planners, NGOs dealing with infrastructure programs and service delivery, CBOs	Sanitation professionals in local government, utilities services, NGOs and consultants
Main focus	Establishing open defecation free villages	Sanitation behaviour analysis and marketing	Planning a sanitation project with multiple stakeholders using participatory tools	Urban sanitation planning framework to develop a comprehensive city-wide plan
Implementation areas	South/Southeast Asia; West/East Africa; Introduced to South Africa in the last five years.	Tanzania, Indonesia, and India	7 countries in Africa, Asia and Latin America	Intended to be used in conjunction with other planning processes such as CLTS or CLUES
Challenges to application in South African urban areas	• Mainly applied in rural areas • Difficult to establish 'quality control' for implementing • Needs modification to accommodate FBSan policy	• Limited examples of application • Mainly applied in rural areas	• Limited suggestions for difficult financial and socio-cultural environments • Time consuming and costly process, not budgeted for in FBSan	• Likely resistance in many urban areas to non-sewered sanitation proposals
Incorporation of sustainability and equity principles	• Focuses on behaviour change most directly linked to socio-cultural sustainability and equity in terms of getting 100% of target community involved	• Focuses on understanding behaviour determinants which may assist with socio-cultural sustainability, but does not directly address sustainability and equity	• Addresses sustainability through guidance on fostering an enabling environment, but does not directly address equity principles	• Broadly advocates for sustainability and equity in sanitation planning at different levels of a city without going into detail

Participatory planning processes require a significant amount of time to assess the users' needs and to reach consensus. Participatory processes also require skilful facilitators and can incur additional costs and require adequate capacity (Lüthi et al., 2011a), which existing municipal institutional arrangements in South Africa often do not account for. Table 2.8 lists potential stakeholders, institutions or individuals who may impact on the institutional sustainability of a sanitation service and have a 'stake' in the planning process or have the potential to affect or be affected by planning decisions (Taing et al., 2013). Note that there is not only socio-economic and cultural diversity between stakeholder groups, but also *within* stakeholder groups which can also influence institutional culture and decision-making. The various stakeholders listed in Table 2.8 play different roles during sanitation service planning and often have different levels of interest and ability to influence decision-making. These differences impact not only on the sustainability of a sanitation project, but also the potential equity of the project's decision-making process and implementation, which reflects the procedural equity mentioned by Haughton (1999). Therefore, the facilitators play a critical role in trying to ensure that the planning process is fair and transparent and acting as mediators between various other stakeholders.

Table 2.8: List of potential stakeholder groups in sanitation service planning (after Taing et al., 2013)

Stakeholder	Role	Stakeholder	Role
Users	Beneficiary of services, should participate in every stage and provide input and feedback on needs and performance	**Social facilitator**	Engages with all stakeholders, mediates conflict and moderates meetings
NGOs/CBOs	Advocate for improved services, and assist with organising and facilitating the process	**Project manager**	Oversees implementation and assists with technical and financial aspects of project planning
Municipal & ward authorities	Service providers and regulators to assure compliance with health and environmental policies -- legal authorities. In South Africa, usually the main financer and owner of infrastructure assets	**Project support**	Academics, administrators, technicians who provide knowledge and specific skills related to a project
Steering committee	Selected during initial stage of project to guide the overall process and report back to various stakeholders	**Consultants & contractors**	Appointed to provide expertise and services during various stages

2.3.4.2 Sanitation policy development in South Africa and role of national government

Policies are an important aspect of institutional sustainability and influence how services are implemented as well as the institutional arrangements used within and between different spheres of government. This section provides a review of policies that impact sanitation services in South Africa. The policy environment in which sanitation services for informal settlements are operating is an important component of context specific influences on how

sustainability and equity are framed and which dimensions are emphasised. The scope of this research has been limited to post-1994 sanitation developments since a new constitution was created after the end of apartheid. Furthermore, there were vast changes in the country's institutions, policies and society over a relatively short period of time. Figure 2.4 highlights some of the most relevant policies and legislation impacting sanitation in South Africa, and selected national events from 1994 to 2015 where relevant. The timeline is not intended to be an exhaustive representation of all related policies and regulations, but rather to depict a relevant policy environment that influenced the development of sanitation services for the urban poor. Some policies that were reviewed are not obviously related to water and sanitation services, e.g. policies related to finance, governance and housing, but still impact sanitation on a strategic planning level.

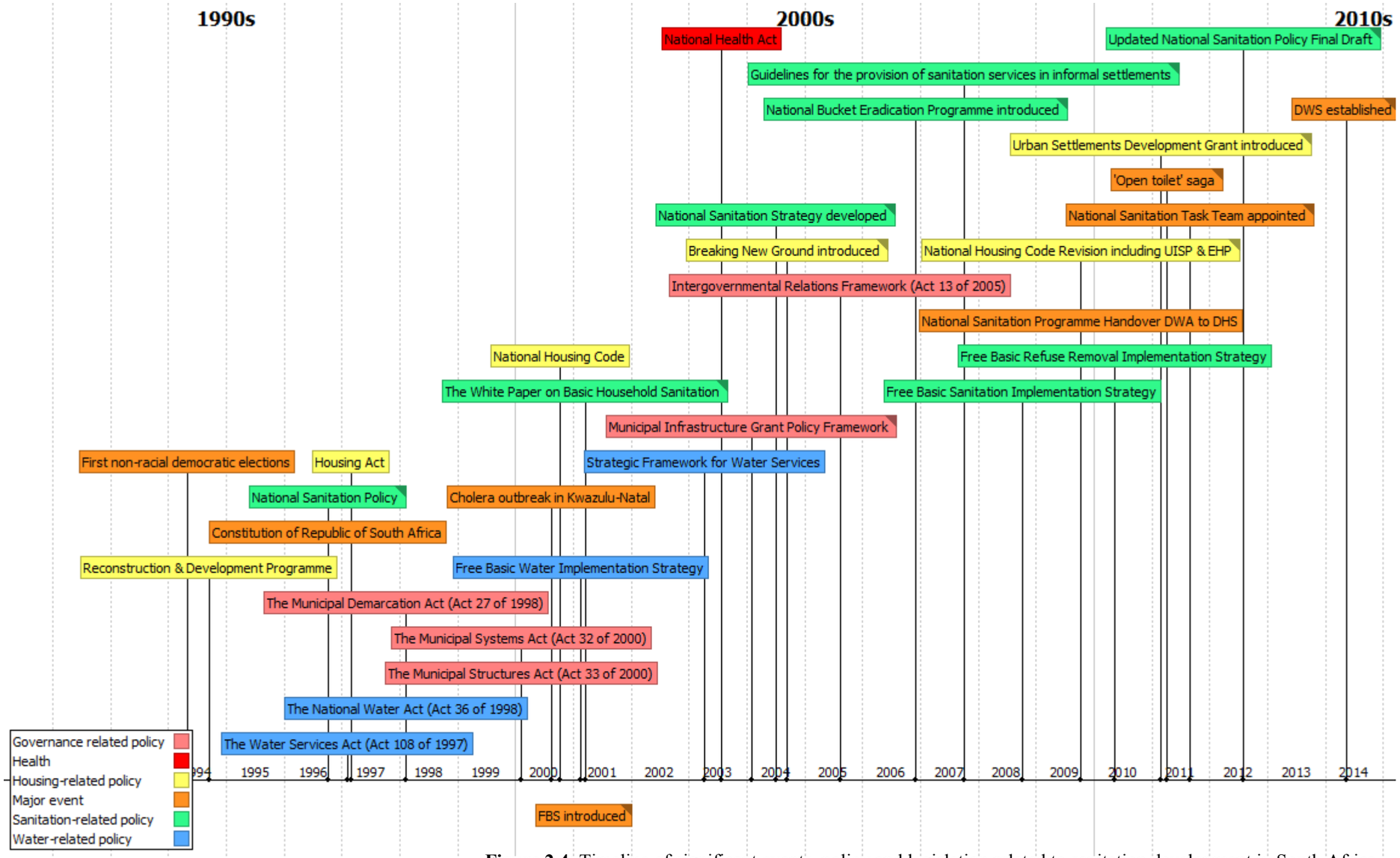

Figure 2.4: Timeline of significant events, policy and legislation related to sanitation development in South Africa

The first major post-apartheid economic development policy developed to assist previously disadvantaged people was the Reconstruction and Development Programme (RDP). The RDP was adopted by the Government of National Unity (GNU) after the 1994 elections. One of the main ideologies promoted, as referenced in the title of the policy document was the need to link reconstruction with development based on economic growth, redevelopment, and redistribution (ANC, 1994). A major component of this was the need to meet basic needs for unserved and underserved people, needs such as land and housing, access to safe water and sanitation, amongst others. Despite receiving widespread support initially, the programme encountered many challenges in meeting its ambitious targets for delivering housing and other services within five years (Blumenfeld, 1997). Furthermore, there were institutional issues with the implementation of the programme and unclear roles for how responsibilities should be shared between the dedicated RDP office and different departments at the national level, which were also experienced in lower levels of government (Blumenfeld, 1997:74-75). The RDP was thus redirected into the less 'socialist' Growth, Employment and Redistribution (GEAR) programme in 1996 which emphasised 'redistribution through growth', cutting government expenditures, and suggested privatization of parastatals to reduce state debt, despite criticisms from labour unions (Peet, 2002); although some projects continued under the auspices of the RDP. As demonstrated by the shift from the RDP to the GEAR programme, the South African government has been criticized for oscillating between the promotion of 'socialist' leaning mechanisms such as strong state interventions and welfare policies, e.g. 'lifeline tariffs' to combat poverty, and 'capitalist' leaning mechanisms such as deregulation, privatization and full cost-recovery (Bond, 2000; Peet, 2002).

The Constitution of South Africa was ratified in 1996, and has been praised for embodying progressive ideals of social and environmental justice[27] in the Bill of Rights (Funke et al., 2007). The right of access to basic sanitation services has been extrapolated from Section 24(a) of the Bill of Rights by officials and rights advocates (Mjoli, 2010; Tissington, 2011). It states that 'everyone has a right to an environment that is not harmful to their health or well-being' (RSA, 1996a). Additional constitutional support has been garnered by rights advocates such as the Social Justice Coalition (SJC, 2013) through connecting sanitation and dignity, basing their argument on Section 10, which protects human dignity: 'everyone has inherent dignity and the right to have their dignity respected and protected' (RSA, 1996a). Using that logic, having to use 'unhygienic, inadequate toilet facilities impairs dignity' (Tissington, 2011). The government mandate for assisting people to gain access to basic sanitation seemed clear from the Bill of Rights, nevertheless ambiguities remained regarding what the government's role should be in guaranteeing these rights.

The National Sanitation Policy was also published in 1996 with the intention of clarifying issues raised in the 1994 White Paper on Water Supply and Sanitation Policy and to guide the development of a national strategy for sanitation. Responsibility for the provision of sanitation infrastructure and services was clearly allocated to local government with support from provincial and national government. Roles for the private sector and NGOs

[27] See Glossary of Terms for definitions.

were also outlined. The concept of a 'lifeline tariff' was introduced as a way to reformulate tariff structures to assist low-income families along with limited grants and subsidies for 'the basic minimum level of service' (DWAF, 1996). Ensuring access to a 'basic level' of service was discussed with specific reference to a Ventilated Improved Pit (VIP) toilet per household, or its equivalent, as the minimum standard in relation to 'cost, sturdiness, health benefits and environmental impact' (DWAF, 1996). Various options that met the criteria of 'adequate sanitation' were also mentioned and ranked according to cost and water-usage. In short, some of the language and concepts supporting FBSan were put in place, but the full-scale policy and implementation were still not established.

Water services, which generally include sanitation, were given a high priority by the government as a crucial element for both economic and social development. In 1997 the Water Services Act was passed, followed by the National Water Act in 1998. The Water Services Act is considered the primary law relating to accessibility and provision of water services by local government in South Africa (Tissington, 2011). The Water Services Act explicitly recognised the right of access to basic water and sanitation (although not free), where basic sanitation was defined as:

> the prescribed minimum standard of services necessary for the safe, hygienic and adequate collection, removal, disposal or purification of human excreta, domestic waste-water and sewage from households, including informal households. (RSA, 1997b)

Similar to the National Sanitation Policy, the Water Services Act designated primary authority to municipalities to administer water and sanitation services, but recognised that all spheres of government have a responsibility to contribute towards sufficient provision of services. Within the Act three main institutional categories relating to water services: water service authority (WSA), water service intermediary and water service provider (WSP) (Appendix 1N). While these categories have different legal and operational responsibilities, as will be discussed in the Johannesburg case study, in practice many South African municipalities merged the responsibilities of water service authorities and providers. The Water Services Act also stipulated that all water services authorities must create water service development plans (WSDPs), which would be updated at five year intervals. One of the key tenets relating to sanitation is to provide at least a basic water supply and sanitation to all residents even if the water services institution is unable to meet the requirements for a full level of service for all existing customers, i.e. 'some for all' rather than 'all for some'.

The National Water Act (RSA, 1998c) addressed the management and regulation of water resources, and introduced the concept of catchment management agencies to assist with coordinating water resource strategies in catchment areas with national water resource strategy (RSA, 1998c). Both the Water Services Act and National Water Act focused on water supply and resource management more than sanitation issues. They are however important pieces of legislation to consider given the links between sanitation and water supply as well as potential environmental impacts of inadequate sanitation.

Another important piece of legislation approved in 1997 was the National Housing Act. The Housing Act is the primary piece of legislation governing housing development in South Africa, and it defined the functions of the different spheres of government in the development process (RSA, 1997a). The National Housing Code, published in 2000 (amended in 2009) in accordance with Section 4 of the Housing Act, set out the policy principles, guidelines, norms and standards for National Housing Programmes. As noted by Tissington (2011:27), the act and subsequent code is relevant to sanitation since sanitation services are considered a fundamental part of the right to adequate housing, and also because the government has linked sanitation service rollouts to its housing delivery programme through the National Housing Subsidy Scheme. Additionally, people's access to sanitation and their desire to invest in infrastructure and home improvements are often connected to tenure issues (WSUP, 2013). The link between sanitation and housing delivery was further promoted when responsibility for the National Sanitation Programme was moved from the Department of Water Affairs to the Department of Human Settlements in 2009; although it was subsequently moved back to the renamed Department of Water and Sanitation in 2014.

In addition to the passage of major water resource and housing legislation, several pieces of legislation were passed between 1998 and 2000 which related to how local government would be managed and structured, including responsibilities regarding the provision of services. The Local Government Municipal Demarcation Act (27 of 1998) established a Municipal Demarcation Board to determine boundaries according to a set of criteria that included 'the provision of services to the communities in an equitable and sustainable manner' (RSA, 1998a:Section 24(a)(ii)). In Cape Town, the Demarcation Act resulted in the consolidation of seven municipalities across the Cape Metropolitan Area into one 'unicity council' (CCT, 2011a) designated as one of eight metropolitan municipalities. Similar consolidation occurred in Johannesburg and eThekwini municipality, which are also classified as metropolitan municipalities, which was a municipal category defined in the Municipal Structures Act (RSA, 1998b). While the Municipal Demarcation Act indirectly influenced by whom and how basic services would be provided, the Municipal Structures Act 117 of 1998 and Municipal Systems Act (32 of 2000) stressed even more directly that providing sustainable and equitable basic services was the responsibility of municipal governments.

The Municipal Structures Act outlined different categories of municipalities and the division of functions and powers between the different categories (metropolitan, district, and local) (RSA, 1998b). A metropolitan municipality has 'exclusive executive and legislative authority in its area' (RSA, 1998b), whereas district and local municipalities share responsibilities for water and other services. The Municipal Systems Act (RSA, 1998b) focuses on the administration and internal systems of each municipality, and introduced the differentiation between a service authority and provider (DWAF, 2002b). The Act also laid out the mechanisms and procedures to 'ensure universal access to essential services that are affordable to all' (RSA, 2000b: preamble), and placed a strong emphasis on fostering community participation in the integrated development plan (IDP), budgets, etc. Where necessary, provincial and national government are permitted to intervene if a municipality does not have adequate capacity to perform its responsibilities, but all three Municipal Acts

were considered part of efforts to decentralise and to facilitate a more responsive democracy through strengthening local government. Although they all contained language supporting sustainable and equitable service provision, how sustainability or equity would be assessed or monitored and supported were excluded.

Following a cholera outbreak in Kwazulu-Natal in 2000, the impetus was accelerated to improve basic water and sanitation services. The policy of free basic services to the poor was introduced in 2001 by the South African national government (Still et al., 2009:108). For water supply, specific guidelines on the quantity of free water (6kℓ per month) were given to the local government (DWAF, 2001a). The basic minimum standard was calculated as 25ℓ per person per day (ℓ/pp/day) or 6kℓ per household based on an estimate of eight people in a household (DWAF, 2001a; DWAF, 2002a), which was modelled after what was already being done in eThekwini municipality. How the policy should be implemented by municipalities was left relatively open-ended according to each municipality's capacity. For sanitation, however, specific guidelines for what constituted a basic level of sanitation service proved more difficult to establish (Still et al., 2009:108).

The White Paper on Basic Household Sanitation was approved by the Cabinet in 2001 as a framework for providing sustainable sanitation services at a basic level to households to mainly 'rural communities and informal settlements' (DWAF, 2001b:5) where the greatest need was identified. A National Sanitation Programme Unit situated in the Department of Water Affairs and Forestry[28] (DWAF) was established in 2002 to help oversee implementation and alignment of sanitation goals across different departments and spheres of government (Tissington, 2011). In line with international best practice, the White Paper promoted a 'demand responsive' approach to household sanitation and 'community participation' with an emphasis on health-focused developmental outcomes (DWAF, 2001b:11; Tissington, 2011). Households should receive direct support from local government, receiving information around O&M, health and hygiene, but should be responsible for choosing an appropriate level of service according to willingness and ability to pay (DWAF, 2001b:13). The local government in turn should receive co-operative support from provincial and national government. A once-off subsidy, administered through DWAF, of R600 towards community development and R600 for the basic toilet structure was provided per household (DWAF, 2001b:29), but a comprehensive FBSan policy was not included. The National Sanitation Programme Unit proposed a revision to the policy framework in 2011, pointing out shortcomings in the 2001 White Paper (DHS, 2011b). Some of the criticisms included inadequate consultation with stakeholders, disconnect with municipal institutions, and a primarily rural focus (Tissington, 2011).

The National Health Act (2003) did not explicitly discuss sanitation services, but Section 83 refers to the role of environmental health officers who are meant to monitor environmental health conditions and to ensure that Section 24(a)[29] of the Constitution is not

[28] The Department of Water Affairs and Forestry has been restructured several times post-1994, from DWAF, to the Department of Water and Environmental Affairs (DWEA), to the Department of Water Affairs (DWA) and currently is the Department of Water and Sanitation (DWS).

[29] Section 24(a) of the Bill of Rights states that "everyone has a right to an environment that is not harmful to their health or well-being" (RSA, 1996a).

violated; which further supports the legal framework for the right to access sanitation services. It also provides legal grounds for environmental health officers to inspect properties which may be in violation of Section 24(a) including on private properties where informal settlement or backyard dwellers may be living without access to water and sanitation services.

The Strategic Framework for Water Services (SFWS) (DWAF, 2003) defined a basic level of sanitation service slightly differently from the 2001 White Paper in that household refuse removal was excluded, likely because a separate Free Basic Refuse Removal policy was proposed. Notably, the SFWS distinguished between a FBSan facility, which is infrastructure-related, and a FBSan service, which pertains to the sustainable operation of the facility, which was not mentioned in the White Paper. Another difference is that previously the White Paper policy had specified that each household should have a toilet facility to meet minimum standards (DWAF, 2001b:6), whereas the later SFWS did not include the specification for individual household toilet facilities. The SFWS however did include recommendations for technology choice related mainly to residential densities suggesting that for dense urban areas near businesses, waterborne sanitation was the most appropriate technical solution. On the other hand, for rural areas with low densities and few businesses, on-site solutions were deemed more appropriate. For 'intermediate areas', the choice would be mainly dependent on the water services provider's ability to maintain and operate the system sustainably with available funds, which would likely be limited to on-site sanitation systems in most cases (DWAF, 2003:30-31). Some subsidy arrangements were proposed, but specific details were not laid out. In essence, the SFWS suggested potential arrangements for providing free basic sanitation services and targets, but stopped short of developing an implementation strategy.

A National Sanitation Strategy was developed in 2004 to complement the SFWS, and to include the development of the Municipal Infrastructure Grant (MIG) to provide some coherent implementation guidance for the Free Basic Sanitation policy. Tissington (2011) noted that while the strategy stated that 'informal settlements must not be treated as emergency situations for the purposes of this strategy… communal facilities and chemical toilets should not be used where the system is expected to have a duration of more than one month' (DWAF, 2004:49); however, this recommendation was not applied in most municipal FBSan programmes for informal settlements nor was the 2010 goal of full sanitation coverage met. Part of the reason for the disconnect between policy and implementation was likely due to an underestimate of the number of toilets needed, capital and operating funds required, and restructuring of sanitation sector responsibilities at a national level.

Funding and other issues pertaining to planning and implementing sanitation programmes often requires action from multiple government departments and agencies. The Intergovernmental Relations Framework Act was passed in 2005 (RSA, 2005) to present a framework for facilitating coordination in implementing policy and legislation in areas including: coherent government, effective provision of services, monitoring implementation of policy and legislation, and realisation of national priorities (RSA, 2005:Section 4). This Act may be particularly relevant if a National Sanitation Agency is established as

recommended by the Department of Human Settlement's ministerial Sanitation Task Team (DHS, 2012), which would require coordination amongst multiple national departments as well as municipal water service authorities (WSAs).

Although earlier policy documents mentioned a FBSan service, the actual FBSan implementation strategy was not released until 2008, followed by the Free Basic Refuse Removal Implementation Strategy in 2010. In the FBSan implementation strategy, a target date for all people in South Africa to have access to a functioning basic sanitation facility was set for 2014 (revised from the 2010 date laid out in the SFWS) (DWAF, 2008), but was not met. The goal of access to basic sanitation for all citizens was qualified with a statement that the policy is mainly targeted at poor households as a poverty alleviation measure (DWAF, 2008). In the implementation strategy the concept of 'free basic sanitation' was acknowledged as a controversial issue, since consumers receive the service without making contributions in cash or in kind, but policy makers justified the policy as a poverty alleviation measure and subsidy targeted at indigent households[30] (DWAF, 2008). The policy stated that water service authorities (WSAs) have no legal obligation to conform to the FBSan policy, but warned that WSAs may be liable to legal challenges from consumers if they can provide evidence that the authority is not using resources to provide services to the poor effectively (DWAF, 2008). Some technical options for sanitation 'hardware' were described along with typical costs, but most attention was given to describing subsidy and tariff options for financing the FBSan services. Although local government revenues were expected to be the primary source of funding for water services, the implementation strategy indicated that national subsidies like the ES funds and Municipal Infrastructure Grant (MIG) could be used to subsidise the operating and capital costs where necessary, particularly for poorer municipalities with a limited tax base (DWAF, 2008). While the implementation strategy provided more detailed guidance for municipalities than the SFWS, several shortcomings still remained. Mjoli et al. (2009) pointed out unrealistic national targets that do not take into account regional differences which push municipalities to focus on supply-driven programmes to deliver toilets, rather than sustainable sanitation services. Sanitation software has not been receiving sufficient or any funds, especially in poorer municipalities who cannot rely too heavily on cross-subsidisation without jeopardising local economic development (Mjoli et al., 2009). The onus is on WSAs to deliver the FBSan services, but there is little guidance on how to support capacity building within the WSAs and households who are meant to benefit from FBSan.

The policy and administrative environment for FBSan may undergo significant changes in 2016. A draft update to the 2001 White Paper on Basic Household Sanitation was released in March 2016 by the Department of Water Affairs and Sanitation; however, as of the time of writing it is still awaiting final approval. The institutional structure for national sanitation responsibilities has also changed. The National Sanitation Programme unit was transferred to the Department of Human Settlements for a five year period, but in May 2014 was returned to the Department of Water Affairs, which was subsequently renamed the Department of

[30] N.B. As implemented by the metropolitan municipalities, all households actually receive a subsidy for the first tariff block of water used since differentiating bills for only indigent households proved too cumbersome and costly.

Water Affairs and Sanitation (DWS). The formation of a National Sanitation Advisory Committee has been proposed to assist with coordinating sanitation planning, regulation and policy making between different national departments, other spheres of government and civil society along with an updated national sanitation policy[31] (DWS, 2016).

Several events in recent history have highlighted the urgent need to improve sanitation in the country, and also brought sanitation into the national limelight. The cholera epidemic in Kwazulu-Natal in 2000 caused national concern over the link between poor sanitation and contaminated water supplies, and led to the development of the FBW and FBSan policies as well as a review of national sanitation policy. More recently, in 2010, the 'open toilet' saga which exposed the unenclosed toilets provided to residents in informal settlements in different areas of the country provoked fierce accusations over who was doing a better (or worse) job at providing basic services between the ruling African National Congress (ANC) party, and the main opposition party the Democratic Alliance (DA) (Gitahu, 2011). This also led to a proposed review of national sanitation policy as noted earlier. These events demonstrate the susceptibility of policy changes to current events and politics, which can have both positive and negative effects on sanitation development. There is also a need to be wary of sanitation services being offered or used for political expediency (Almansi et al., 2011; Gitahu, 2011; McGranahan, 2015) resulting in unsustainable and inequitable provision.

2.3.5 Socio-cultural sustainability

In sustainable sanitation literature, most of the socio-cultural sustainability criteria relate to the acceptability of a particular system in relation to the social and cultural norms and behaviours of a given society. With regards to sanitation, social acceptability is a major criterion for the socio-cultural sustainability of sanitation systems (Kalbermatten et al., 1982; Kvarnström et al., 2004; Panesar et al., 2011) (Critera 2 and 3 in Table 2.9). User preferences may relate to religious beliefs and cultural norms such as anal cleansing practices, i.e. 'washing' with water instead of 'wiping' with paper or 'sitting' using pedestals and 'squatting' using squat pans (de Bruijne et al., 2007; Tilley et al., 2008). There are also cultural attitudes towards the reuse of human excreta, which should be acknowledged prior to selecting a sanitation system: 'faecophilia', a positive attitude towards human excreta where it is valued as a resource and there is no fear of handling it, and 'faecophobia', a negative attitude towards handling human faeces because of its odour and association with danger or 'uncleanliness' (Winblad et al., 2004). How privacy is defined or valued can also vary significantly between different cultures as George (2008) observes. User habits can change over time because of the need to adapt to changing circumstances (de Bruijne et al., 2007), but preferences and perceptions as part of socio-cultural acceptability should be taken into account when planning a sanitation system and designs and management plans modified

[31] An updated draft national sanitation policy has been released in the government gazette and is undergoing a public participation process (March 2016) (DWS, 2016). The updated draft policy aims to address many of the sanitation gaps identified in the 2012 draft policy.

accordingly. Assessing the wants and needs[32] of users will assist not only with the selection of an appropriate technology, which is the mechanism to deliver the service, but also with the design of sanitation as a service which meets the wants and needs of users insofar as possible. Assessment can also assist with understanding the priorities of user groups which may help or hinder the social acceptability of sanitation services (Lüthi et al., 2011a).

Behaviour change is another area of socio-cultural sustainability that needs to be considered. Sohail et al. (2005) have identified behaviour change amongst both users and service providers as a potential key to long-term improvements to O&M practices with respect to better use of facilities and better maintenance performance, e.g. not only reactive maintenance but pro-active planned periodic maintenance programmes are required but often neglected. An important note is that prior to changing behaviour it is important to 'define *what* behaviors should be improved and identify *whose* behavior needs to be changed' (Devine, 2009:3). Furthermore, as indicated in Criterion 4, it is important to ensure that the information needed to make decisions about sanitation services including costs, benefits and impacts on health and hygiene (Section 2.3.6) need to be readily available to stakeholders to support socio-cultural sustainability and equitable access to services and information.

Table 2.9: Socio-cultural sustainability assessment criteria (after Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004).

Criteria	Indicator
Socio-cultural and institutional assessment criteria	
1. Convenience (comfort, personal security, smell, noise, attractiveness)	Qualitative
2. Appropriateness to current local cultural context	Qualitative
3. System perception (including towards reuse of waste)	Qualitative
4. Ability to address awareness and information needs	Qualitative

Socio-cultural sustainability is one of the areas in which equity concerns can be most readily addressed. For example with Criteria 1, convenience may be defined differently by different people. As Patkar & Gosling (2011) mention, people who may be more socially vulnerable such as women, children and the elderly may have different requirements for personal security than men. The concern for the different needs of different people ties into equity of access which will be discussed in Section 2.4. As will be discussed, while all dimensions of sustainability are important to contextualise, socio-cultural sustainability is particularly important to characterise in a local context because it can vary so widely even within a single neighbourhood or household.

[32]McGregor *et al.* (2009:136) assert that the 'value of a theory of human need in policy processes is that it provides a way of interrogating what are claimed as needs by assessing whether there is evidence that their denial in that context results in harm', although if psychological and relational dimensions are included 'the theoretical distinction between needs and wants begins to fade away' (McGregor *et al.*, 2009:140)

2.3.6 Health and hygiene

Improving health is one of the main objectives or drivers for sanitation, discussed previously, (Hutton & Bartram, 2008). Health and hygiene are typically associated with the socio-cultural aspects of sustainability, although sometimes they are considered in their own category for sanitation assessments. To be considered 'improved sanitation', a sanitation facility must 'ensure hygienic separation of human excreta from human contact' (WHO & UNICEF, 2013) to prevent the risk of infection (Criteria 1 in Table 2.10).

Access to water and sanitation facilities, however, is not always enough to ensure sustained health improvements without concomitant hygiene promotion (Criteria 3) (Potter et al., 2011). Some of the major diseases associated with poor sanitation include infectious diarrhoea, acute Hepatitis A and helminth infections (Prüss et al., 2002), which can be prevented through good hygiene practices such as hand washing with soap after defecating or changing diapers and before eating or preparing food. The availability of hand washing facilities and soap as part of sanitation improvements is thus important to support health benefits. Additionally, beyond household hygiene measures, environmental conditions across an entire neighbourhood or settlement have an impact on individual household health, e.g. greywater poured into open channels may be contaminated and expose individuals in its path to pathogens or harmful substances (Criteria 2) and inadequate solid waste management may attract disease vectors such as rats. Sanitation interventions thus need to consider multiple pathways for infection as well as integration with safe water supply and hygiene programmes across the entire 'target community' (Eisenberg et al., 2007). Various household faecal-oral disease transmission pathways are shown in Figure 2.5, known as the F-diagram. The boundaries of interventions will be determined by the scope of the project or programme being implemented. Achieving improved health and hygiene outcomes through provision of sanitation services is one of the main objectives of sanitation; therefore, sustained health and hygiene improvement is an important element to consider in assessing the sustainability of a given sanitation service.

Another aspect of hygiene that has been included as an important sub-category of health and hygiene promotion is menstrual hygiene management. Menstrual hygiene management (MHM) is defined as:

> Women and adolescent girls using a clean material to absorb or collect menstrual blood, and this material can be changed in privacy as often as necessary for the duration of the menstrual period. MHM includes soap and water for washing the body as required, and access to facilities to dispose of used menstrual management materials. (Sommer et al., 2015)

Ensuring that MHM is included as part of sanitation services also connects to equity dimensions relating to access, particularly since women and adolescent women who are menstruating can be stigmatised (Sommer et al., 2015). A lack of MHM facilities may also have adverse effects on sanitation systems since MH products may cause blockages in sewer systems if flushed down the toilet and can also negatively affect on-site sanitation systems

such as pit latrines or septic tanks since the products are often not easily biodegradable and can cause pits to fill up more quickly and make them harder to empty (Truyens et al., 2013).

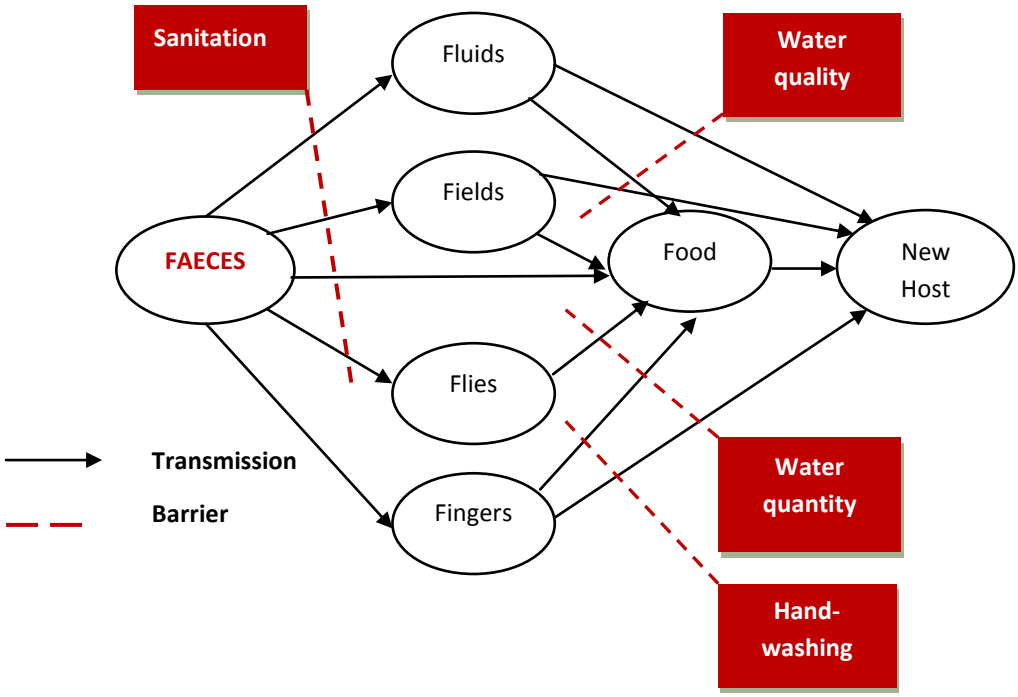

Figure 2.5: F-diagram (after Wagner & Lanoix, 1958 in Potter et al., 2011)

Health and hygiene are often used as justification for investment in sanitation services (Hutton et al., 2007) and are critical objectives of sanitation that need to be considered when planning for sanitation, including all of the criteria shown in Table 2.10.

Table 2.10: Health and hygiene sustainability assessment criteria (after Hellström et al., 2000, Balkema et al., 2002 and Kvarnström et al., 2004).

Criteria	Indicator
Health and Hygiene	
1. Risk of infection	No. of affected persons per year, risk assessment or qualitative
2. Risk of exposure to toxic substances	Risk assessment or qualitative
3. Hygiene promotion programme (including MHM)	Qualitative

2.3.7 Drivers for sanitation services in South Africa and relevance to sustainability

As mentioned previously, generally cited objectives of sanitation are to promote human health and to protect the environment (DWAF, 2002d; Rosemarin et al., 2008; SuSanA, 2013). The linkage between inadequate access to a safe drinking water supply and sanitation and inadequate hygiene has been well established (Mara et al., 2010; WHO, 2012). Water pollution is also a significant concern which can be linked to poor sanitation practices (Govender et al., 2011) if waste is not collected and treated or disposed of adequately. There is, however, also a need to consider other drivers for sanitation improvements, to not only accelerate service delivery rates but also to ensure that services are sustainable and equitable. Oftentimes, efforts to promote hygiene or to provide sanitation facilities have short-lived success because of a 'needs-based approach', which presents people as 'passive recipients' or 'beneficiaries' in contrast to a 'rights-based approach', which 'aims to bring about sustainable and long term structural change in policies, procedures and laws, as well as changes in attitudes and behaviours' (Gosling, 2010:7). Research indicates that users may not be particularly motivated by health or environmental concerns, but rather may be more motivated by other quality of life improvements and socio-cultural aspects such as:

> increases in comfort, privacy, convenience, safety for women and children (especially at night), dignity and social status, modernity, cleanliness, property value and rental incomes; and reductions in odour and flies, embarrassment with visitors or in-laws, accidents and conflict with neighbours. (Isunju et al., 2011)

In addition to ongoing health and hygiene education and awareness promotion, linking sanitation to human dignity and human rights has become an important legal tool used to advocate for improved services in low-income urban areas (COHRE et al., 2008; Mjoli et al., 2009; SAHRC, 2014b). Positive effects of the linkage between sanitation and human rights include: the promotion of demand for sanitation services amongst residents in low-income urban areas, increased pressure on responsible government authorities to deliver services, financial and political support for improved sanitation services from international and national agencies, and a legal/institutional framework for ensuring that services are 'of good quality and accessible to all, including groups that are frequently excluded' (de Albuquerque, 2012:45). A caveat is the need to find a balance between emphasising the right to sanitation, and responsibilities of different stakeholders without overemphasising rights over responsibilities or vice versa.

One of the issues encountered in South Africa is the politicisation of service delivery in general and specifically sanitation services. A recent example of the politicisation of sanitation service delivery is when the Democratic Alliance (DA)[33] party accused the African National Congress (ANC) youth league (ANCYL) of using 'poo protests' in Cape Town in 2013 as part of a campaign to unseat the DA local and provincial government in the run-up to

[33] At the time of writing, the DA was the main opposition party to the African National Congress (ANC), the ruling party in all of the provinces of South Africa except for the Western Cape.

2014 elections (Zille, 2013; Robins, 2014). While these accusations were denied by local ANC leaders, there is an undeniably political undertone to the numerous sanitation service delivery protests which have taken place across South African urban centres, which has as much to do with different levels of sanitation service provided to different socio-economic groups and access to services as it does to party politics (Phakati & Ensor, 2013; Robins, 2014). The concept of what a 'proper' or 'dignified' toilet is, is further complicated in South Africa by negative racialised associations of on-site portable systems with the 'bucket system' (George, 2008) and the desire of informal settlement residents 'who simply want modern, flush toilets, just like the ones in middle class homes' (Robins, 2014:3). The choice of sanitation technology at least from the user interface side and linkage to the level of service, therefore, has particularly strong implications for socio-cultural sustainability and equity in the South African context. It is therefore critical to note the influence of drivers on how and where sanitation services are provided, which has a direct impact on sustainability and equity.

While socio-cultural sustainability in relation to sustainable sanitation literature generally refers to acceptability (hence the emphasis on participatory processes) and behavioural change issues, in general sustainable development literature, social sustainability ties in more closely to the promotion of social equity and community cohesion (Dempsey et al., 2011), which are concepts that have not been emphasised as much in the discourse of sustainable sanitation. Equity in relation to sanitation service delivery will be discussed further in Section 2.4.

2.3.8 Summary of sustainability criteria for assessing sanitation services

Lennartsson et al. (2009) demonstrate how a sustainability assessment can be used to compare various sanitation systems using environmental sustainability and other criteria in comparison to a 0 alternative, i.e. baseline existing system (or no system). They recommend the use of a weighting system which is based on a multi-stakeholder participatory process, but do not discuss the challenges of utilising an extensive multi-criteria assessment tool for decision-making. As noted by Lennartsson et al. (2009) and Starkl & Brunner (2004), the objective of an assessment of sustainability is not to produce a standardised set of criteria since they will need to be tailored to each project and the local context (regulatory framework, existing systems, capacity level, resource availability, etc.) , but rather to get a wide variety of stakeholders to critically engage with sustainability beyond narrowly focusing on cost and to assist with making decision-making processes more transparent. The six dimensions (environmental, economic, technical, institutional, socio-cultural and health and hygiene) presented in this thesis reflect those that were identified widely in sanitation specific sustainability literature and also suit the South African case studies evaluated in Chapter 4. There is some overlap with some socio-cultural and health and hygiene sustainability criteria and the equity criteria that will be discussed in Section 2.4.

2.4 Equity in sanitation

As mentioned in Chapter 1, equity is an 'ethical concept' relating to notions of 'social justice, fairness, and human rights' based on need as a foundation for the distribution of resources (Scott et al., 2012) and power (Oden, 2010). Although equity is frequently associated with a sustainable development framework, Oden (2010:31) posits that 'a meaningful concept of equity has not… been seriously integrated into most sustainable development scholarship and practice.' Furthermore, part of the reason for avoiding discussion on equity is that 'easy consensus often unravels when equity issues are seriously engaged' (Oden, 2010:33). Equity is, however, critical for social inclusion and justice (Haughton, 1999) and should be brought to the centre of sustainable development discourse rather than be considered as an add-on or peripheral issue (Oden, 2010). In South Africa, an extremely inequitable distribution of wealth and power remains as the Achilles' heel that needs to be addressed to enhance its overall development. For example, in a UN-Habitat (2012) report assessing the prosperity factors[34] for cities around the world, while Cape Town and Johannesburg scored highly ('solid prosperity factors') for most areas of the prosperity index, they scored the lowest in comparison to other cities in the same prosperity category for the equity criterion.

Equity links primarily to economic, socio-cultural and institutional dimensions of sustainability. There are regional disparities in sanitation coverage, such as between rural and urban areas (Freeman et al., 2011) or between different economic groups within the same city. For example, sanitation coverage and levels of service in informal settlements are usually much lower than in formal areas (Stats SA, 2010). There are also inequalities relating to how people access information and can influence decision making around sanitation services, which Haughton (1999) refers to under the category of procedural inequity.

Inequity in some ways is easier to identify than equity in sanitation, e.g. some people having access to services and others not having access to services is clearly both unequal and inequitable. There is, however, also a subtle difference between equality and equity of access which relates to a difference in where people's baseline or starting point is. Equality implies that 'fairness' equates to uniform distribution and assumes that there is a level playing field; whereas equity acknowledges that 'fairness also demands remedies to redress historic injustices that have prevented or diminished access in the first place' (Kranich, 2005), which more suitably describes the situation regarding services in South Africa given the apartheid system of enforcing inequalities in access to infrastructure and social services across different racial groups (Özler, 2007). Put another way, *historically disadvantaged portions of the population*, predominantly those identified as 'black' and 'coloured' and vulnerable people within those racial groups, *will need more assistance than others to achieve access to services*, which is a major motivation for the basic services policies described in Section 2.3.4.2 as part of a human rights-based approach to services.

[34] As defined by UN-Habitat, prosperity goes beyond focusing narrowly on economic dimensions but includes five elements: productivity, infrastructure development, quality of life, equity and social inclusion and environmental sustainability (UN-Habitat, 2012).

As with sustainability, there are different dimensions to be considered such as how resources are allocated for sanitation service delivery, barriers to accessing facilities with key considerations for gender and age aspects along with physical and mental disabilities. There is also the nuanced and amorphous dimension of perception which differs slightly from the system perception (is this particular system acceptable or good) referred to under socio-cultural sustainability in that it relates to the potential *difference* between expectations of what is equitable or dignified and what is actually made available through a particular sanitation system, or similar to what Morales, Harris and Öberg (2014) term the 'urban sanitation imaginary'. The following sections will thus address equity frameworks and three identified aspects of equity in relation to sanitation: resource allocation, access and perceptions.

2.4.1 Equity frameworks and principles

In general, while there was a large body of literature relating to sustainability assessment frameworks for sanitation (Section 2.3), there was less available relating specifically to equity. Two were identified from WaterAid and Luh, Baum and Bartram (2013). The NGO WaterAid has developed a framework for equity and inclusion as pertains to access to water and sanitation. Equity at a local level pertains to 'relative disparities or disadvantages within families and communities' to address barriers to access for disadvantaged or vulnerable people (Gosling, 2010:6). The boundaries of the 'local level' would probably be best defined by household and settlement given that service level ratios are measured at a settlement and/or suburb level, although wards (which may include several settlements or portions of suburbs) are recognised for political administration purposes.

People who may be disadvantaged or vulnerable to exclusion from access to services and negative consequences from lack of access include: children, the elderly, HIV/AIDS affected, the disabled, and women (Hutton et al., 2008; Gosling, 2010). Various groups may be disadvantaged for different reasons, which are highlighted in Table 2.11.

Table 2.11: Limitations to accessing WASH services for different groups (Patkar & Gosling, 2011)

Groups	Barriers to accessing WASH
People with disabilities	Physical, environmental, social and institutional barriers
People with HIV/AIDS	Social barriers such as stigma and discrimination may result in denial of access
Women	• Social and cultural barriers resulting in low participation in investment and design decisions, although women and girls are often *de facto* managers of WASH services • Fear of violence when trying to access facilities • Menstrual hygiene is often not included in sanitation system design
Children & the elderly	• Often schools lack WASH facilities • Children may be at risk of falling into pits because pedestals/squat pans are not designed for children • The elderly may face physical challenges

One of the ways to address barriers to access is to use an inclusive design process, which allows vulnerable groups to give input on facility designs, e.g. ramps for wheelchairs, menstrual hygiene disposal facilities, child friendly taps, etc., and to suggest modifications where necessary, which may require specific budget allocations (Patkar & Gosling, 2011). Additionally, it is important to try and ensure that stakeholder groups, such as steering committees, are representative of groups who may be excluded due to gender, disability, ethnicity or religion (Greed, 2003; Patkar & Gosling, 2011).

The approach recommended by Patkar & Gosling (2011) is to 'mainstream equity' in sanitation services by applying an 'equity lens' to national monitoring frameworks and instruments using a set of 10 questions, with equity and inclusion related sub-questions. Overall, the main purpose of the framework proposed by Patkar & Gosling (2011) (Figure 2.6) is firstly to establish whether or not a country is using what is considered international good practice and following through with commitments regarding sanitation planning and program implementation. Secondly, the aim is to incorporate equity considerations through a polar question (yes/no) monitoring framework at various levels (national, regional and local) by examining budget allocations earmarked for vulnerable groups, designs that cater to those who may experience physical barriers, and representation in institutions responsible for service delivery.

1. Did they sign the eThewini Declaration and who signed it?
2. Is there a national sanitation policy?
3. Is there one national plan to meet the SDG** target?
4. What profile is given to sanitation within the poverty reduction strategy paper* (a document required by the International Monetary Fund and World Bank before a country can be considered for debt relief and a requirement from most major donors and lenders to low-income countries)?
5. Is there a principal accountable institution to take leadership?
6. Is there one coordinating body involving all stakeholders?
7. Is there a specific public sector budget line for sanitation?
8. Is 0.5% of GDP allocated to sanitation?
9. Is there a sanitation monitoring and evaluation (M&E) system?
10. Do institutional sanitation programs include gender sensitive and inclusive interventions?

*N.B. South Africa does not submit poverty reduction strategy papers given its status as a middle-income country.

** Question 3 was updated to reflect the SDGs which have succeeded the MDGs.

Figure 2.6: Proposed national sanitation equity monitoring framework (after Patkar & Gosling, 2011)

Luh, Baum and Bartram (2013) developed an index to measure progressive realisation of the human right to water and sanitation and inequalities based on rates of change rather than the level of achievement. While their study focused on demonstrating how the index could be used to measure inequities in water services, they also proposed four indicators which could be used for measuring progress in sanitation access which are:

i) Do national sanitation policies or strategies include specific provisions for vulnerable and marginalized groups?

ii) What is the estimated percentage of the sanitation budget that is targeted to address the sanitation situation of the poor?

iii) What is the rate at which the proportions of rural and urban populations with access to improved sanitation converge?

iv) What is the rate of decrease of the proportion of the population using an unimproved sanitation technology compared to the rate of decrease of the proportion of the population using shared sanitation (where the total population is classified into categories of unimproved, shared sanitation, and household sanitation)?

While the framework and indices produced by Patkar & Gosling (2011) and Luh, Baum and Bartram (2013) are helpful for guiding the assessment of equity in sanitation at a global and national level in terms of resource allocation and access (in a broad sense), the author proposes that finer detail and tailoring of assessments would be required at a local scale, which will be emphasised more in this thesis while bearing in mind the global context.

Haughton (1999) introduced five interconnected dimensions of equity that link environmental justice with sustainable development:

i) *Intergenerational equity* relates most closely to the Brundtland Commission (WCED, 1987) definition of sustainable development relating to meeting the needs of the present without compromising the ability of future generations to meet their needs or the 'principle of futurity' (Haughton, 1999).

ii) *Intra-generational equity* is associated with contemporary social equity or social justice that '[seeks] to address the underlying causes of social injustice, not simply dealing with redistributive measures' (Haughton, 1999:235). Levy (2009) similarly adds that using the lens of social justice to examine intra-generational equity importantly leads one to question in whose interest does redistribution (of responsibility, services and resources) take place using the example of the privatised water services that excludes poor people as a warning about the limits of redistribution without addressing underlying causes for inequity.

iii) *Geographical equity* or 'transfrontier responsibility' is concerned with connecting equity concerns from the local to global and ensuring that environmental costs are not simply passed on to someone or somewhere else (Haughton, 1999).

iv) *Procedural equity* "holds that regulatory and participatory systems should be devised and applied to ensure that all people are treated openly and fairly" and adds that a critical way to operationalise this form of equity is to ensure a general right to access information that would relate to making decisions with environmental consequences (Haughton, 1999:236).

v) *Inter-species equity* concerns the survival of other species and the need to preserve biodiversity and ecosystems "which reflect a broader concern with environmental stewardship" (Haughton, 1999:237).

Although not directly linked to sanitation, Haughton's principles of equity that need to underpin general sustainable development mentioned in Section 2.1 are worth elaborating further in relation to the equity dimensions that will be discussed subsequently. In particular, intra-generational, geographical and procedural equity are reflected in the equity dimensions of resource allocation, access and perception utilised in this thesis.

Looking at dynamics that result in disparities between different regions is important in order 'to direct support to those with the least influence or access to services' (Gosling, 2010:6). Levels of service and 'incremental upgrading'[35], which relates to the gradual improvement in human settlements in stages, are important concepts related to municipal service delivery in South Africa. For low-income residents, particularly those living in informal areas and those who qualify as indigents[36], a 'basic service' level is subsidised. Basic household services provided by the municipality are envisioned as part of a broader indigent policy to provide a 'social safety net' to address poverty and exclusion (DPLG, 2008). While differentiating levels of service and tariffs is fairly straightforward for services such as water supply and can be adjusted by flow rate and pressure; the process is not so straightforward for sanitation services. One of the main differentiations for different levels of sanitation service relates to whether or not the toilet is shared (communal or public) or by the type of technology. Jaglin (2008) highlights that a municipally controlled process of service differentiation, which enables 'social redistribution under public control', may help preserve the 'institutional and financial public capacity' to deliver subsidised services to the urban poor. There is, however, still 'a risk of locking deprived communities in substandard supply systems dissociated from premium networked areas' (Jaglin, 2008:1905). Therefore, careful attention must be paid to how to integrate sanitation services for informal areas into the city's overall sanitation system and development plans as part of an equitable system of delivery rather than reinforcing intra-urban inequalities.

2.4.2 Equity in resource allocation

Similar to sustainability, the definition of equity includes a degree of subjectivity depending on whose perspective is incorporated, and requires qualitative assessments for many aspects. There is, however, at least one aspect of sanitation service equity which can be quantified, which is to look at public resource allocation for different sectors of society or geographical regions (Table 2.12). Measuring financial expenditure by water service authorities on sanitation services for both capital and O&M costs (Criteria 1) across different regions of a city is one component of resource allocation which can be examined during M&E assessments. Another or complementary approach would be to look at the number of staff (Criteria 2) who serve either specific regions of a city, or as in the case of Cape Town, different residential typologies, e.g. Cape Town has created departments in both their utilities and human settlements directorates specifically for informal settlements (Section 4.3). The

[35] See Glossary of terms for further explanation.

[36] The DPLG (2008) (now CoGTA), defined indigent according to a 'lack of the necessities for life' such as sufficient water and sanitation rather than according to household income, whereas municipal indigent policies consider gross household income as a criteria for qualification, excluding informal households.

number of staff allocated to specific sectors relates to both human resources and financial resources, since employee-related costs generally constitute one of the highest proportions of municipal operating expenditure (Scott et al., 2012; NU, 2014). While the exact proportion of resources that should be spent in a particular area is open to debate[37], monitoring expenditure at a disaggregated level across different regions of a city can serve as an indicator of whether or not spending is commensurate with need or where there may be bottlenecks (NU, 2014).

Table 2.12: Equity assessment criteria for resource allocation

Criteria	**Indicator**
Resource Allocation	
1. Funds allocated for sanitation services	ZAR/HH
2. Number of staff	Staff/HH

The Minister of Water and Sanitation released the national budget for the department for the 2015-2016 financial year in May 2015 (PMG, 2015b) (Appendix 1F). The total departmental budget for water and sanitation programmes was R16,446,530,000, which represented approximately 0.36% of South Africa's estimated gross domestic product for 2015. Although that amount did not include some of the grant money that was intended for water and sanitation related infrastructure (see Table 2.3 for sources of public funding), it was well below the 0.5% commitment agreed to in the eThekwini Declaration (AMCOW, 2008) that was recommended to be specifically earmarked for sanitation and hygiene. Furthermore, it appears that the majority of programme funding was intended for water supply infrastructure rather than sanitation (PMG, 2015b).

One of the challenges of assessing this dimension of sanitation equity is that most government budgets fail to distinguish separate budget lines for sanitation and hygiene programmes from water, which is an unmet challenge to national governments mentioned in the eThekwini Declaration (AMCOW, 2008). Furthermore, in addition to a lack of disaggregated financial information between water and sanitation projects or formal and informal areas, even when the information is available access to it is often restricted by government officials for fear of negative political repercussions, indicating procedural inequity and a problem that needs to be addressed (Muller, 2016). A discussion on inequities in not only physical access to sanitation services, but inequalities in access to information and processes of decision-making will be addressed further in Section 2.4.2.

[37] Estimated financial and staff allocation for sanitation in informal settlements for each municipal case study is presented in Table 5.4: Comparison of municipal levels of sanitation service (CCT, 2009; EWS, 2010; CJ, 2010; Crous, 2014; EWS, 2014aa; CJ, 2014cb; CCT, 2014cc; EM, 2015d; JW, 2015ce)

2.4.3 Equity in access to sanitation

In addition to the need to examine resource allocation at a disaggregated level, unpacking coverage statistics, considering the needs of vulnerable populations and transparency in decision-making processes are also important to assess the equity of service delivery. Sanitation access in South Africa is measured primarily by counting the number of toilets per household and the type of sanitation technology with a differentiation between and urban and rural areas and the type of dwelling (Stats SA, 2012a). Assessing the condition of facilities and quality of service, however, is done on a more ad hoc basis, which means that while sanitation facilities may be present, the service may be dysfunctional or inaccessible. For example, on-site container based systems may become full before they are scheduled to be emptied leading people to resort to open defecation or to use a night soil bucket; or users, especially women and children, would be at risk of being attacked if they walk to communal facilities at night. The need to shift the focus of basic sanitation service provision towards emphasising the quality of service and desired outcomes such as reducing open defecation and improved hygiene behaviour rather than on the numbers of facilities provided has been highlighted previously in reports on the status of sanitation services in South Africa (Mjoli et al., 2009; SAHRC, 2014b). Furthermore, examining who has access to what and how that is decided is an important equity consideration with potential generic criteria presented in **Table 2.13**.

Table 2.13: Equity assessment criteria for access

Criteria	**Indicator**
Access	
1. Number of functioning sanitation facilities	Toilets/HH
2. Measurable disparities in access	Access ratios between genders, urban/rural area; income bracketss
3. Needs of vulnerable groups considered including MHM	Qualitative
4. Fair decision-making including accessibility to information	Qualitative

An additional consideration in the regarding access to sanitation services in South Africa and other countries with differentiated levels of service are the socio-political underpinnings of different groups receiving different levels of service. A study focusing on politics and sanitation conducted in Mumbai's informal settlements linked better sanitation services and accelerated delivery to political patronage and religious affiliation, running the risk of marginalising minority groups and preventing meaningful participation (McFarlane, 2008). Recommendations for the assessment of the sustainability and equity of a sanitation service as part of the O&M activities to ensure that vulnerable or minority groups are not being excluded will be discussed further in the case studies in Chapter 4.

Although national statistics on sanitation do not include the condition of the sanitation facility, they do indicate some of the disparities that need to be considered, which are often correlated to race, gender and where a person lives. Figure 2.7 shows the type of sanitation facility used by different population groups from the 2013 *General Household Survey* (Stats SA, 2014a) results, and demonstrates the disparities that still exist between different racial groups, e.g. the group with the highest proportion of the population in South Africa with below basic standards for sanitation facilities identifies as 'Black African'.

Additionally, there is also a statistically significant relationship[38] between the gender of the head of the household and access to a sanitation facility, e.g. a higher percentage of female headed households lack access to sanitation than male headed households as shown in Figure **2.8**. Furthermore, a higher percentage of male headed households have access to flush toilets, which is considered the highest level of service. There are also noticeable disparities in the type of sanitation facility between urban and rural areas and formal and informal areas as shown in Figure 2.9. People living in urban formal areas are the most likely to have access to at least a basic level of sanitation service or higher, while people living in traditional areas are the least likely. (N.B. Traditional areas may include peri-urban areas in municipalities such as eThekwini which incorporated areas formerly considered as 'homelands[39]' under the apartheid government.) Although urban informal areas appear to have the second highest percentage of people with access to a basic level of sanitation service, access is more likely to be in the form of shared or communal sanitation facilities than in other settlement types.

[38] The chi-squared test was performed to test for statistical significance for *p*-value 0.05 based on publicly available data from StatsSA, 2011.

[39] Homelands under the Apartheid government were areas designated for black South Africans, and were part of the government's strategy to remove black South Africans from urban areas. They were designated as separate administrative regions to the rest of the country or 'white South Africa' and reinforced segregationist policies.

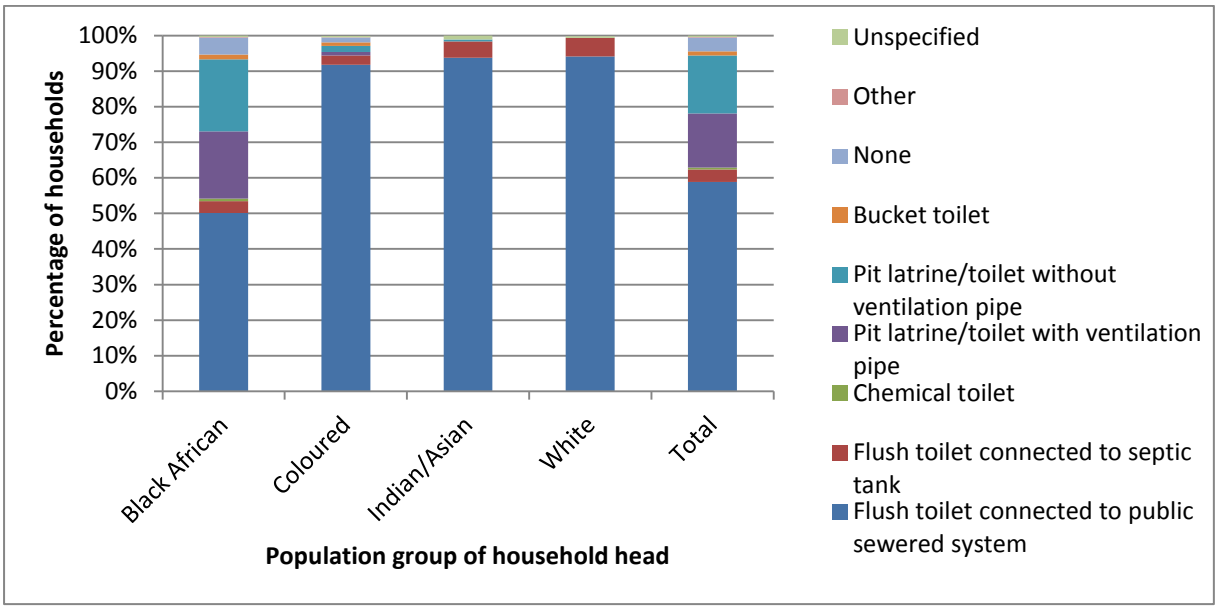

Figure 2.7: Sanitation facility usage by population group represented by the head of household (after Stats SA, 2014a)

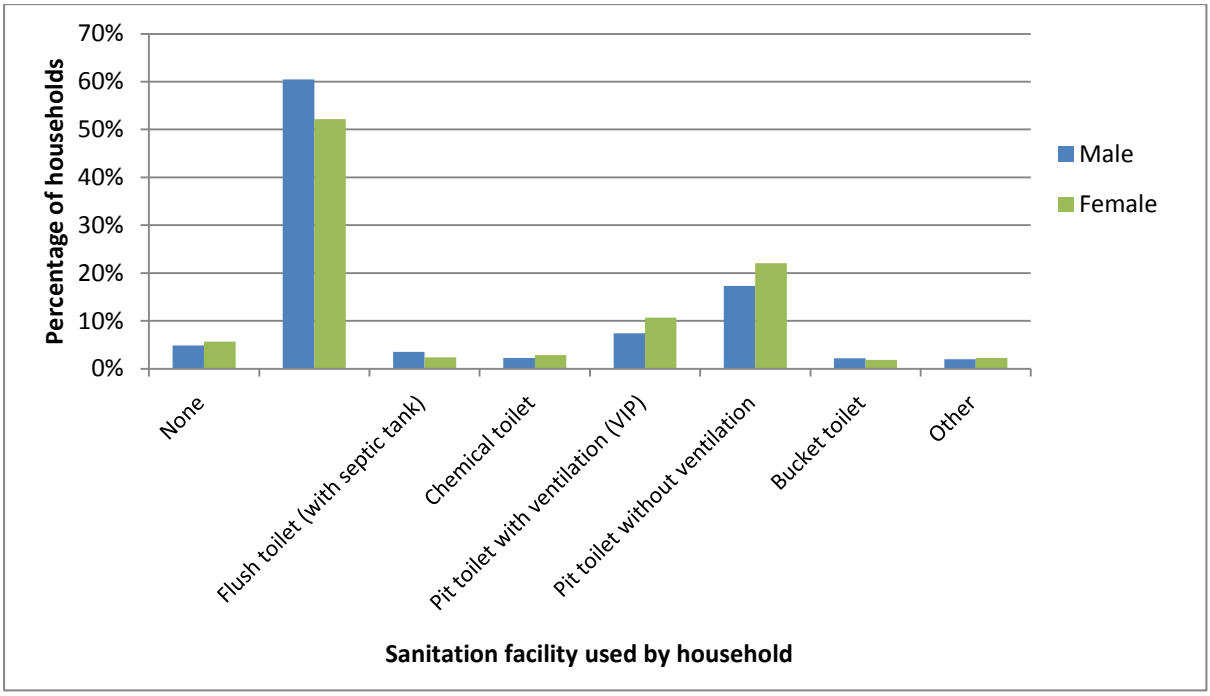

Figure 2.8: Sanitation facility usage by gender of household head (after StatsSA, 2013)

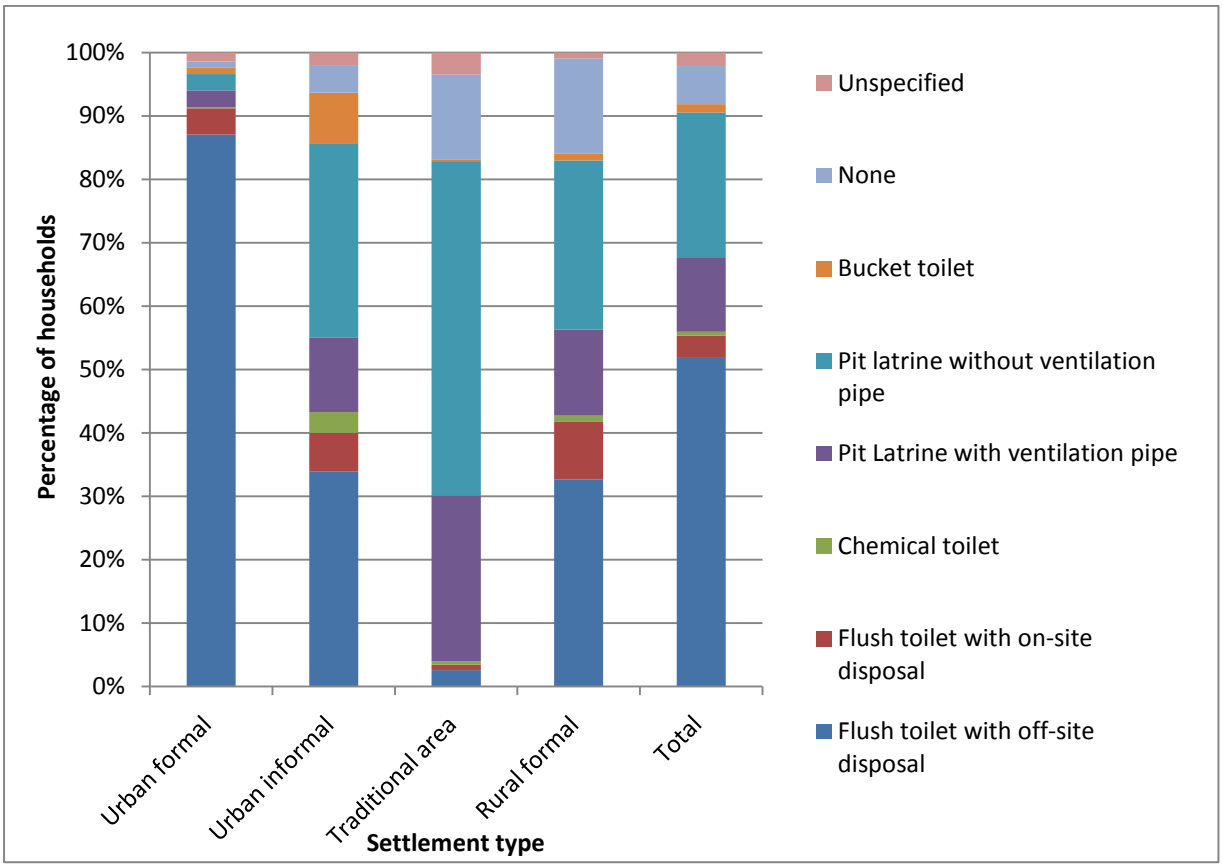

Figure 2.9: Sanitation facility usage by settlement type (after Stats SA, 2011)

The sanitation situation in South Africa is inequitable as demonstrated by Figure 2.7 – Figure 2.9 in terms of physical access to services and the LoS provided in different regions to different racial groups. There are historical reasons for this, but there are also underlying tensions between some of objectives of sustainability and equity that also contribute to the perpetuation of inequities and negative perceptions of alternative sanitation systems, which will be discussed in Section 2.4.4.

In addition to inequities in access to a basic LoS, there is also an issue in terms of social inequity and exclusion of vulnerable groups for social reasons or failure to include their needs in design of facilities. Although 'gender mainstreaming' in policy and service development has been a topic of discussion for decades internationally and in South Africa (Levy, 1996; Morna, 2000), in practice, it is rarely observed to influence the design of sanitation services in informal settlements. For example, the distribution of menstrual hygiene products to indigent women has been promoted in South Africa through the Sanitation is Dignity campaign by national government (WIN-SA, 2012), but without a system for MHM in place, disposal of menstrual hygiene products can end up having an negative impact on sanitation systems (Truyens et al., 2013). Furthermore, the objective of promoting dignity for women cannot be accomplished with the distribution of sanitary products alone without adjusting infrastructure design to facilitate MHM (WIN-SA, 2012).

Accessibility of sanitation to people with impaired mobility is another consideration that needs to be made when assessing the equity of access to sanitation services. One of the key inclusive design principles is to ensure that the built environment does not impose disabling barriers with specific recommended design features such as support rails, modified seat designs and ramps instead of steps (Jones & Reed, 2005). The challenge in providing sanitation services to low-income areas is that 'non-standard' designs or higher levels of service may come with additional costs that are not budgeted for or unfamiliar to stakeholders which is where wider dissemination of information is important.

In addition to the physical barriers to accessing sanitation, a lack of information relating to what sanitation system alternatives exist, costs, associated O&M responsibilities and regulatory frameworks can also pose as a barrier to accessibility. While participatory processes[40] have been promoted as a way address this barrier to make decision-making around services more inclusive, a significant challenge still often exists in trying to bridge the gap between what is deemed realistic and possible between different stakeholder groups. This disconnect will be discussed in Section 2.4.4.

2.4.4 Perceptions of equity in sanitation

Sanitation as dignity has been connected to concepts of urban citizenship and modernity (Morales, Harris & Öberg, 2014:2816; Robins, 2014). 'Water is life and sanitation is dignity' is a slogan that has been widely promoted in the South African water sector which was adopted in the 2003 Strategic Framework for Water Services. Linking sanitation to dignity ties it into the broader human rights argument for basic services (George, 2008). While the association between basic services and human rights has many merits, there is a potential disconnect 'between sanitation expectations' and 'the practices required by proposed sanitation solutions' (Morales, Harris & Öberg, 2014).

This difference often plays out in relation to urban residents' association with sewered systems as a 'signal of wealth and political power' (Morales, 2016) and something to aspire to (Robins, 2014) which has been observed in countries with rising (albeit unequal) standards of living such as Argentina, Inner Mongolia (an autonomous region in China) and South Africa (Rosemarin & Han, 2012; Morales, Harris & Öberg, 2014; Robins, 2014). Morales, Harris and Öberg (2014:2823) trace the primary cause for this disconnect or 'urban sanitation imaginary' to 'a feeling that a citizen should be disassociated from their excreta and related management processes'. The effects of relative deprivation (Duckitt & Mputhing, 2002; Posel & Casale, 2011) also likely influence negative perceptions towards non-sewered sanitation systems in the South African context. The correlation between flush toilets and higher status will be discussed further in Chapter 4. Four expectations for urban sanitation systems were identified by Morales, Harris and Öberg (2014) in a case study of a low-income urban community in Argentina:

[40] An example of this are the social audits of facilities conducted in Khayelitsha (SJC, 2013) or the community enumerations conducted by SDI affiliates (Bradlow, 2013).

i) an urban citizen does not engage physically or mentally with their faeces or its management,

ii) an appropriate urban sanitation system requires flushing,

iii) systems that require a user's engagement with their faeces and its management signify rural, underdeveloped, and backward lifestyles, and

iv) urban sanitation is a state responsibility, not a local one.

In South Africa, similar expectations for flush toilets have been observed (Matsebe & Osman, 2012; Taing, 2015), which has a potentially negative effect on the socio-cultural sustainability of non-sewered sanitation systems.

Beyond the disconnect between users' expectations for flush toilets and the ability of the state to provide them, Taing (2015) highlights the need to consider the often 'conflicting rationalities' at play amongst a wide range of stakeholders (Table 2.8) who may have vastly different views on what an equitable (and sustainable) sanitation service should look like. The need to incorporate the perceptions and perspectives of different stakeholders' in equity and broader sustainability assessments will be discussed in Section 3.3 as part of the research methods employed in this thesis. Potential assessment criteria for the equity of sanitation services relating to various stakeholder groups are presented in Table 2.14. Criterion 1 addresses the concern with dignity mentioned earlier and Criterion 2 relates to the need to consider various perspectives on what sanitation services should look like, even if it is not achievable in the short-term.

Table 2.14: Equity assessment criteria for perceptions of sanitation

Criteria	**Indicator**
Perceptions	
1. Meets users' notions of dignity	Qualitative
2. Perspectives of key stakeholders are integrated	Qualitative

2.5 Summary and conclusions

As described in the preceding sections, sustainable sanitation has multiple dimensions that need to be considered. Equity in relation to sustainability is an area that has not been given sufficient attention in sanitation service delivery although it overlaps strongly with socio-cultural sustainability criteria, in particular the dimension of perceptions used in this thesis. There may however be conflict between economic development and environmental protection goals (Figure 2.1). The definitions of sustainability and equity incorporate a high degree of subjectivity, which is one of the major challenges with trying to measure whether goals are being met or not and to what degree. Thus, the importance of including the perspectives of multiple stakeholder groups in planning and assessing sanitation services was

discussed in the literature review, and will be examined further in the case studies in Chapter 4.

In relation to the context being considered in this thesis, socio-economic inequality is one of the defining features of South Africa in the present day, which is one of the primary reasons that equity is highlighted in relation to sustainability in this thesis. These inequalities are especially visible in urban areas. The urban informal settlement context is defined in many ways by social and economic deprivation and exclusion, and thus increasing equity in access and the quality of service should be one of the primary objectives of sanitation service delivery programmes in these areas. Different approaches to sanitation service delivery in informal settlements will be assessed and compared in the three selected case study municipalities utilising the six dimensions of sustainability (environmental, economic, technical, socio-cultural, health and hygiene) and three dimensions of equity (resource allocation, access and perceptions) discussed, which have been tailored to the South African context. Ideally, all sustainability and equity dimensions mentioned in the literature could be addressed simultaneously; however, given multiple constraints which will be discussed in the case studies, some dimensions are likely to be prioritised over others in the short-term requiring trade-offs between different dimensions of sustainability and equity (to be discussed in Chapter 5).

3 Research methods

This chapter describes the methods used to conduct the research including the literature review, field research and methods of data collection and analysis described.

3.1 Literature review

The literature review took place concurrently with data collection and was utilised to explore existing frameworks for understanding sustainable sanitation, to identify knowledge gaps, to contextualise sanitation service delivery in urban informal settlements in South Africa and to identify and discuss various dimensions of sustainability and equity in relation to sanitation services. Existing planning tools were investigated in relation to their incorporation of sustainability and equity principles. Frameworks for assessing the sustainability and equity of planning and managing sanitation systems were reviewed to assess their relevance to the South African context. Policy documents pertaining to water and sanitation service levels, technical guidelines, national and municipal assessment tools such as the COGTA Key Performance Indicators and municipal corporate scorecard were also consulted, to provide information on the policy context for sanitation provision in municipalities as a whole, and for informal settlements in particular. A combination of resources including journal articles, news articles, reports and policy documents were reviewed. As it became clear that equity – a key component of social sustainability – was a critically important issue that needs to be addressed in the South African context, more attention was given to this issue.

3.2 Data collection

Both primary and secondary forms of data were collected. Table 3.1 shows the categories of data collected and the purpose for collection. The data collection took place between July 2012 and May 2015 and included both quantitative and qualitative data. Interviews were conducted in order to get a better understanding of the knowledge, opinions and perspectives of stakeholders in different sectors involved with decision-making and steering the development of sanitation services and their conceptual understanding of sustainability and equity. 46 unstructured interviews were conducted: two with provincial government officials, 29 with municipal (local) government officials (14 from Cape Town, 8 from Johannesburg, 6 from eThekwini, 1 from Ekurhuleni) one with a national government official, one academic, ten with representatives from NGOs, and three with representatives from the private sector. The interviews were recorded, transcribed and then coded using Nvivo software[41] according to categories relating to sustainability and equity of sanitation services, with broad categories around institutions, politics and governance, environment, health, social, and economic issues with sub-categories*, e.g.* cost, design, safety and participation. A full list of 'nodes', i.e.

[41] Nvivo is a software program developed by QSR International to assist with qualitative research analysis. Research material (documents, photographs, audio files, etc.) can be imported or entered directly into the program. Nodes are 'containers' for gathering related material together 'to look for emerging patterns and ideas' (QSR, 2014).

coded references used to tag specific themes, is included in Appendix 1I in addition to the list of interviewees. A 'snowball sampling'[42] method (Morgan, 2008) was employed to expand the network of interviewees from initial contacts. In addition to the unstructured interviews, informal conversations with residents of informal settlements including two group discussions facilitated by the Social Justice Coalition (SJC) and the Community Organisation Resource Centre (CORC), and visits to 17 informal settlements in the Cape Town (7), eThekwini (4) and Johannesburg (6) surrounding areas between 2012-2015 helped contextualise perspectives, priorities, and barriers to sustainability and equity in the implementation of sanitation services. Photographs and field notes from observations and conversations with residents were then used to assist with description and for identifying dimensions of sustainability and equity that were or were not being addressed. Examples of field notes and a transcribed interview are given in Appendix 1J.

Table 3.1: Various types of data collected for case studies

Data type	Data collected	Purpose
Primary	Photographs taken during field visits	Visual aid for detailed description of conditions in informal settlements
	Field notes	Understanding context for lived reality in informal settlements, and environmental conditions
	Unstructured interviews with sanitation stakeholders	Perspectives and priorities of sanitation professionals relating to concepts of sustainability and equity
	Informal conversations and group discussions	Supplementary information mentioned outside of interviews, in one on one and group discussions, especially with informal settlement residents to reveal perspectives and attitudes towards sanitation services
Secondary	News articles	Adding to contextual information on current events and public perception around sanitation services
	National census data	Providing national and provincial statistics on water and sanitation access and household demographics (equity and access)
	National treasury reports	Providing budgetary information for water and sanitation programmes and projects (economic sustainability/resource allocation)
	Municipal reports	Municipal statistics on water and sanitation access, costs for different types of sanitation services, O&M issues, customer satisfaction (equity/sustainability assessment)
	Reports from NGOs	Detailed household level self-enumeration data and progress on projects related to housing and service upgrades (equity and access)
	GIS data for municipalities	Spatial information on the location of informal settlements and facilities to assist with equity assessments

The secondary data was collected using publicly available records such as the national census data or national treasury reports and also unpublished reports. Although some

[42] In snowball sampling, the initial pool of interviewees introduces the researcher to acquaintances in their social networks who could potentially contribute to the study.

municipal reports were available, such as those linked to the IDPs and WSDPs, other documents were unpublished and had to be requested from municipal departments of water and sanitation, human settlements, and environmental health. As with the municipal reports, some of the reports that came from NGOs were published, whereas other reports and documentation were unpublished and had to be requested from personnel working at the NGOs. Some of the GIS data sought after, such as the location of water and sanitation facilities in informal settlements could not be obtained for eThekwini and Johannesburg municipalities due to concerns over information being misused for political agendas in the case of eThekwini, or because the information was not available in the case of Johannesburg. Given that the author was based in Cape Town, there was more opportunity and time to acquire data for Cape Town, and thus the most complete GIS dataset was obtained for this city.

3.3 Method of analysis

Various methods of analysis were employed to bring cohesion to the combination of qualitative and quantitative data obtained and to build a systemic view of sanitation services at different scales. Post-1994 national policies that were either directly related to or indirectly influenced sanitation service delivery were reviewed in Section 2.3.4.2 as part of the literature review. A timeline was created to assist with mapping out important policies and to make links with events that influenced policy development (Figure 2.4). Policy changes over time pertaining to basic sanitation services were also investigated to provide a policy context for sanitation services in informal settlements analysed in the case studies.

Conceptual mapping provided a way to integrate information visualisation with knowledge acquisition and sharing (Canãs et al., 2005), and was used to 'illustrate relations, identify patterns, [and] present an overview and details' of complex issues arising in water and sanitation projects (Tiberghien et al., 2011). The primary sources were coded[43] by themes using Nvivo software and a summary of nodes (coded themes and key words) is provided in Appendix 1I. Coded statements from the various sources of data were used to construct conceptual maps as a way to visualise the information provided from the field observations, interviews, informal conversations and documents such as news articles and municipal reports to show relationships between key themes that emerged around the different dimensions of sustainability and equity identified in sanitation services and factors influencing service delivery in informal settlements.

Case studies formed the core of the analysis, and a comparative case study approach was taken. The case study methodology was selected to root the research in real-life experiences and practice, and to delve into some of the issues and complexities of using, planning, implementing, operating and maintaining sanitation services in informal settlements. One of the criticisms of case study methodology is that generalisations are difficult to draw from a limited number of case studies, and secondly the reliability of

[43] Coding in the Nvivo software refers to 'the process of gathering material by topic, theme or case. For example, selecting a paragraph about water quality and coding it at the node "water quality"'(QSR, 2014).

explanatory theories derived from case studies is difficult to verify due to non-standardised methods of data gathering (Yin, 2003). As argued by Stake (1998), however, 'As a form of research, case study is defined by interest in individual cases, not by the methods of inquiry used'. As mentioned in the introduction, sanitation service provision in the context of informal settlements is still an emerging field of research; thus, the exploratory nature of case studies is well-suited to the primary research aims to analyse dimensions of sustainability and equity in relation to sanitation services and to explore how sustainability and equity can be applied as conceptual frameworks to improve sanitation service delivery in informal settlements. A major feature of case study methodology is that different methods are combined in order to examine a case from different perspectives so as to 'triangulate' the output by combining methodologies, collaborations between different researchers, and potentially data sources, and theories (Johansson, 2003). As part of the research process, and to support an ethical approach to research using human subjects, interviewees were given a chance to review information shared during the interviews prior to inclusion in the case studies.

The case study unit of analysis was sanitation services for informal settlements provided at a municipal level. The municipality was chosen as the unit of analysis because under South African legislation, municipalities (local government) are given primary responsibility for providing water and sanitation services. The three most populous municipalities in South Africa, with the largest number of informal settlement households, Cape Town, Johannesburg, and eThekwini, were selected as case studies. All three are metropolitan municipalities and have some of the largest sanitation service backlogs in their respective provinces. Metropolitan municipalities are the most autonomous category of municipality and thus were useful for focusing the case studies on municipal approaches to sanitation service provision as opposed to smaller municipalities which are often more reliant on assistance from provincial and national governments. These three case studies were selected due to: the large scale of service delivery required, availability of municipal data, varied geographic and climatic conditions, range of sanitation technologies used, O&M routines and institutional arrangements employed. From the GIS data that could be obtained from the different municipalities, land area, housing density, and type of water and sanitation service provided were analysed and compared across different regions of the municipalities to identify any observable trends in the level of service provided. Detailed tap and toilet survey data, including the location of facilities, in informal settlements were obtainable for 2011 and 2013 for the City of Cape Town only; thus a more detailed analysis of progress in sanitation service delivery could be conducted in Cape Town than in the other two municipalities.

Embedded cases were selected to highlight the sustainability and equity of various aspects of sanitation service delivery. For eThekwini municipality, the embedded unit of analysis were the Communal Ablution Block (CAB) and Urine Diversion Dry Toilet (UDDT) programmes, which have been provided in peri-urban and dense informal settlements. Those two programmes form the basis for eThekwini's approach to sanitation service delivery in informal settlements and will be discussed in Section 4.1.5. For Johannesburg municipality, the embedded unit of analysis was the Diepsloot pilot wastewater recycling CAB, which is one of the pilot on-site sanitation systems that the municipality is testing for suitability in

informal settlements and is discussed in Section 4.2.5. For Cape Town municipality, the embedded unit of analysis was the participatory reblocking approach used in Mtshini Wam informal settlement, which was part of a pilot programme to use reblocking as a method for in situ upgrading of informal settlements to improve living conditions, such as water and sanitation services and is discussed in Section 4.3.5. Different scales for programmes versus pilot projects were selected for the embedded cases in part due to data and time limitations, but also to demonstrate the applicability of the evaluation guidelines presented in Section 3.3.1 which were developed out of the case studies.

A template was developed to describe the status quo of water and sanitation services, institutional arrangements for managing sanitation services in informal settlements, the levels of service used in each municipality and for assessing the sustainability and equity of the selected programme or project. The municipalities' overall approaches to sanitation service provision in informal settlements were compared and evaluated according to factors that hindered or supported the sustainability and equity of the selected case before moving to focus on specific embedded cases. An embedded unit of analysis within each case study was either a specific project or programme implemented within informal settlements in each municipality and was used to 'suggest clues to possible cause-and-effect relationships' (Yin, 2003:69). The embedded cases could go into greater depth and detail about project or programme specific issues hindering sustainability and equity that could be used to inform decisions about whether or not to expand a specific project or programme and how to improve it.

3.3.1 Framework used for evaluating sustainability and equity

The framework for assessing the sustainability and equity of a sanitation programme or project presented here was developed for the case study analysis and to complement existing decision-support tools and M&E assessment frameworks used in South Africa (Appendix 1V). As noted in Sections 2.3 and 2.4, sustainability and equity are difficult to define, but identifying some criteria for assessing progress is possible and useful, although the costs versus benefits of collecting data for each criterion needs to be considered prior to starting an assessment. The focus should not specifically be on collecting data, but rather to ascertain what is pertinent and useful for the purpose of improving the sustainability and equity of the given sanitation service being assessed. The assessment findings can be used to adjust the sanitation service or as input for planning a future service delivery project (Step 5 in Figure 3.1).

Step 1. Determine the purpose of the evaluation

The purpose of a sustainability and equity assessment can be manifold, e.g. to assess a specific technology as with the Technology Assessment Framework described in Table G.1a1 (Appendix 1G) to compare different programmes, or to monitor O&M. Once the purpose is determined, then appropriate assessment criteria and methods can be selected. The evaluation

should be able to assist decision-makers with answering specific questions relating to the intended purpose so that actions can be taken (Cotton, 2000). For example, for the case studies the purpose was to evaluate the application of sustainability and equity principles.

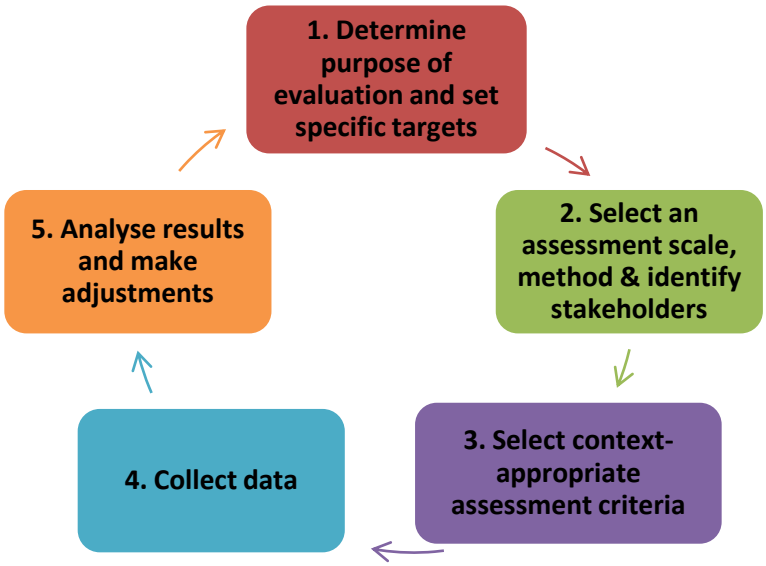

Figure 3.1: Guidelines for assessing the sustainability and equity of sanitation services

Step 2. Select an assessment scale, method and identify stakeholders

It is important to choose at what scale the assessment is taking place to determine appropriate performance assessment criteria within the selected scale. A proposed scale for considering three dimensions (institutional, spatial and temporal) to assess the sustainability and equity of sanitation services within is presented in Figure 3.2. As important as the selection of the assessment scale is the method of assessment that will be used. There are several methods of inquiry that can be used such as the case study approach that was used in this thesis.

Identifying which stakeholders will be conducting the assessment or consulted as part of the assessment is also critical to the assessment. Stakeholder analysis tools, which have been used widely in the public health field (Schmeer, 1999) can assist with identifying key stakeholders and their potential influence on the sustainability and equity of a sanitation service. Perspectives of different stakeholders are important to incorporate into the assessment as suggested by Olschewski (2013). In this thesis, the primary stakeholders identified were residents of informal settlements (users), NGOs, service providers and government officials.

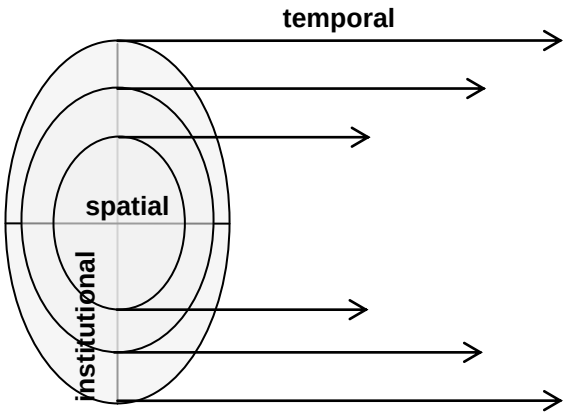

Figure 3.2: Dimensions of assessment scale

3. Select context-appropriate assessment criteria

There are variety of sustainability and equity assessment criteria that can be used, some of which were presented in Sections 2.3 and 2.4 . There is a cost associated with collecting information for training, travel, labour, materials, thus the availability of information and resources available for getting data for various criteria needs to be taken into consideration when selecting assessment criteria. The categories of sustainability and equity identified previously were used to assess the case studies presented in Chapter 4.

4. Collect data

Collecting the data for the various assessment criteria can be completed by various stakeholders depending on what type of data is sought after and what type of training and equipment may be necessary to collect it. For example, much of the data used for this thesis was collected internally by regulators who are typically municipal officials in South Africa based on existing information in the water and sanitation or other municipal departments. Or, it may be more expedient to hire external consultants (Cotton, 2000) to assist where either time or skills and capacity are not available within the municipality. There are also instances where other stakeholders may be better positioned to collect and provide data such as with the enumeration surveys conducted by NGOs and informal settlement residents for re-blocking.

Various costs are associated with data collection, and will vary by region[44]. One way to reduce assessment costs would be to use internal M&E capacity if available rather than hiring external consultants or paying for external facilitators, but there is also an opportunity to train users to assist with assessments. Therefore, the costs and benefits of capacity building and training as opposed to adding responsibilities to existing regulatory M&E officers, or

[44] As a ballpark figure, applying the TAF as performed in Ghana over a three day period came to an average of US$3,000 per assessment with the majority of costs associated with labour costs, salaries for the TAF facilitators and allowances for participants who were coming from outside the assessment district (Olschewski, 2013).

external consultants should be compared. There are also opportunities to involve the academic sector, e.g. university students could assist with assessments as part of their coursework or training on a volunteer basis or for paid internship. For example, eThekwini Municipality has a contract with the University of Kwa-Zulu Natal to assist with surveys of UD toilet users in rural areas (Gounden, 2015, pers. comm., 20 May), and the University of Cape Town Architecture and Urban Planning department has participated with residents from several informal settlements and the NGO CORC on 'design studios' including mapping out the settlements and developing models for incremental upgrading (Tshabalala & Hendeler, 2014).

5. Analyse results and make adjustments

The final part of the assessment is to analyse the data and compile it into an assessment report that can assist decision-makers to make adjustments to existing sanitation services and/or to inform future sanitation service projects, e.g. whether or not to expand a pilot project or not and under what conditions. Depending on the nature of the assessment, whether it is more quantitative or qualitative or mixed, verification methods for the assessment results will vary. For example, using conceptual maps is helpful for identifying linkage between problems and effects as well as for drawing connections and conclusions where results are not easily quantified as demonstrated in the case study. Conceptual maps that help with visualising relationships between different issues and sustainability and equity concerns can be used to complement existing matrix based assessment frameworks such as the Olschewski (2013) technology assessment framework. One caveat is that verifying or validating qualitative data analysis, may be more time consuming and less straight-forward than quantitative data analysis, and less familiar to stakeholders with a primarily technical background. Two potential methods are to have a third party review the analysis: either through respondent verification, i.e. returning to study participants and asking them to validate analyses or, through peer review, 'whereby another qualitative researcher analyses the data independently' (Burnard et al., 2008). Ideally, this would have been possible for this study, but when study participants were asked to validate analysis results from case studies, the author received no responses likely due to their lack of availability. (N.B. Leaving more time and getting a commitment from participants earlier would have been helpful for this final step to help with the verification process.)

Adjustments can be made based on the assessment of sustainability and equity with priority given to the criteria that score the lowest or areas that are identified as the most critical for improvement of services by the stakeholders involved with the assessment. It is important to try and identify root causes various problems detected rather than identifying symptoms. A timeline should be set for remedial actions as well as clarity linking remedial actions or redesign of the service or facility to specific problems for short-term, medium-term and/or long-term objectives. Again with this last step, the recommendations for adjusting sanitation services are limited by the level of decision-making authority given to the assessor. However, dissemination of results can potentially assist with advocating for the need to make adjustments.

Steps 1-5 were applied to the case study evaluations presented in the next chapter, except for getting verification and making adjustments to sanitation services and programmes due to the limitations mentioned by the author, which primarily related to insufficient time to get verification from all research participants (and potentially lack of interest on their part) and no decision-making authority as a researcher to deliver sanitation services on the ground.

3.3.2 Applications for the framework

The framework developed through the case studies was generalised by design, with the intention that assessments for sustainability and equity could be undertaken by a variety of stakeholders in different institutions and at different scales. The guidelines were written intentionally to supplement existing water and sanitation service M&E tools in South Africa (Appendix 1V), since the primary focus of those tools is not on sanitation services. In the South African context, municipalities are the most likely institution to be responsible for regular M&E of water and sanitation services. There are, however, opportunities for users to participate in M&E as well as NGOs, who may also find the guidelines helpful if conducting their own sanitation service sustainability and equity evaluations. Specific assessment criteria need to be determined for the purpose of the evaluation as well as based on available resources. Selecting appropriate assessment criteria can be a multi-stakeholder process, and is a good way to get stakeholders engaged and actively thinking about sustainability and equity issues. The main objective is, therefore not so much on selecting the perfect set of indicators, but rather on promoting a 'reflective learning process' (Scott et al., 2008), and to identify areas that need improvement to be linked with remedial actions.

Potential sustainability and equity criteria from existing international assessment frameworks as well as some tailored to the South African context were presented in Table 2.1, Figure 2.6 and in Appendix 1G. The framework promotes the need to follow-up with adjustments to services after an evaluation if areas are identified as unsustainable or inequitable, which may require a physical re-design of facilities, increased investment in a particular part of the sanitation chain, or a revised policies and financial or management models. The ultimate purpose for conducting the evaluation should be to improve the quality of sanitation services in informal settlements to meet multiple objectives (health, environmental protection, convenience, security, etc.) according to sustainable and equitable principles as described in Sections 2.3 and 2.4.

3.4 Summary

Through the literature review process and comparative case study analysis, it became evident that one of the key aspects of sustainability in sanitation that was missing in the context of urban informal settlements is the need to address service inequities particularly around access, resource allocation and perceptions. The type of data collected and the method of analysis including the framework developed for assessing programmes and projects within the case studies were presented in this chapter. The next chapter begins with an introduction

to the spatial and institutional scale and time frames discussed in each case study, followed by the case studies for eThekwini, Johannesburg and Cape Town municipalities.

4 South African Municipal Sanitation Case Studies

Case studies in the three largest metropolitan municipalities in South Africa are presented in this chapter. Each municipality's approach to sanitation service delivery in informal settlements is discussed. Each case study presents an overview of the sanitation status quo, service delivery planning, institutional arrangements and levels of service and concludes with an assessment of selected projects and programmes using concept maps to visually represent various dimensions of sustainability and equity.

The spatial and institutional scales referenced in the case studies are presented in Figure 4.1. As mentioned in Section 2.3.4.2, municipalities have been given the legal responsibility to ensure that water and sanitation services are provided to residents, although provincial and national government are still expected to offer support and regulatory guidelines, *e.g.* the FBSan policy. The municipality includes wards, settlements and households, which respectively correspond to political, administrative and social units.

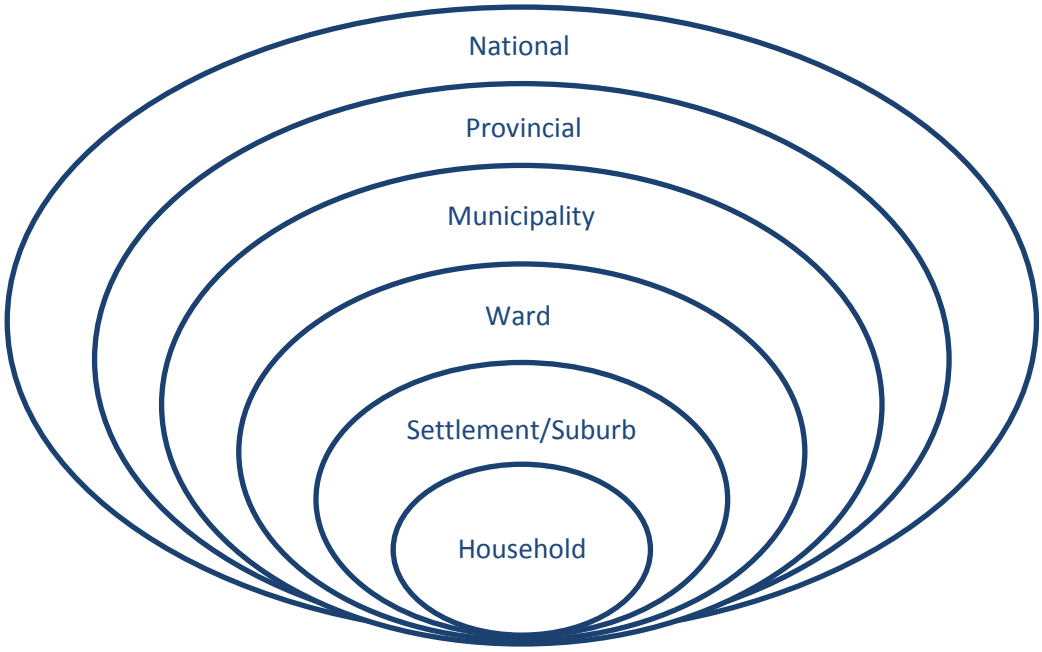

Figure 4.1: Spatial and institutional levels in South Africa starting with households (after IWA, 2006)

The time scale for service delivery is also an important consideration. The time frames referenced in the case studies are shown in Figure 4.2. In South Africa, national and municipal elections take place every five years[45], which is the same time scale used for the Integrated Development Planning frameworks (IDPs) that fit into the short to medium term category. The long-term planning time frame (30+ years) is based on the time scale that was

[45] N.B. at present national and municipal elections are not synchronised, which can result in major political shifts at intervals shorter than every five years, *e.g.* the last national elections were in 2014, while municipal elections are in 2016.

used for long-term visioning exercises undertaken by Cape Town, Johannesburg and Durban, which will be discussed in relation to their impact on sanitation service planning for each municipal case study.

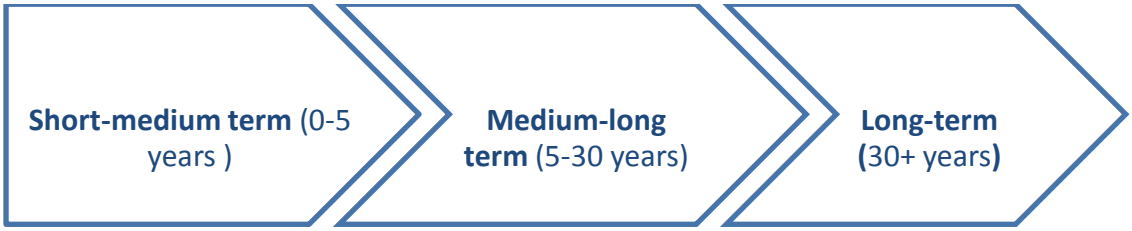

Figure 4.2: Planning time frames

A level of service (LoS) framework is used in South Africa for most utility services in the country with generally three levels of service that can be roughly categorised as 'emergency' and/or 'basic', 'intermediate' and 'full' with occasional overlap between emergency and basic levels of service. This differentiated level of service approach applies to the type of sanitation service that informal settlements receive. The LoS is determined by several factors that will be discussed. An overview of the LoS, sanitation service delivery status and strategies to address backlogs in informal areas will be discussed in each case study. Figure 4.3 shows the location of each municipality.

Figure 4.3: Map showing: Cape Town, Johannesburg, Durban (eThekwini) (Google Maps, 2016)

eThekwini municipality is discussed first, followed by Johannesburg, then Cape Town. eThekwini has a much larger proportion of the population categorised as rural than the other two municipalities, as well as tribal authority governance structures to co-govern with, which

presents an interesting case demonstrating the challenges of urbanisation and how institutional issues can affect service delivery. Johannesburg is notable for its formation of municipal owned entities (MOEs) that were created in 2001 as a response to a financial crisis in the municipality, which has a significant impact on institutional arrangements and strategic planning. In Cape Town, sanitation services in informal settlements have become a political focal point (Section 2.3.7). Backlash from 'top down' methods has led to more participatory responses to service delivery from the local government. Each case also includes an embedded case study of a specific project or programme that highlights various dimensions of sustainability and equity. The chapter concludes with a brief summary of the case studies.

4.1 eThekwini Municipality

4.1.1 Introduction

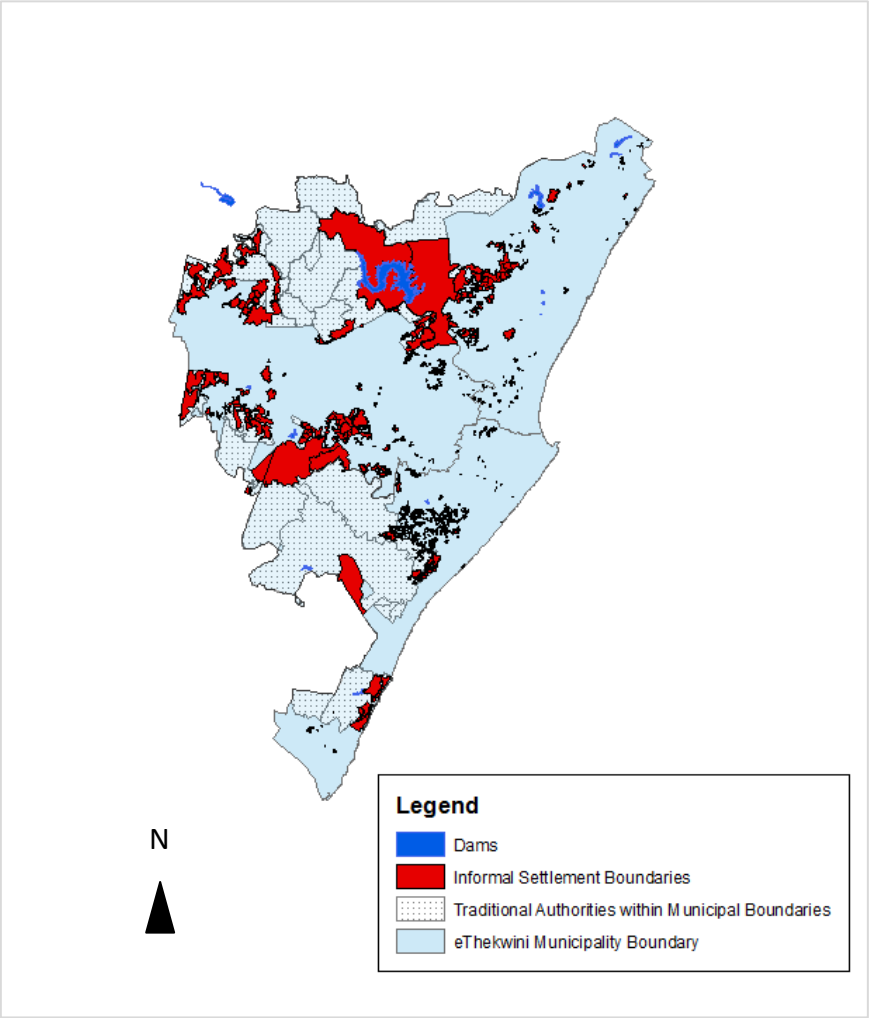

Figure 4.4: Map showing tribal authority areas and informal settlements in eThekwini municipality (EM, 2015a)

eThekwini municipality (EM) is located in Kwa-Zulu Natal province on the east coast of South Africa. It is the third most populated municipality in South Africa (Stats SA, 2012b) and has a humid sub-tropical climate. (N.B. Durban is often used interchangeably in reference to the municipality since it is the largest municipality that was incorporated into eThekwini as part of municipal restructuring in 2002.) EM is recognised as a sector leader in delivering water and sanitation services nationally and internationally, particularly for developing innovative sanitation services for rural and peri-urban areas and informal settlements (Schneider, 2016). EM has a larger proportion of the city's area considered to be rural and a higher baseline backlog for water and sanitation services than either Johannesburg or Cape Town. The 'rural'[46] conditions and significant baseline backlog have implications for planning and implementing sanitation services. The reason for this relates to the history of the municipality's[47] development. During apartheid, the homeland[48] of KwaZulu was governed separately from the City of Durban, 'resulting in a dense under-developed zone of rural and peri-urban households on the edge of the city' (Sutherland et al., 2013:52). In 2002, as part of the national municipal demarcation process, 75,000 'rural' households were added to the City as part of a strategy to '[redistribute] urban resources to rural hinterlands' (Sutherland et al., 2013), many of whom reside in areas under tribal authority (Figure 4.4). Population, household and unemployment statistics for eThekwini Municipality are presented in Table 4.1 indicating that in 2011 21% of households were considered informal, which was a slight increase (1.9 percentage points) from 2001.

Table 4.1: Basic demographic statistics for eThekwini municipality (Stats SA, 2012b)

Population	# of Households (HHs)	% Informal (HHs)	% Point Change in % Informal HH (2001-2011)s	Population growth (2001-2011) (% p.a.)	Unemployment rate (%)
3,442,361	956,713	21	1.9	1.08	30.2

Statistics for water and sanitation services in eThekwini municipality are given in

Table 4.2. EM uses consumer units rather than household counts for their backlog database and modelling. A consumer unit or delivery point is 'an entity to which a water or sanitation service is delivered, and which receives one bill if the service is billed' (EWS, 2012b:28), which the municipality argues relates more readily as a unit of measurement for the delivery of water and sanitation services. The national government typically uses households as a unit of measurement, but technically the number of households and consumer units do not

[46] Although designated as 'rural' some areas have a relatively high density and would more accurately be described as peri-urban settlements. See Glossary of Terms for more on peri-urban settlements.
[47] For more details on the spatial history and development of a spatially differentiated service delivery model see Sutherland *et al.*, 2014.
[48] Homelands also known as bantustans were territories set aside for black inhabitants of South Africa and South West Africa (now Namibia), as part of the policy of apartheid, and typically had lower levels of service than urban areas and areas designated for other racial groups. See Glossary of Terms.

coincide 1:1, e.g. blocks of flats, stands where multiple households live in the same dwelling but receive one bill, or for public taps (EWS, 2012b). Therefore, the number of consumer units will likely be less than the number of households.

Table 4.2: Water and sanitation service statistics for eThekwini Municipality (EWS, 2012b[a]; Stats SA, 2012b[b]; Sutherland et al., 2013[c])

Water and sanitation coverage	Percentage (2001)	Percentage (2011)	Consumer units (2011)
In-house piped water supply (% households)[b]	51.2	60.2	596,511
Piped water within 200m of dwelling	n/a	91	852,391
Non-revenue water (%)[a]	n/a	33.2	n/a
Sewerage coverage (% households)[b]	61.3	63.4	498,341
Sanitation backlog (% below basic level)[b,c*]	n/a	23.7	209,847

*Backyard shacks are not counted as part of the water and sanitation backlog, although they may be part of the housing backlog (EWS, 2012b).

In addition to large numbers of 'traditional' rural households, there are also large areas classified as informal settlements, some of which overlap with areas under tribal authority (Figure 4.4), which adds to the regulatory and institutional complexity of providing water and sanitation services in these areas.

4.1.2 Service delivery planning

In 2010 EM conducted a long-term visioning project known as Imagine Durban, which although not a legally mandated planning framework like the five year IDPs required under the Municipal Systems Act (No.32) of 2000, has influenced long-term planning in the city at least conceptually (EM, 2010; Arde, 2014). Six thematic areas were identified, of which extending water and sanitation services was categorised under 'promoting an accessible city'. Strategy 2.F is to 'ensure equitable access to housing and household services' for all residents' (EM, 2010:13). The projected time-frame for meeting backlogs was in the short-term or within 10 years, i.e. by 2020, which is incongruent with the rate projected in other planning frameworks such as the five-year IDP and WSDP.

The 2015/2016 IDP included an estimate that it would take 18-23 years to address sanitation backlogs based on available funds, the 2014 backlog figure of 182,271 consumer units and a delivery rate ranging between 8,000-10,000 households per annum (EM, 2015b). Figure 4.5 shows the reduction in the sanitation service delivery backlog between 2010 and 2015. Some of the household counts used for earlier backlog calculations were updated in 2013, which may partially account for the significant drop between 2012 and 2013. Large-scale roll-out of communal ablution blocks (CABs), communal sanitation facilities that include shower facilities and laundry basins (Section 4.1.4), also contributed to the increased service delivery rate and decreasing backlog. Two major challenges with calculating

sanitation backlogs[49] are to verify that data is accurate, and to identify whether or not people genuinely have access because even if a facility is present, it may not be used for various reasons discussed in Section 2.4. Furthermore, whether or not shared facilities qualify as a basic sanitation service impacts backlog calculations. Backlog estimates should therefore be viewed as rough estimates indicating progress towards universal sanitation access rather than as absolute measures.

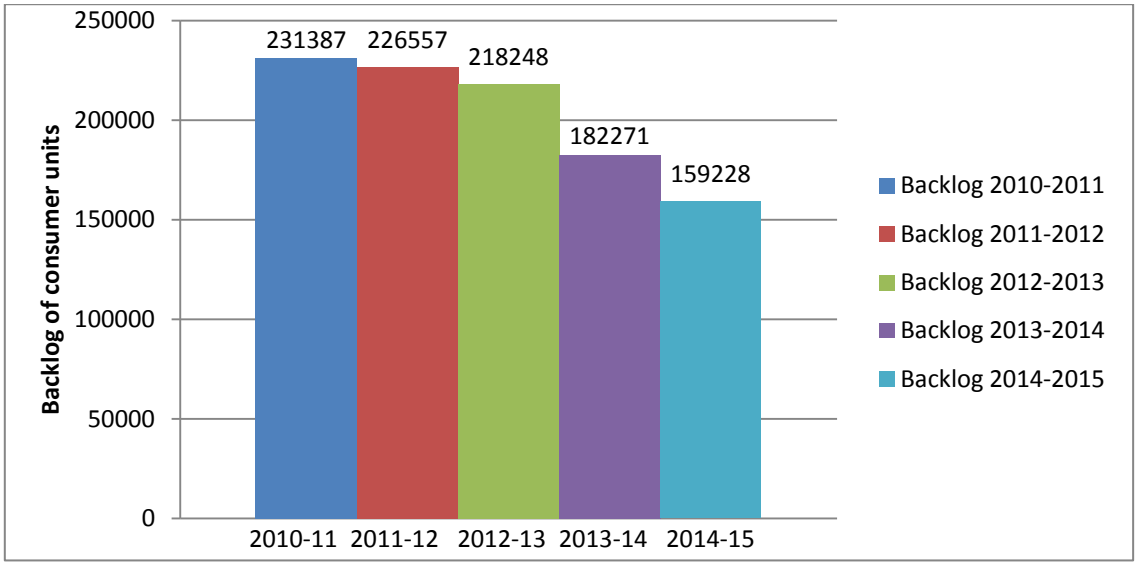

Figure 4.5: Sanitation backlog between 2010-2014 (EM, 2012b; EM, 2013a; EM, 2015b, EM, 2016).

EM has developed the concept of an 'urban development line' (UDL), which 'demarcates the urban development zone from the rural development zone' and 'which marks the outer edge of waterborne sewerage provision' (Sutherland et al., 2013). The logic behind the UDL policy within the IDP is stated as a desire to promote a more 'accessible, compact, efficient, equitable and sustainable settlement form' through managing growth patterns, and to indicate where it is cost-effective to extend municipal services (EM, 2013a; EM, 2015b). There has however been criticism of a spatially differentiated level of service model, which is based more on socio-economic relations rather than spatial relations as claimed, given exceptions to the UDL policy for private development (Bond, 2012, pers. comm., 9 September cited in Sutherland et al., 2013); although the counter-argument is that private developers are willing to pay the cost for extending water and wastewater services whereas public funds would have to be used to extend FBSan services to areas outside the UDL. Another criticism of the UDL is that the construction of a divide between the 'urban core'[50] and 'rural hinterland'[51] creates

[49] See Glossary of Terms. Households with access to communal facilities are not counted in the backlog.
[50] The urban core is defined by EM as 'being the urban centre, which generally has servicing capacity and thus opportunity for densification and can support thresholds for a range of services, industry and public transport' (EM, 2015b:93).
[51] The rural hinterland is described as having 'a different character, lifestyle and development intensity and where access is poor and servicing costs are high. Such areas are seen as important for protecting agricultural

a dichotomy that needs to be regularly re-evaluated for its relevance to the actual needs and wants of eThekwini residents living in rural/urban and formal/informal areas, processes of urbanisation, and its impact on the sustainability and equity of sanitation and other infrastructure services (Bustillos, 2015). The proposed UDL was informed by a cost surface model developed by the Council for Scientific and Industrial Research (CSIR) (Figure 4.6) (EM, 2015b). Levels of service for water and sanitation will be discussed further in Section 4.1.4, but the implications of the UDL on sanitation described in the WSDP, IDP and the linked Spatial Development Framework (SDF) are that areas within the urban core will primarily be served by waterborne sewerage that transports waste to various WWTWs prior to being discharged into the Indian Ocean. Rural, peri-urban and informal settlements outside the UDL will be provided with on-site systems, largely VIPs and urine diversion dry toilets (UDDTs) in less dense areas (EM, 2013d), with communal ablution blocks (CABs) as a third option for dense informal settlements as part of an interim services programme (EM, 2015b).

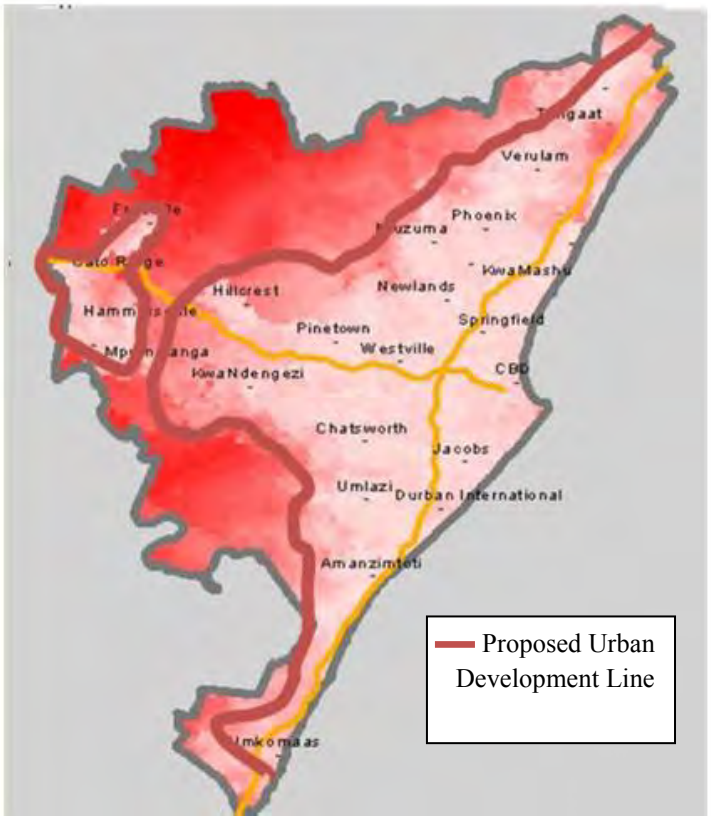

Figure 4.6: Cost-surface model and proposed urban development line for eThekwini (EM, 2015) (N.B. Lighter areas indicate a lower cost for extending water services).

The WSDP references the SDF, IDP, and Imagine Durban as development frameworks, however, it also cites the need to conduct a strategic environmental assessment

resources, ensuring food security, addressing social needs and building the resilience of communities' (EM, 2015b:94).

and gather more environmental information, in addition to 'the difficulties presented to water services planning by ongoing changes in the UDL', which likely would result in increased demand for sewage treatment (EM, 2012b:58). Service delivery plans for informal settlements are especially challenging to implement and susceptible to frequent changes given that informal areas are already operating under a higher degree of uncertainty with regards to tenure, access to services, and environmental risks than most other areas of the city (Joubert & Martindale, 2013).

4.1.3 Institutional arrangements and expenditure on sanitation in informal settlements

In terms of governance structures, eThekwini has an executive mayor elected by a 205 member council and supported by an executive committee. There are also 17 Amakhosi (traditional leaders) within the municipality's area of jurisdiction who liaise with the municipal management (EM, 2013b). The City Manager reports to the mayor and executive committee, and is assisted by seven deputy city managers (Appendix 1M). Service delivery is overseen by eight administrative clusters, which are broken down further into service units, of which eThekwini Water and Sanitation (EWS) falls under Trading Services (EM, n.d.). EWS is the unit primarily responsible for delivering water and sanitation services to the City as both the water services authority and provider, although other departments such as health may be involved with certain aspects such as health and hygiene promotion. An organogram for EWS is shown in Figure 4.7.

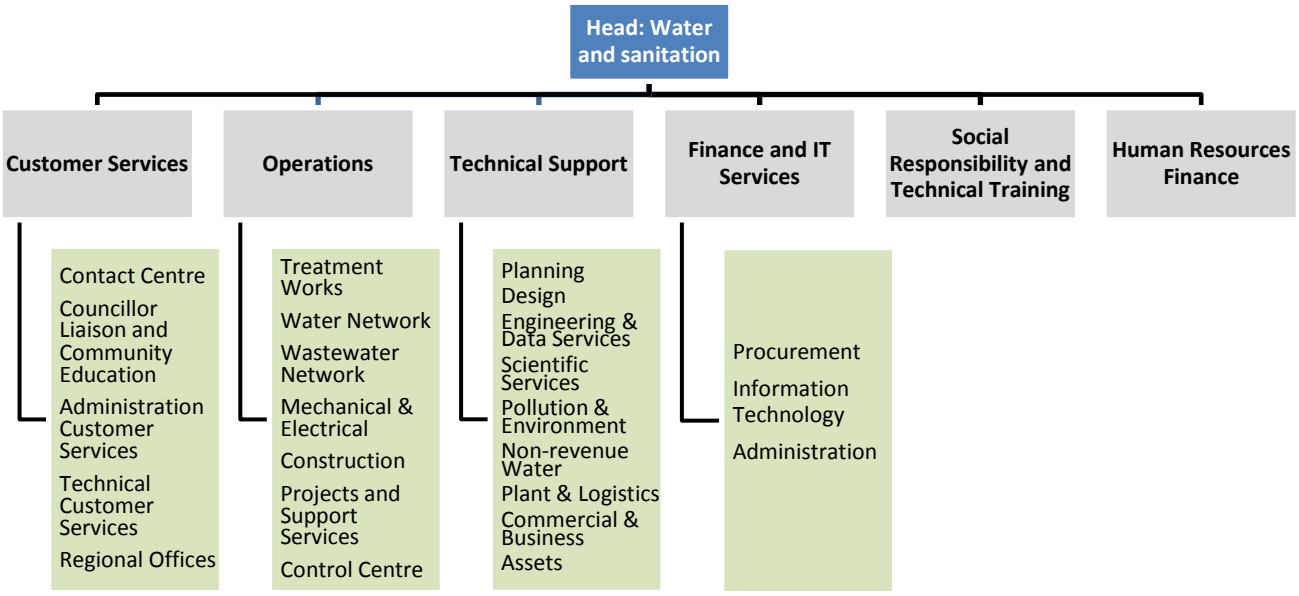

Figure 4.7: Organogram for eThekwini Water and Sanitation unit (EWS, 2012b)

EWS, as an administrative unit of the municipality acts as both water service authority and provider. As mentioned previously, approximately one third of EM's land is under traditional authority. The Amakhosi and Ingonyama Land Trust which operate as a separate administration to the municipality's are some of the additional institutions that EWS have to make arrangements with in regards to planning and providing water and sanitation services (Harrison, 2014, pers. comm., 29 July; Bustillos, 2015). One of the challenges of this arrangement is that the municipality legally has no jurisdiction over land use in the area—which comprises approximately a third of the municipality's land area (ITB, 2014); nor as of 2015 were they able to charge tariffs for water and sanitation services even when households exceeded the free basic limit (Table 4.4). Municipal officials believe users in traditional areas should pay for to services over the basic level to promote both financial and environmental sustainability (Harrison 2014, pers. comm., 29 July; Gounden, 2015, pers. comm., 18 March cited in Bustillos, 2015). Furthermore, another concern with the inability to collect payment for water and sanitation services in areas under tribal authority is that even households who can afford to pay for services are moving into the area and expecting a high level of service for free (Harrison, 2014, pers. comm., 29 July) creating an area akin to a 'rates haven', which means that less funding is available to invest in services for indigent households.

One of the distinguishing institutional arrangements that EWS has made are long-term research agreements focusing on water and sanitation for underserved communities. The research collaboration started in 2003 with the University of Kwa-Zulu Natal's (UKZN) Pollution Research Group and has been formalised through various Memoranda of Understanding (MOU) (PRG, 2015) with UKZN and other organisations such as the Bremen Overseas Research and Development Association (BORDA), a German NGO, and Eawag, the Swiss Federal Institute of Aquatic Science and Technology. These research collaborations have primarily focused on 'alternative' sanitation systems such as the UDDTs, VIP sludge treatment, and Decentralised Wastewater Treatment Systems (DEWATS) that are primarily used by low-income residents in rural and informal settlements. Close collaboration with research institutions appears to have resulted in improved designs of the UDDTs through an iterative design process (Gounden, 2014, pers. comm., July 29), CABs and to some extent O&M routines (Bustillos, 2015), which will be discussed further in Section 4.1.5. Sutherland et al. (2014) ascribe the willingness on the part of the City to support innovation and research to a combination of 'experimental governance and incremental learning' observed in the organisational culture of EWS.

The budget for selected Free Basic Services from 2012-2016 is shown in Table 4.3 alongside the budget for the CABs, which makes up approximately 43.9% of the budget for Free Basic Services in informal settlements for 2015-2016. Such a high proportion of the informal settlement services budget being allocated to CABs indicates the City's high priority to reduce sanitation backlogs in informal settlements. Funding for the FBSan service comes from a variety of national transfers (Table 2.3) and municipal revenue. There are also project funds from external organisations such as the Bill & Melinda Gates Foundation that have supported water and sanitation-related research, but are not included in the budget presented in Table 4.3.

Table 4.3: Costs for FBW and FBSan services and CAB budget for EM (EM, 2012a; EM, 2013c; EM, 2014b; EM, 2015c)

Description	2012/13	2013/14	2014/15	2015/16	2016/17 Medium Term Revenue & Expenditure Framework		
Revenue costs (R'000)	**Outcome**	**Outcome**	**Outcome**	**Adjusted Budget**	**Budget Year 2016/17**	**Budget Year 2017/18**	**Budget Year 2018/19**
Free Basic Water (Formal)	233,367	169,258	181,888	205,177	256,019	280,340	306,973
Free Basic Sanitation (Formal)	89,328	86,984	93,884	131,301	139,304	142,939	147,256
% Change from previous year	--	-2.7	7.3	28.5	5.7	2.5	2.9
Free Basic Services (Informal)	844,786	749,425	828,847	943,525	1,097,866	1,175,889	1,259,574
Budget for CABs	100,000	275,000	319,500	414,200			
CAB as % of FBS (informal)	11.8	36.7	38.6	43.9			

4.1.4 Level of service and O&M for sanitation services in informal settlements

EWS has laid out several levels of service for water and sanitation which are outlined in Table 4.4. CABs and UDDTs are two of the systems that are used in peri-urban areas and informal settlements, depending on the settlement conditions. CABs are considered to be an interim level of service, whereas UDDTs are considered to be more permanent, albeit as an intermediate or basic LoS.

An interim service delivery programme is being promoted by EM, which is intended to provide services for informal settlements that are not planned to be upgraded or relocated to housing projects in the next three or more years (Byerley, 2014, pers. comm., 28 July). An interim LOS is the one that most informal settlements receive. CABs, as mentioned previously, fall into the interim level of service category. The system is connected to a sewer where available or to a conservancy tank or pit. The facilities can potentially be removed and refurbished if a settlement is upgraded or residents are relocated (Crous, 2014), although examples of this have not yet been documented as of 2016. VIPs and chemical toilets are also installed, but only under 'exceptional circumstances' and if approved by the Head of Water and Sanitation services (EWS, 2012a:6).

Table 4.4: Levels of service for water and sanitation in eThekwini (Crous, 2014; EWS, 2014b)

Level	Water	Sanitation facility	Service description
Emergency	Water sachets or water tanks for prolonged interruptions	Chemical toilet	Used as a temporary service during construction
Interim	Communal standpipes/water dispensers	CABs	Daily caretaker, ad hoc maintenance
Intermediate*	300ℓ per day via ground tank or metered flow limiter connected to a yard tap	UDDT with double vaults per household	Free emptying service every 2 years
	Semi-pressure supply received by household via roof tank	Waterborne sanitation with on-site collection and off-site disposal, *e.g.* conservancy tanks with emptying and disposal by tanker; or waterborne sanitation with on-site disposal – septic tank & soakaway*	Ad hoc de-sludging by tankers
Full	Full-pressure water supply from the City's water supply network	Conventional waterborne sanitation – connection to sewerage	Routine maintenance, no rates charged for sewage disposal if <9kL of water used

*N.B. VIPs are also still serviced by the municipality although no longer being constructed.

Figure 4.8 and Figure 4.9 show what a CAB interior and exterior[52] look like, with separate facilities for men and women including urinals, showers and basins that can be used for hand washing or laundry. CABs are designed to serve a population within 200 meters of the facility or a maximum of 75 households (Crous et al., 2013). Caretakers are employed by the municipality from the settlement to assist with distributing toilet paper, cleaning the facility and reporting issues such as broken fixtures or blockages. They are a critical part of the O&M service for the CABs, and anecdotal evidence indicates that the successful operation of a CAB is dependent on how diligent the caretaker is (Zuma, 2015, pers. comm., 20 August). Residents make their own arrangements for opening and closing times of the facility, *e.g.* facilities may be closed in the evening but residents can go to the caretaker's home to ask for a key. CABs are being implemented as part of an interim services programme with the aim of installing up to 220 CABs per annum (Crous, 2014), although the rate of delivery is dependent on the available budget (EM, 2012). Initially CAB services were only going to be provided for informal settlements that fell within the UDL. The reason was primarily because of the financial cost for treatment and extending sewerage networks, but due to political pressure, a pilot CAB facility using a DEWAT system was tested (Crous, 2014). There are now plans to promote CABs even outside of the UDL, where feasible, if DEWATS can be successfully operated (Smith et al., 2012, pers. comm., 9 February cited in Crous, 2014).

[52] Some of the older CABs that were first installed by the environmental health department have brick and mortar structures, but shipping containers were utilised for the later design after EWS took over the CAB programme to enable a faster roll-out (Grau, 2014, pers. comm., 29 July).

Figure 4.8: Parkington Grove CAB exterior and urinal with signage (Pan 20/5/2015)

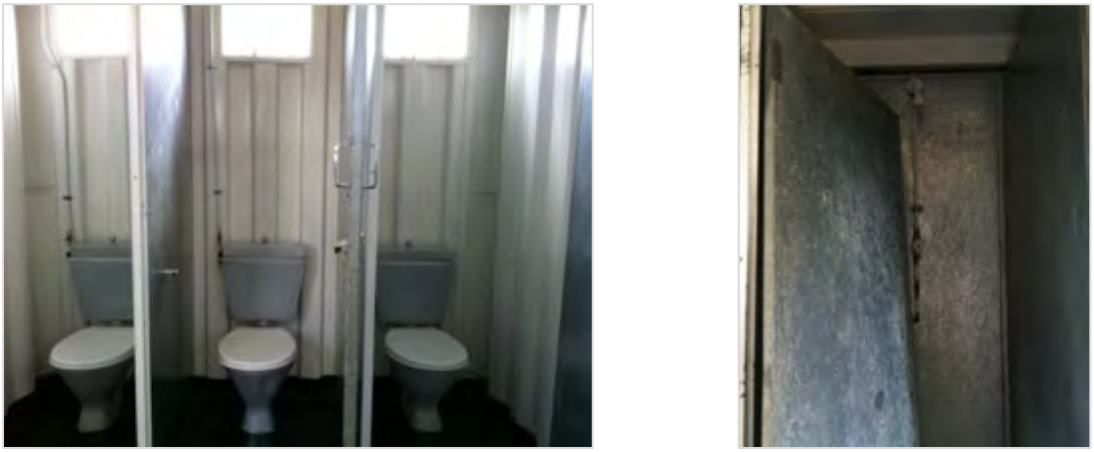

Figure 4.9: Parkington Grove CAB flush toilets and shower (Pan 20/5/2015)

Whereas CABs and other forms of waterborne sanitation systems are considered appropriate for medium to high density urban informal settlements, urine diversion dry toilets (UDDTs) are recommended for lower-density peri-urban informal settlements[53] in areas with a limited volume of water supply (Table 4.4) where on-site drainage is possible. Double vaulted UDDTs (Figure 4.10) were developed as an alternative system to VIPs given logistical challenges for O&M and the high cost of emptying conventional VIPs (Buckley et al., 2008). Urine from the toilet or urinal is diverted to soakaways while the faeces, anal cleansing and bulking material is collected in a vault below the specially designed pedestal (Figure 4.11). The pedestal is moved over to the second vault once the first vault is full. Facilitators go to households receiving the UDDT to provide educational materials and teach households how to use and maintain the UDDT (Gounden, n.d.). The original O&M plan when the UDDTs

[53] It should be noted that UDDTs are primarily promoted and used in areas classified as rural by the municipality, where on-site burial is considered to be a feasible disposal option; although, there are ~5000 UDDTs servicing informal settlements.

were first installed in 2003 was for each individual household supplied with a UDDT to have the responsibility for emptying the vault manually once it was full[54] and to bury the faecal waste on-site. Since the inception of the programme, however, the municipality took over responsibility for emptying UDDT vaults and treating/disposing faecal waste because (Gounden, 2015, pers. comm., 20 May):

- additional research conducted by UKZN indicated that the risk of exposure to helminths is high in the absence of good hygiene practices and appropriate barriers such as personal protective equipment (PPE) (Buckley *et al*., 2008),
- equity concerns that households provided with other sanitation services such as the CABs or VIPs are not responsible for handling faecal waste, and
- surveys indicating people's dissatisfaction with emptying the vaults.

Figure 4.10: Mzinyathi double-vaulted UDDT top structure front and back (Pan 20/5/2015)

Figure 4.11: UD pedestal, alternate chamber cover, urinal and newspapers for anal cleansing (Pan 20/5/2015)

[54] The vault was designed with an expected fill rate of 6-12 months for a maximum of 8 people per household (WIN-SA, 2006; Buckley *et al.*, 2008).

The revised O&M plan is for UDDTs to be emptied on a two year cycle by municipally hired workers who are provided with training, immunizations and PPE to minimize the hazards of pathogenic exposure. In 2015, two methods were considered for treatment and/or disposal:

i) on-site burial (space and groundwater conditions permitting),

ii) or removal to a black soldier fly (BSF) treatment facility for productive reuse.

On-site burial is preferred to removal for off-site treatment by EWS due to lower costs. There were, however, proposals to investigate the potential value that can be derived from beneficial reuse of faecal sludge and the BSF product resale, which would be handled through a PPP arrangement (Alcock, 2015; Gounden, 2015, pers. comm., 20 May) to help subsidise O&M costs. Contracts for emptying and transporting faecal sludge from the UDDTs could be split amongst a number of small emerging contractors (sub-contractors) overseen by a main contractor, which is seen as a potential mechanism for job creation and capacity building within informal settlements (Gounden, 2015, pers. comm., 20 May).

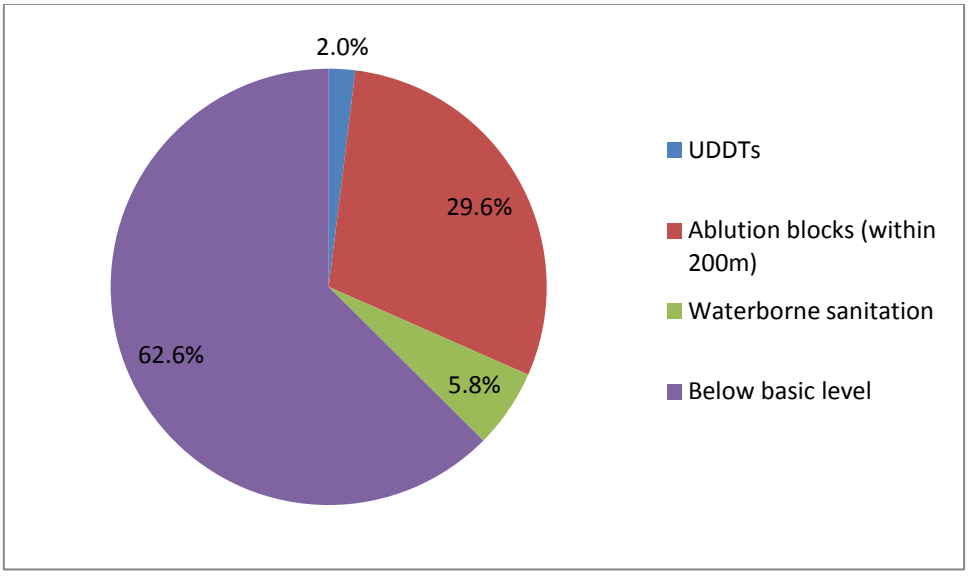

Figure 4.12: Sanitation service types in informal settlements in eThekwini (EM, 2014a)

Figure 4.12 shows a breakdown of the different sanitation services provided by EM in informal settlements in 2014. Nearly two thirds of informal settlement households used below the basic level of sanitation service, which means that either there was no sanitation service provided or the only service/facility available fell below the basic LoS, *e.g.* chemical toilets (maintained by the municipality) or a self-built unimproved pit latrines (not maintained by the municipality). Some of the commonly cited service delivery challenges included being located on privately owned land, inaccessible terrain, high densities, rapid population growth and a highly mobile population (Gounden et al., 2006; Harrison, 2014, pers. comm., 29 July). Of the households with access to what is considered to meet the basic or interim LoS, the majority are served by CABs, followed by either communal or individual household

waterborne sanitation facilities, and only 2% of informal households were using UDDTs (EM, 2014a). The push for waterborne facilities in informal settlements is driven mainly by social and political pressures such as the association of dry sanitation as being sub-standard and smelly (Matsebe & Osman, 2012; Roma et al., 2013) and electioneering campaigns using sanitation services or the lack of 'dignified' sanitation facilities to score political points (Tissington, 2011).

Customer satisfaction surveys are conducted annually for all sectors that EM serves. There have also been specific studies conducted focusing on users' experience and perception of both UDDTs and CABs given that they are considered new or at least alternative systems that the municipality has implemented and monitored over the last ~15 years. Post-implementation surveys of UDDT users conducted in 2010, nearly a decade after installation indicated decreasing levels of satisfaction since the initial survey was conducted in 2003/04, dropping from 78.4% of respondents reporting some level of satisfaction to below 30%, with the primary hurdles to acceptance being linked to smell/odour and the distance of the facility from the household (Roma et al., 2013). The municipality appeared committed to continuing to increase users' acceptance of UDDTs and to improve the level of service provided by taking on the responsibility of emptying vaults once filled (Gounden, 2014, pers. comm., 29 July). One of the proposals made by Roma et al. (2013) to increase users' acceptance of UDDTs was to emphasise 'the importance and potential of waste as a useful resource' through educational activities and participatory approaches. The study did not identify whether any respondents were drawn from areas classified as informal settlements, but did indicate some of the post-implementation user acceptance challenges associated with UDDTs. CAB-related user assessments resulted in a change from the original management model where there were no caretakers, resulting in poor maintenance, to the adjusted management model where caretakers are paid and employed by the municipality (Roma et al., 2010b). Another major factor in CAB usage and user acceptance detected by assessments was the distance required to walk to the CAB (Crous, 2014). The majority of non-users (59%) of the CAB facilities cited non-use due to distance as the main reason for non-usage (Crous et al., 2012), indicating the importance of the distance from dwellings to the facility as a design factor to take into consideration regarding the LoS provided.

4.1.5 Sustainability and equity assessment for the CAB and UDDT programmes

As mentioned in Section 4.1.4, CABs and UDDTs are two of the primary sanitation systems provided to urban and peri-urban informal settlements in EM as part of basic service delivery. The programmes for delivering CABs and UDDTs are compared with regards to various dimensions of sustainability and equity in this section.

CABs are considered as part of a package of interim services that is meant to include access routes using roads and footpaths, which are designed for stormwater control (Jooste, 2014, pers. comm., 28 July). One of the advantages of the CABs is that they are also used as water access points and for laundry washing facilities. An additional strength of the CAB

programme is the health and hygiene promotion campaigns that are included as part of the CAB rollout programme. Two of the most important decision criteria for installing a CAB relate to the density of the settlement or the location of the settlement either within or outside of the UDL, although that may change with increased political pressure. The CAB programme is being rolled out on a large scale in the municipality using connections to existing infrastructure where possible, which lends itself towards the economies of scale argument for economic sustainability; although infrastructure upgrades and DEWATS will be required to serve some informal settlements. There is also staff familiarity with conventional sewerage and WWTWs. A centralised or semi-centralised system also fits into existing institutional structures, which favours the CAB programme as a form of sanitation service.

From an environmental sustainability perspective, however, the CABs are potentially less environmentally sustainable than non-waterborne systems given water resource constraints since water is required for flushing, and waste streams are mixed making resource recovery less straightforward than with the UDDT system. Although it should be noted that one of the technical advantages of the system is its ability to handle greywater disposal, which is an advantage of waterborne systems in general over dry sanitation systems. Other hindrances to the sustainability of the CAB programme include social and economic issues. A primary social concern is that since the CAB is shared between large numbers of users, there is a high risk of vandalism or theft of materials or general wear and tear of facilities (Crous, 2014). During the author's daytime visits to four CABs in 2014 and 2015, facilities seemed to be in relatively good condition although there were some broken toilets and doors, which primarily were attributed to wear and tear. However, it should be noted that the author was always accompanied by municipal officials who selected the sites to visit so it is possible that there was a bias towards taking visitors to well maintained facilities. Caretakers have been hired to help reduce incidences of vandalism and theft, for daily O&M activities and reporting problems and are an important part of the CAB programme. There is, however, a high risk of the programme failing if O&M funding to pay for caretakers is reduced or unavailable in the future.

For the UDDT programme, the arguments that favour the sustainability of the programme tie most strongly to environmental benefits such as an increased reuse potential given the separation of waste streams and no need for flush water (Figure 4.13). It should be noted, however, that the original drivers for implementing the UDDTs were not primarily for environmental reasons, but for technical and financial reasons to provide services in non-sewered areas and to reduce the logistical challenges and O&M cost associated with emptying VIPs in the peri-urban and rural areas of the municipality (Buckley et al., 2008). In the original design of the UDDT system nutrient reuse and recycling from human excreta was not specifically incorporated. Since the UDDT programme first started the design of the facilities and the O&M service has been modified for several reasons (Section 4.1.4). The cost for emptying vaults and transferring contents for off-site disposal still needed to be determined as the pilot treatment facility was still under development as of 2015. Off-site treatment for UDDTs could potentially cost as much as the emptying service for the VIPs depending on the distance to the facility; thus, the original premise for UDDTs has shifted in emphasis from a cost-effective alternative to VIPs towards exploring resource recovery

opportunities through converting urine to struvite for fertiliser or using BSF to convert faecal sludge into animal feed. The cost-effectiveness of resource recovery as compared to merely treatment and disposal was still being evaluated as of 2015, but it is being explored as a potential way to off-set the costs of providing the O&M service. If resource recovery proves to be too expensive, however, the municipality will likely have to revert to a cheaper treatment and disposal method which may detract from the environmental sustainability of the UDDT programme.

Two other prominent areas of concern with regards to the UDDT programme relate to socio-cultural, health and hygiene and technical issues. The primary socio-cultural issue relates to user acceptance. Several studies have indicated hurdles that need to be overcome for UDDT systems to be accepted including: odour, maintenance issues, distance from the household, discomfort handling excreta, concerns over comfort, privacy and security, and general preference for a flush toilet (Holden et al., 2003; Duncker et al., 2006; Roma et al., 2013). While some of the hurdles to acceptance are not unique to UDDTs, others such as discomfort handling excreta and a negative comparison to flush toilets are unique to UDDTs and more generally dry sanitation systems. Another shortcoming of the UDDTs is that they do not come with hand washing facilities which hinders health and hygiene promotion. The primary technical concern with the UDDT programme is its limitation to low-density settlements since there is no greywater disposal system. For low-density settlements greywater can be drained into the surrounding soil, depending on the soil type, but as density increases, the volume of greywater generated is likely to exceed the soil's absorption capacity and increases the risk of environmental pollution. The municipality is facing rapid densification in the areas served by UDDTs (Harrison, 2014, pers. comm., 29 July) which threatens the technical sustainability of the programme if UDDTs cannot be adapted for higher density settlements, or unless the growth of settlements can be managed.

An overview of the UDDT and CAB programmes suggests that in the short to medium term, both programmes can be considered to be performing well in certain areas of sustainability as indicated by the predominantly favourable linkages shown in Figure 4.13, particularly with regards to technical and institutional dimensions. For the UDDT programme, one of its strengths is the potential to promote resource recovery from human excreta and individual household access, whereas the strength of the CAB programme is its potential to serve a large number of underserved high-density informal settlements and to assist with greywater management. Both programmes, however, need to address several potential hurdles to sustainability. For example, CABs are designated as an interim level of service for any settlements not being upgraded within the next three years, indicating that there should be an increase in the LoS provided sometime in the future, which raises questions as to what the next 'rung' up the ladder will. Also, as mentioned one of the primary concerns with the UDDTs is the socio-cultural sustainability given that many peri-urban areas are becoming more 'urban' and as with the general trend in South Africa view waterborne services as more in line with urban and modern lifestyles. From technical and institutional dimensions the UDDT and CABs may seem sustainable, but users may perceive them as inequitable and consider them inconvenient. More on this will be discussed in the next section relating to equity concerns.

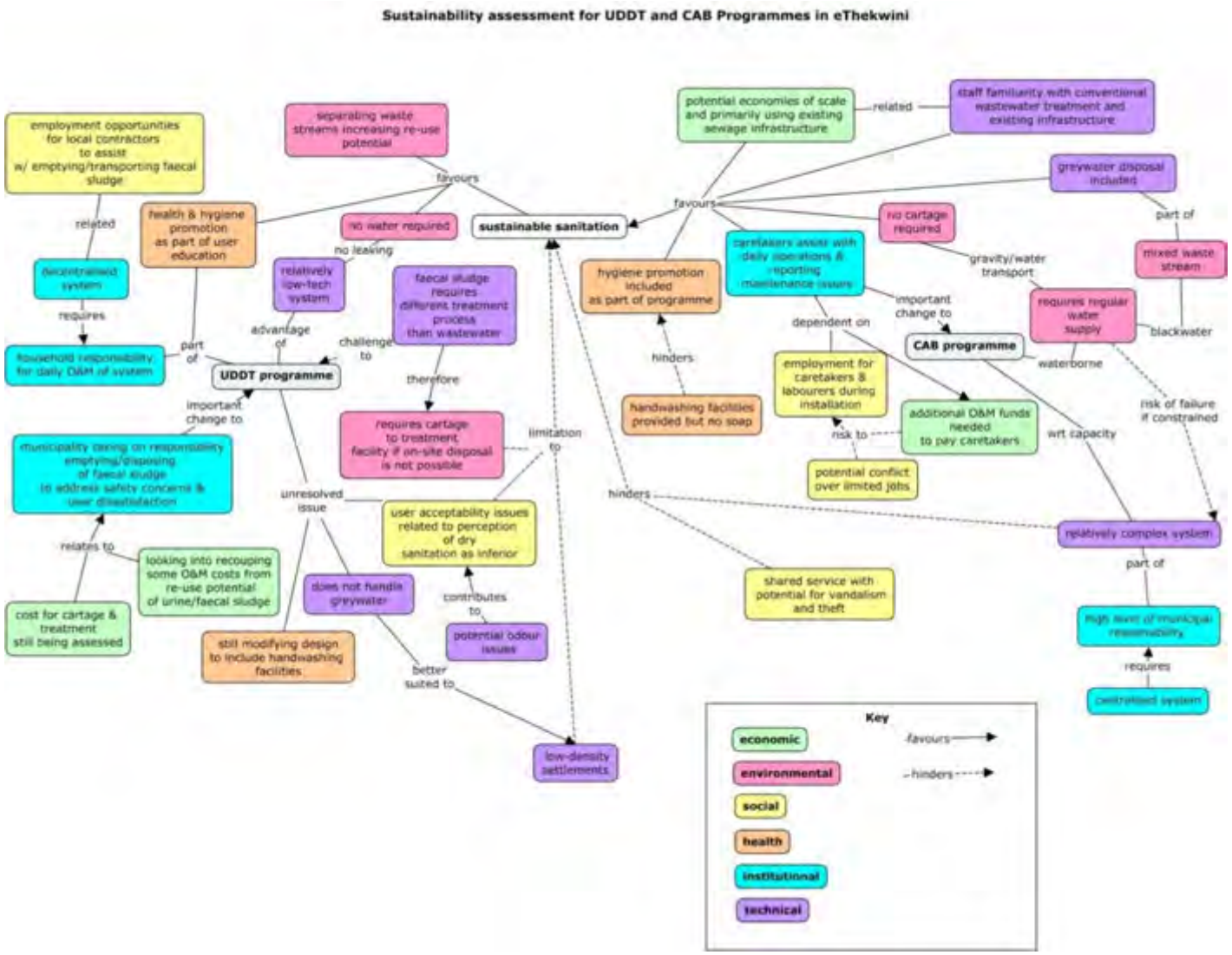

Figure 4.13: Sustainability assessment concept map for UDDTs and CABs in EM

Equity was evaluated by the author in relation to access, resource allocation and perceptions (Figure 4.14). With regards to access, the UDDTs have the advantage of being designed for individual households, which theoretically makes it easier to address individual household needs, whereas CABs are designed for communal use located at a further distance from most households than the UDDTs[55]. As Crous (2014) observed, the distance of a CAB facility (in addition to the hilly terrain of many informal settlements) limits the viability of communal facilities for the elderly, disabled people and children (vulnerable people); therefore, additional assistance for households with members that have special needs are needed to supplement the CAB programme.

A neglected area of many WASH programmes is menstrual hygiene management (MHM). Part of the issue is that MHM overlaps with solid waste management, thus it does not easily fit into other water and sanitation services. There is also a need to 'sensitise engineers, planners and water managers with regard to infrastructural design that supports MHM' (WIN-SA, 2012). EM has collaborated with various partners to research MHM in the municipality. Researchers from PATH, a global health NGO, found several MHM-related issues such as blockages related to sanitary products, concern from caretakers over contracting diseases from handling sanitary products and a lack of waste bins inside facilities (Truyens et al., 2013). During site visits to two CAB facilities in 2014 and 2015, the author observed a plastic bag that was hanging outside of one of the CAB facilities that presumably was used for either MHM or general waste collection and a municipal bin used for solid waste collection, but there were no disposal facilities within individual cubicles for female users which would increase privacy and convenience for those who want to change and dispose of sanitary pads. The PATH research did not include an evaluation of MHM practices for households with UDDTs, but as mentioned previously the advantage with UDDTs is that they are designed for individual household usage, which inherently includes greater privacy than communal facilities.

The majority of funds for sanitation services in informal settlements have been allocated to CABs (Table 4.4), indicating a decisive shift towards waterborne facilities for interim services. Furthermore, records from 2012-2014 indicate that no new UDDTs were installed for informal settlements (EM, 2012a; EM, 2014a). The decision is in part due to technical and financial criteria. There is also a prevailing perception in South Africa that dry sanitation is inferior due to its association with low-income developments. Whatever type of sanitation system is used to provide basic or interim levels of service, a potential issue that service providers encounter is people's perception that one type of system is better than another or associated with a higher status, particularly if more than one type of system is used in the same settlement. Negative perceptions may cause conflict if not addressed, preferably during the needs assessment stage (pre-planning) of a project.

Do communal services provide an equitable level of service for all users 24 hours 7 days a week? This research indicates that the answer is no if equity of access cannot be

[55] Although UDDTs may be at a closer distance than the CABs, there are also potential design issues for UDDTs relating to how the facility looks to users, the fact that users still have to walk outside to get to the facility which may make UDDTs less attractive.

achieved or certain needs such as MHM are not catered for. People who are physically disabled or elderly need supplemental sanitation services if they are unable to walk to CAB facilities, and MHM is not being adequately addressed. Night time access is also an area of concern. The author was unable to visit CAB facilities at night, but research from informal settlements in other municipalities indicates that generally women and children do not feel safe visiting communal facilities that are not visible from their households at night. For UDDTs, one of the unresolved issues is their appropriateness in the context of urbanisation and dense informal settlements. Furthermore, social acceptability of UDDTs remains a challenge. Anecdotally in South Africa, and based on experience from the failure of one of the largest urban dry sanitation projects in the world in northern China, as residents' standard of living rise, they may become less inclined to accept dry sanitation, viewing dry sanitation as 'something backward in a modern urban setting' (Rosemarin et al., 2012) which is associated with negative equity perceptions.

As indicated by some of the issues highlighted in the assessment of the UDDTs and CABs, addressing equity concerns has an impact on overall sustainability, particularly in relation to socio-cultural sustainability. Furthermore, to maximise public health and environmental benefits of sanitation services, all residents must be able to utilise sanitation services, otherwise these benefits are mitigated. The concerns between environmental sustainability and social equity mentioned relate to the 'development conflict' (Campbell, 1996). Financial sustainability is of course another critical focus from municipal officials' perspectives. While EM has tried to balance these principles, one of the shortcomings of the programmes evaluated relates to what Penner (2010) discusses, an issue of asking and addressing the wrong questions. A great deal of emphasis has been placed on iteratively improving the technical design of the systems used, which has and should rightfully be commended, but that mainly answers the question of 'how do we make sure that this system isn't considered substandard.' Instead, the question that should be asked is 'how can we address the structural inequalities of sanitation provision?' (Penner, 2010), which is less straightforward, but more important for long-term sustainability and equity. This would require a re-examination of how sanitation service levels are defined, for whom and by whom, which will be discussed further in Chapter 5.

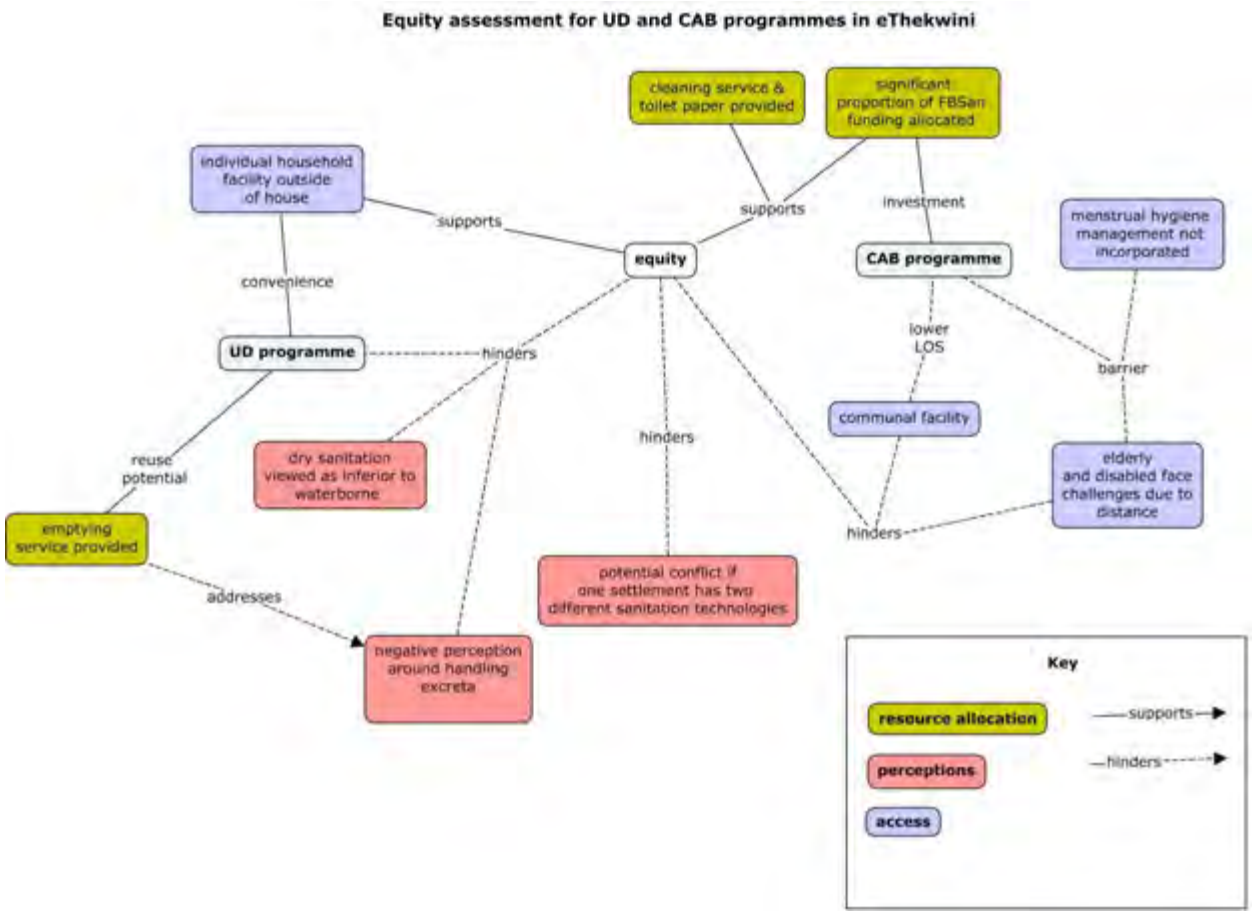

Figure 4.14: Equity assessment concept map for eThekwini

4.2 Johannesburg

4.2.1 Introduction

The City of Johannesburg (CJ) is located in Gauteng province, which is the wealthiest in terms of its contribution to Gross Domestic Product (GDP) (Stats SA, 2015). CJ is the largest city in terms of population in South Africa and covers an area of 1,645km^2. Its climate is classified as warm and temperate with the majority of rainfall occurring during the summer months (Conradie & Kumirai, 2012). CJ also has the highest population growth rate (Stats SA, 2012b) of all the metropolitan municipalities. Table 4.5 gives basic demographic statistics for the municipality from the 2011 census, which indicated that 19% of households were considered informal (a decrease in the proportion of informal compared to formal from 2001), whether located in an informal settlement or backyard shack. Johannesburg is categorised as a metropolitan municipality and was formed from the consolidation of 13 separate administrations that had historically been divided along racial lines in 1995 (SALGA, 2011). There is now a single council that governs the city, which is divided into seven administrative regions (A-G). The administrative regions differ from the regions used by the City's water and sanitation department (Figure 4.15) and the corresponding municipally owned entity (MOE), Johannesburg Water (JW), which divides the City into six regions served by ten network depots and six wastewater treatment works (JW, 2015a).

Table 4.5: Basic demographic statistics for Johannesburg municipality (Stats SA, 2012b)

Population	# of Households (HHs)	% Informal (HHs)	% Point Change in % Informal HH (2001-2011)s	Population growth (2001-2011) (% p.a.)	Unemployment rate (%)
4,434,827	1,434,856	19	-2.1	3.18	25

Table 4.6 presents the water and sanitation service delivery statistics for CJ from 2001 and 2011. There has been progress since 2001 in terms of overall water and sanitation service coverage; however, there are still over 100,000 households remaining in the service delivery backlog. Addressing the backlog is difficult due to the rapid population growth and slippage.

Table 4.6: Water and sanitation service statistics for the City of Johannesburg (Stats SA, 2012b[a]; JW, 2013b[b]; CJ, 2014a[c])

Water and sanitation coverage	Percentage (2001)	Percentage (2011)	# of HHs (2011)
In-house piped water supply (% households)[a]	50.1	64.7	928,352
Piped water within 200m of dwelling[c]	n/a	96.7	1,387,506
Unaccounted for water losses (%)[b]	n/a	29.5	n/a
Sewerage coverage (% households)[b]	82.3	87.1	1,249,760
Sanitation backlog (% households below basic level)[a,c]	13.9	7.3	104,240

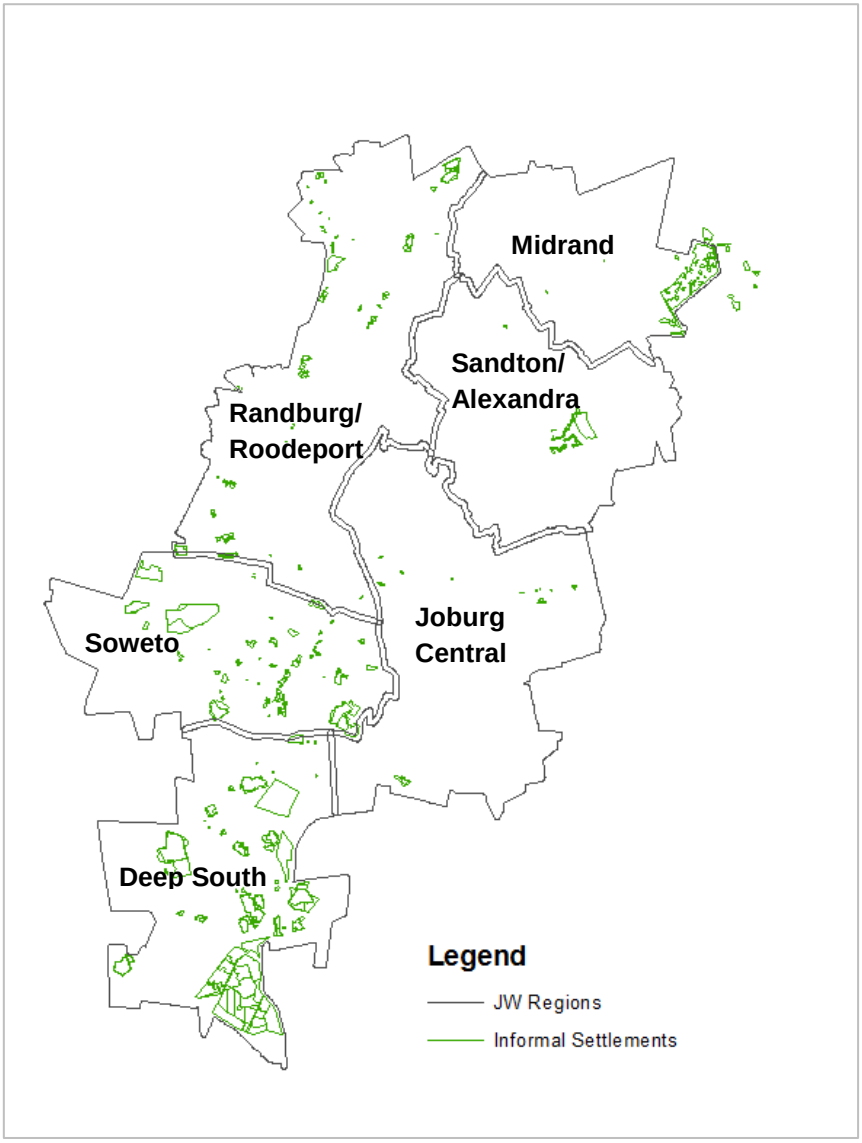

Figure 4.15: Informal settlements in the City of Johannesburg (JW, 2015b)

4.2.2 Service delivery planning

The overall development strategy for the City, the Joburg Growth and Development Strategy (GDS), indirectly impacts sanitation service delivery to informal settlements and is outlined in Figure 4.16. The GDS represents a long-term vision and goals for the City and is supported by medium-term plans in the five-year Integrated Development Plans (required for all municipalities), which in turn are supported by the annual IDP plan revisions and the annual Service Delivery and Budget Implementation Plans (SDBIP). The GDS is intended to serve as 'an aspirational strategy' that 'provides a set of defined strategic directions that frame the five-year IDP and other medium-term plans', but is not intended to serve as a 'spatial vision or statutory plan' (CJ, 2011:9). Three overarching goals of the GDS are 'resilience, sustainability and liveability' for Johannesburg (CJ, 2011). Sanitation for the urban poor is

intended to be addressed by Outcome 2 in the GDS, which is to 'Provide a resilient, liveable, sustainable urban environment – underpinned by infrastructure supportive of a low-carbon economy' (CJ, 2011:94), infrastructure including water, sanitation, energy, etc.

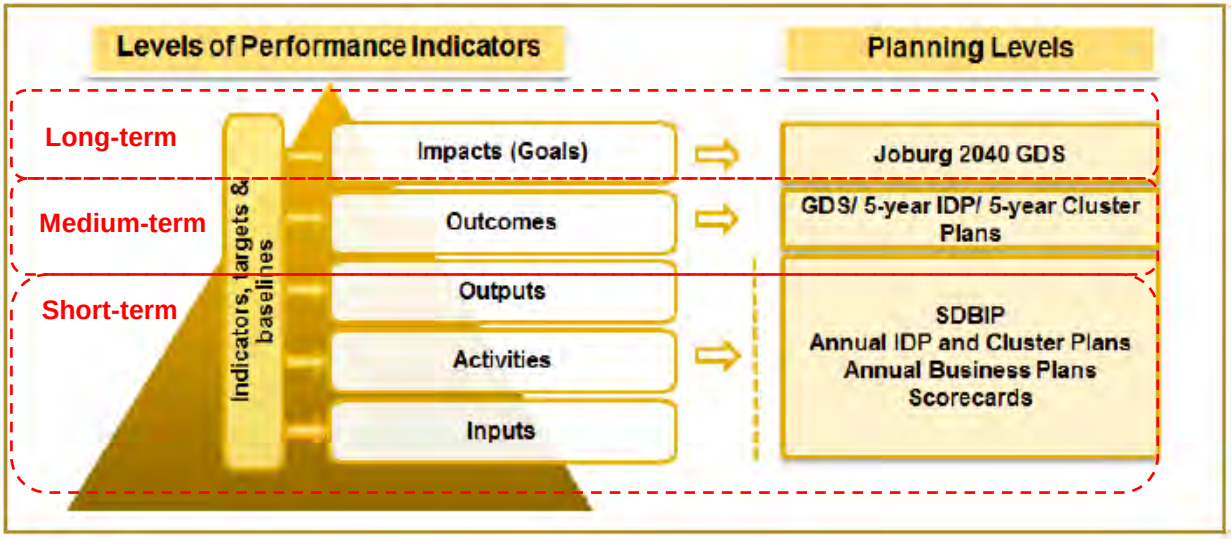

Figure 4.16: Aligning levels of performance with planning mechanisms in Johannesburg (after CJ, 2013a)

The 2012/2016 IDP included the goal of universal access (100% coverage) to basic sanitation services, defined as at least LoS 1 (Section 4.2.4), by 2014, which was not met (Table 4.6). The associated KPIs were to improve customer satisfaction and access to adequate services with a target of increasing by at least 0.5 percentage points each year using 2011 as the baseline (CJ, 2014c). Customer satisfaction surveys were used 'to [determine] the perceptions of customers about the quality of service' (Masondo, 2010). Satisfaction with sanitation services was the lowest amongst all of the utilities at 78.9% (CJ, 2014c), which was attributed to dissatisfaction from residents in areas without flush toilets, such as in informal settlements or low-income developments (Masondo, 2010). According to Figure 4.17, the rate of service delivery between 2010-2013, notwithstanding a slight increase in the backlog between 2012-2013, exceeded CJ's target of 0.5 percentage points per annum; however, verifying backlog figures is difficult given the fluctuating estimates on the number of informal households which are calculated using a variety of sources from various national and municipal records such as Stats SA, the Housing Department, and Regional Directors' offices. The backlog figures used in this thesis were calculated from the sources referenced in Figure 4.17 with a backlog being considered either no services, or at a service level below what qualifies as a basic level of service in the municipality. Figures are verified through surveys conducted by housing officials, but this is not done on a regular basis due to capacity constraints (Ramatsoele 2015, pers. comm., 18 Mar). Given a 0.5 percentage point increase in sanitation coverage each year it would take approximately 15 years (from 2011) for CJ to achieve universal access to at least a basic level of sanitation service.

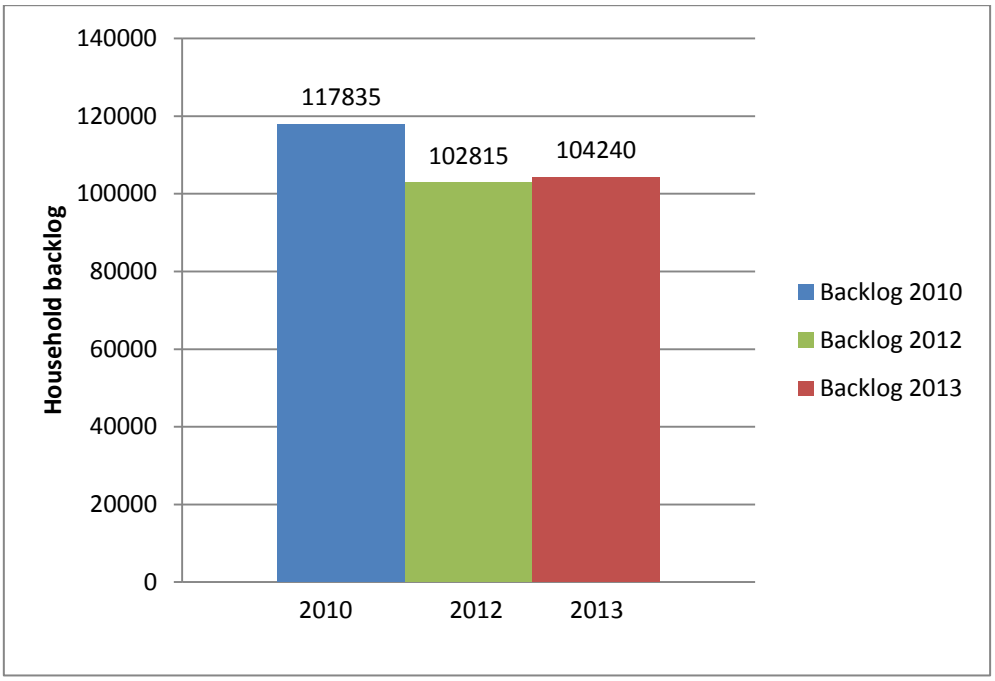

Figure 4.17: Backlog of households in informal settlements below a basic level of service from 2010-2013 (Kunene, 2010; MSTT, 2012; JW, 2015c)

The SDBIP is intended to link short-term budgeted activities with 'medium-term outcomes' (as described in the IDP) and 'long-term goals' (GDS) (CJ, 2014a). The proposed capital expenditure for various departments, MOEs, and projects for the given and following two financial years are included in the SDBIP. Activity indicators for the SDBIP are linked to IDP outcomes and GDS goals for water and sanitation service delivery under the Sustainable Services Cluster shown in Table 4.7. More on the use of indicators for M&E will be discussed in Section 4.2.3. One issue with the SDBIP as a planning tool is the difficulty of linking specific project budget items with the associated activities and outcomes, which makes it difficult to assess whether financial resources are being allocated equitably, e.g. only one project could be clearly identified as a basic water and sanitation service project in the SDBIP (2014) (VIP toilets in Orange Farm to be managed by JW). Furthermore, as mentioned in the literature review on equity in sanitation (Section 2.4), one of the challenges with assessing the equity of resource allocation for sanitation services in informal settlements is that water and sanitation budgets are often lumped together with more funding allocated to water supply projects than to sanitation projects. The lack of identifiable basic sanitation service delivery projects in the SDBIP, which is an important municipal planning tool, highlights the issue of sanitation service delivery to informal settlements as a low priority in Johannesburg despite the inclusion of increased household access to basic services as an outcome in the IDP and the GDS.

Table 4.7: Basic water and sanitation service indicators from SDBIP (CJ, 2014a)

GDS Institutional Impact Indicator	Indicator Description	IDP Outcome Indicator	Institutional SDBIP Activity/ Output Indicator	Indicator Description
Number and percentage of households with access to basic services	The number and percentage of households with access to basic water services demonstrates the city's success in providing access to services for all of its citizens. It is a constitutional obligation to provide citizens with basic services such as water, sanitation, electricity *etc.*	Percentage of household with access to basic services	Number and percentage of households with access to basic water services	The indicator measures the number and percentage of households with access to basic water services in Johannesburg
			Number and percentage of households with access to basic sanitation services	The indicator measures the number and percentage of households with access to basic sanitation services in Johannesburg

4.2.3 Institutional arrangements and expenditure on sanitation services in informal settlements

CJ has three layers of management with various responsibilities. The City Manager's office liaises with the executive mayor who heads the mayoral committee that includes political portfolios which correspond to various departments such as Environment and Infrastructure Services, which is where services such as water and sanitation and electricity are managed. A simplified CJ management structure for water services only is shown in Figure 4.18; for a complete management structure diagram see Appendix 1O.

The institutional structure of Johannesburg differs from eThekwini and Cape Town in that a number of MOEs were formed in Johannesburg as a way to resolve financial problems in the municipality, which was considered 'technically bankrupt' by the late 1990s, as part of a contracting model called Igoli 2002 (SALGA, 2011). The MOEs were created as 'service delivery companies' that would be owned entirely by the municipality, but would act essentially as utilities service providers operating on a corporate model enabling the service providers to 'bill for services, collect their own revenues, assume debt for capital projects, and make capital expenditures, with Board approval, to improve and extend services' (SALGA, 2011:1) with CJ acting as the 'client'. JW is considered to be the water service provider (WSP), whereas the water service authority (WSA) responsibility rests with CJ[56], specifically the Water Services department in the Environment and Infrastructure Services Directorate (EISD) (SALGA, 2011). JW was able to assist with the financial turnaround strategy and started turning a profit by 2006, but fragmentation of functions and responsibilities between the WSA (EISD) and WSP (JW) have resulted in problems with

[56] There is not always a distinction between the water service authority and water service provider depending on the institutional arrangement. For clarification on the roles of water service authorities and water service providers see Appendix 1N.

enforcing regulation (SALGA, 2011) and contributed to major gaps in the provision of basic services and low prioritisation of basic service projects (Manus 2014, pers. comm., 24 March), which do not generate revenue for JW.

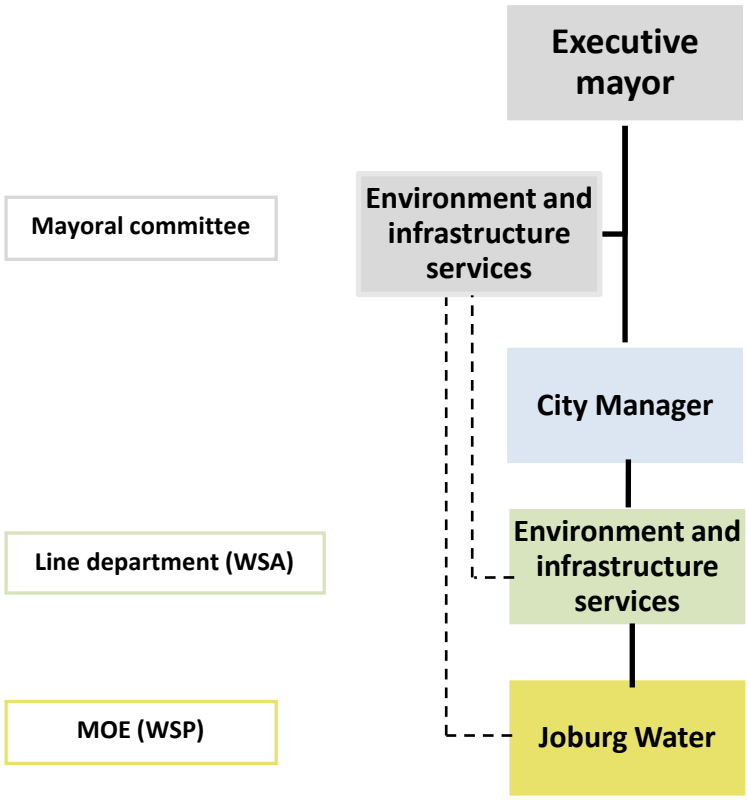

Figure 4.18: Management structure for water services in City of Johannesburg (after CJ, 2013b)

Under the regulatory framework established by CJ, CJ acts as a regulator of the services provided by JW. CJ's main function is 'to monitor the performance of the WSP' (CJ, 2014c). Thus, the service delivery agreement (SDA) between CJ and JW 'sets out the norms and standards and delivery targets expected of JW and serves as a regulatory tool (CJ, 2013c). A regulatory performance checklist developed by the EISD is included in Appendix 1P and includes a wide range of assessment criteria focusing on toilet and sludge disposal facility conditions and health and hygiene awareness promotion. Although monitoring tools such as the checklist have been developed, one of the challenges cited by CJ staff is inadequate staff capacity to conduct monitoring activities on a regular basis given the large number of informal settlements (~180) spread throughout the municipality (Figure 4.15). Thus, some M&E activities such as a full run through of the checklist in Appendix 1P are only conducted on an ad hoc basis (Mafoke, 2014, pers. comm., 2 December). The majority of informal settlements are located in the Deep South region, but there are also large pockets of informal settlements in the northern Midrand region in Diepsloot; thus the large number of settlements to cover over a large geographical area adds to the monitoring challenge. In addition to the EISD department specific monitoring checklist, an M&E framework has been developed for

the entire city to offer guidance for how to link indicators to various planning mechanisms (CJ, 2013a) (Figure 4.16). There is, however, the danger of reducing assessment of progress in basic sanitation service delivery to a sole indicator measuring the percentage of households with access without a more detailed evaluation of the quality of the service. A more detailed evaluation of basic water and sanitation services is better represented in the EISD proposed checklist in Appendix P.

The EISD collates data from JW for municipal reports used for M&E, but most of the data is managed by JW. The JW staff members involved with informal settlements primarily perform monitoring and administrative activities because the O&M responsibilities are contracted to external service providers (Ncube 2015, pers. comm., 13 April). JW had a staff size of approximately 2530 employees in 2015 (JW, 2015a) of whom only an estimated 30 staff directly support water and sanitation services in informal settlements. A copy of the Johannesburg Water organogram can be found in Appendix 1Q. Responsibilities are divided between the Capital Projects and Infrastructure Department, which includes a Basic Services team responsible for managing the construction of new water and sanitation infrastructure.

The operations department and associated regional depots in JW are responsible for ensuring that O&M responsibilities are carried out by contractors hired to clean and desludge chemical toilets and VIPs in each region (Ncube 2015, pers. comm., 13 April). The revenue cost for providing free basic water and sanitation services is shown in Table 4.8. A caveat mentioned previously is that in urban areas that are densely populated, such as many informal settlements in Johannesburg, greywater disposal becomes a problem when water is supplied without any means of treating and removing the greywater; thus basic sanitation services need to include greywater management to be more effective.

Table 4.8: Revenue costs[57] for Free Basic Water and Sanitation in CJ (CJ, 2014b)

Description	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15 Medium Term Revenue & Expenditure Framework**		
Revenue costs (R'000)	**Outcome**	**Outcome**	**Outcome**	**Adjusted Budget**	**Budget Year 2014/15**	**Budget Year 2015/16**	**Budget Year 2016/17**
Free Basic Water	313,627	224,802	227,023	227,598	236,681	246,701	247,252
Free Basic Sanitation*	76,946	54,634	65,787	72,414	84,729	99,111	106,918
% Difference from previous year	--	-40.8	17.0	9.2	14.5	14.5	7.3

[57] These cost figures are higher than the costs listed solely for FBSan, which in CJ is considered separately from services for informal settlements, *e.g.* cost for 'rudimentary services' such as chemical toilets would not be included in the FBSan costs, but in this thesis informal settlements and emergency or rudimentary services are included as part of FBSan evaluations.

4.2.4 Level of service and O&M for sanitation services in informal settlements

CJ has by-laws which outline three different levels of service (Table 4.9). As evident from the service delivery backlog, there are also residents, primarily living in informal settlements, who receive service levels that are considered to be rudimentary or below level of service (LoS) 1 ('basic'). These residents are served by water tankers and chemical toilets (JW, 2013b). LoS 2 is no longer being supported given significant implementation issues encountered (Kunene, 2010). Chemical toilets are not considered to meet a basic LoS, but given a variety of technical and legal constraints, they are still widely used as a form of sanitation service in informal settlements. The types of sanitation facilities provided in informal settlements and associated LoS used from 2010-2014 are shown in Table 4.10.

Table 4.9: Levels of service for water and sanitation services in Johannesburg (CJ, 2004)

Level	Water	Sanitation
1	Communal standpipes	Ventilated improved pit (VIP) for each site
2*	Unmetered water connection to each stand with an individual yard standpipe	Waterborne connection connected to either a municipal sewer or a shallow communal sewer system; or a pour flush toilet
3	Metered full pressure water connection to each stand	Conventional waterborne drainage installation connected to the Council's sewer

*LoS 2 for sanitation was discontinued between 2004 and 2009

Table 4.10: LoS and sanitation facility types in informal settlements (Kunene, 2010; JW, 2015c)

LoS	Access ratio	Sanitation types
Pilot	Discontinued	Easy Loo (composting)
Pilot	Discontinued	Aquaprivies
Rudimentary	Shared	Chemical toilet
Rudimentary	n/a	Unimproved pit latrine
1	Shared	Ablution blocks
1	1:1	VIP
3	1:1	Waterborne

Some of the pilot sanitation facilities have been discontinued due to implementation challenges. Figure 4.19 shows the breakdown of sanitation services used in informal settlements in Johannesburg by sanitation type. In informal settlements, most sanitation systems are on-site systems. Most households use chemical toilets (41.2%), followed by VIPs (35.2%), unimproved pit latrines (10.4%), conventional waterborne toilets (5.4%), and finally ablution blocks (1.3%) (JW, 2015c). 6.5% of households in informal settlements are not provided with any form of sanitation and have not constructed their own pit latrines. Unimproved pit latrines are often constructed by informal residents at their own expense so that they have their own household facility as opposed to some of the other sanitation types

that are supplied and serviced by the municipality at no cost to users but are shared amongst multiple households. Different sanitation types are associated with different levels of service and are provided on either a shared or individual household basis (Table 4.10).

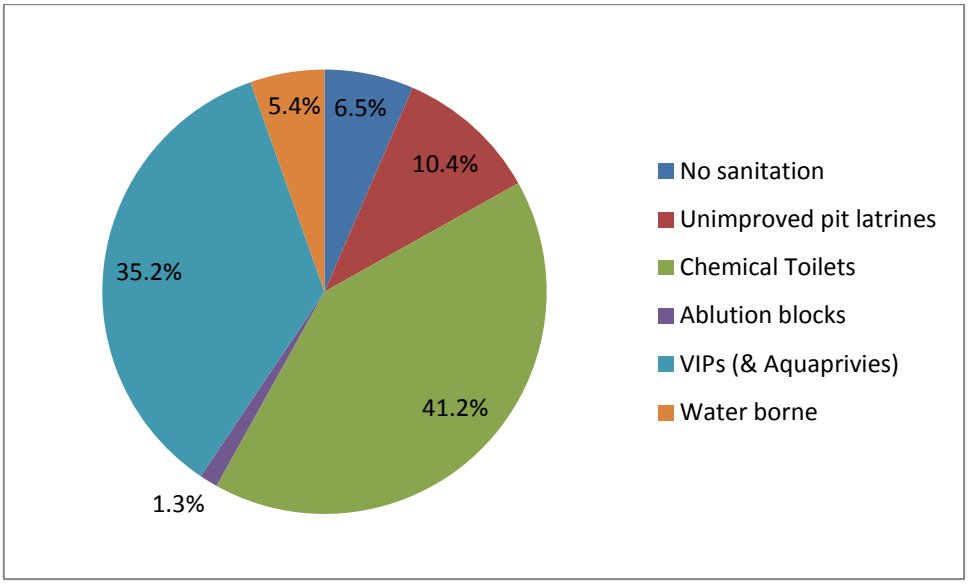

Figure 4.19: Sanitation services provided in informal settlements (JW, 2015c)

The unit costs for servicing VIP (de-sludging) and chemical toilets (cleaning and desludging) are given in Appendix A. Some of the O&M challenges JW faces with regards to on-site sanitation systems include:

- Users using VIPs and chemical toilets as refuse bins, i.e. throwing solid waste into the pits resulting in the need for a higher frequency of desludging than the five year design period.
- The location of VIPs often makes them inaccessible to the trucks used for desludging since shacks are built in a cluster around some VIPs making them difficult to reach.
- The sludge collected from VIPs and chemical toilets also has a negative impact on wastewater treatment works that were not designed to handle the faecal sludge loads.
- Desludging VIPs is done on an ad hoc basis due to budgetary constraints upon councillors' requests in their respective wards. JW is also understaffed with regards to on-site sanitation services. Therefore, JW officials cannot always monitor the quality of service provided by contractors hired to do desludging or to ensure that sludge is collected and disposed of properly (Nelson, 2015, pers. comm. May 14).

Customers can also contact municipal call centres to request desludging services. The targeted turnaround time for requests is three days. Sludge is transported to disposal points located in different operational regions which are linked to WWTWs owned by either CJ, or

in the Deep South region to an outfall that is shared between CJ and Metsi Alekwa municipality (Nelson, 2015, pers. comm., May 14).

Figure 4.20: Interior and exterior of a well maintained VIP in Finetown (Pan 17/2/2015)

Users are given the responsibility to clean individual household toilets, provide their own anal cleansing material (operational activities), and maintain structures for VIPs (Figure 4.20) and conventional waterborne toilets, but maintenance such as desludging or repairing leaks is considered to be a municipal responsibility. Shared sanitation facilities such as CABs and chemical toilets are operated and maintained by the municipality, although users are responsible for providing their own anal cleansing material for chemical toilets. CABs have caretakers who are responsible for cleaning the facility, reporting damages to JW and distributing toilet paper. They are waterborne systems linked to either a septic tank or sewerage. O&M arrangements for a pilot communal ablution block that is connected to a decentralised wastewater treatment system (DEWATS) will be discussed in Section 4.2.5. There are some lingering ambiguities around the division of responsibilities given the concept of household 'ownership' versus users' expectations of municipal O&M responsibilities, e.g. if the top structure is damaged due to inclement weather or theft, will households be assisted with replacing the door if they cannot afford to do so on their own, and how many times? The impact of unclear O&M responsibilities on sustainability and equity of sanitation services is discussed further in Section 4.2.5.

4.2.5 Sustainability and equity assessment for the Diepsloot sanitation service pilot project

Informal settlements are treated as housing emergencies or 'temporary' settlements until they are either relocated or upgraded; however, the reality is that some settlements have been in existence for over 20 years. As such, finding an appropriate level of service and system can be challenging. A comparison of services between 2001 and 2014 levels in informal settlements indicates that of 33 settlements that could be matched by name and region: 22 had undergone a change in the LoS provided. Services in 21 settlements improved while the LoS in one settlement decreased (JW, 2001; JW, 2015c). The condition of facilities was not recorded. The change was mainly from either no service or chemical toilets to VIPs. Of the 11 informal settlements that did not experience changes in the level of service, ten continued to be serviced by chemical toilets and one by ablution blocks, indicating that chemical toilets have been in use for at least 13 years, and will continue to be used as a rudimentary level of service until a better alternative is found.

Johannesburg, similar to eThekwini and Cape Town is trying to promote 'off grid' basic sanitation and energy services in informal settlements (CJ, 2014a) as a way of increasing sustainability. One of the off grid pilot projects is a CAB in Diepsloot, which uses recycled water for flushing and is connected to a DEWAT system. The aim of the project is to provide an alternative system to VIP and chemical toilets that have relatively high O&M costs and a detrimental effect on WWTWs (JW, 2013a). The Diepsloot CAB includes handwashing facilities with separate facilities for men and women. The system was designed by a private company, Calcamite Water & Sanitation Solutions, for use by 50 families selected for the pilot who are living within proximity of the facility with an estimated average household size of seven people per household with five stalls for women, five for men and an additional four urinals. The contractors managing O&M for the facility requested that JW restrict access to the facility to the 50 families who were identified and given access cards and to engage with them during the pilot period to be able to compare the facility to other sanitation types (Masondo, 2015 pers. comm., April 13); however, access cards were shared with other households outside of the pilot selection to the contractors' frustration (Ncube, 2015, pers. comm., 20 August). (N.B. From the author's visit in 2015, it appeared that access cards are no longer required to use the facility.) Another issue that arose early on was that the handover of the facility was delayed by a year due to gaps in the O&M planning and a lack of coordination between the New Services Department staff and the O&M staff at JW (Masondo, 2015, pers. comm.. 13 April).

A drawing of the facility is included in Appendix R. The toilet facilities are built in a metal containerised unit (Figure 4.21). The DEWATS consist of three parts: underground septic tanks, followed by a biological reactor, and then a final settling tank after which the treated water is pumped and reused for flushing the toilets[58] (JW, 2013a). The energy required to power the system and to provide lighting is provided by solar panels (Figure

[58] For a more detailed description of the system see Appendix R.

4.21). Two caretakers have been hired to help clean the facility, to hand out toilet paper and to report damages to the municipality.

There are several discrepancies between how the project was designed and what is happening on the ground, indicating a mismatch between the project design and social dynamics in informal settlements. As mentioned, users are lending their access cards to friends and neighbours; thus access is no longer restricted to 50 families. Furthermore, according to the municipality the facility is supposed to be open 24 hours a day, but according to the caretakers, the facility is closed between 8pm and 6am. At night people either use a night soil bucket or chemical toilets in the vicinity (Figure 4.22).

Figure 4.21: Exterior of the Diepsloot pilot CAB (Pan 28/1/2015)

Figure 4.22: Chemical toilet in Diepsloot near CAB (left) and flush toilet in CAB (right) (Pan 28/1/2015)

During the author's daytime visit to the facility (28/1/2015), the facility appeared to be in good condition and the two caretakers gave positive feedback, but the number of residents using the facility was not being recorded as of August 2015. Chemical toilets adjacent to the facility also continued to be used, and it was unclear whether the CAB service as designed would be able to meet the 50 households' needs without the supplemental chemical toilets. Two implementation problems, causes and effects noted by JW are highlighted in Figure 4.23 and Figure 4.24.

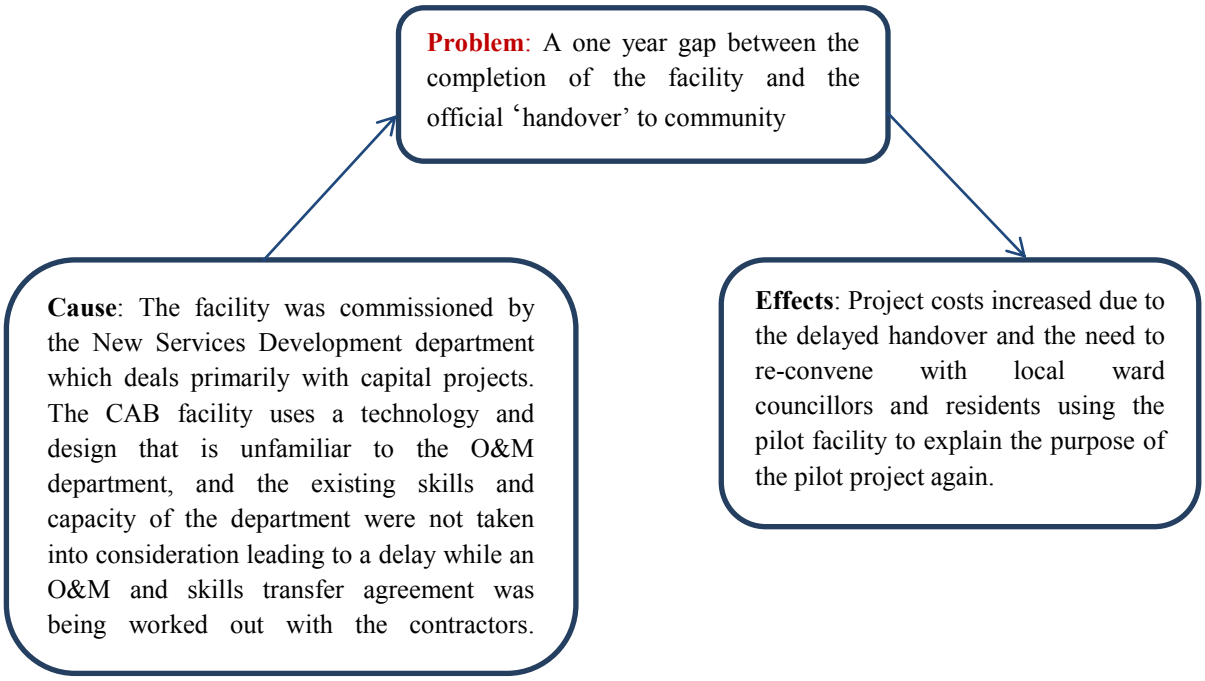

Figure 4.23: Summary of handover problem with Diepsloot pilot CAB

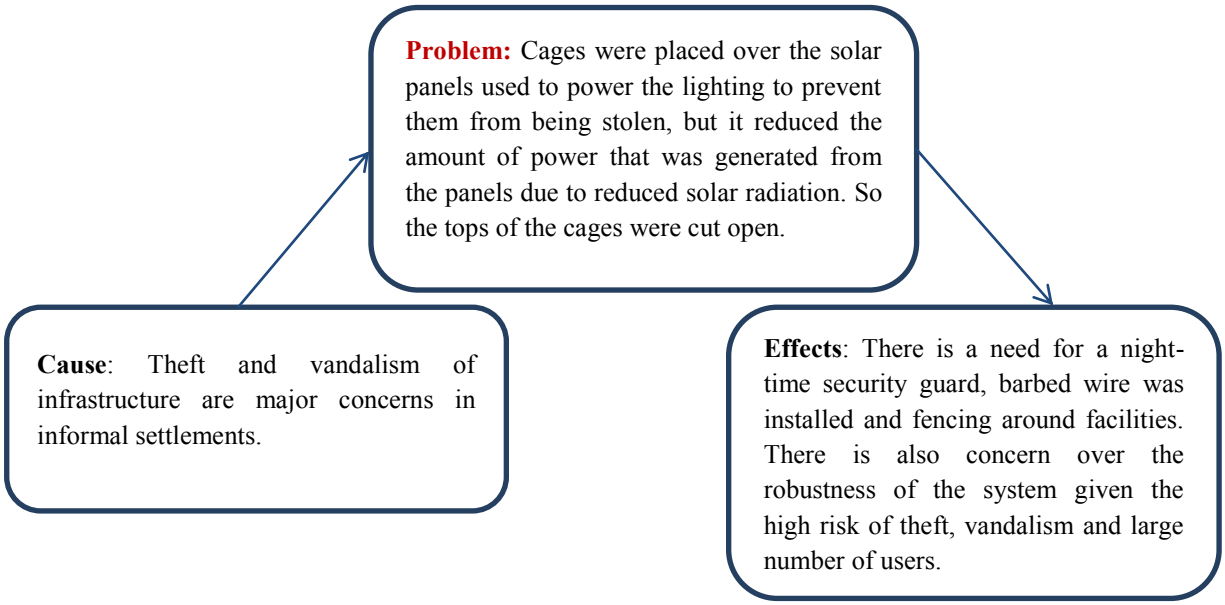

Figure 4.24: Summary of solar panel and security issue

The causes for problems identified in Figure 4.23 and Figure 4.24 are not unique to the Diepsloot pilot project, and indicate general institutional and social issues related to sanitation service delivery in informal settlements. There are, however, implications for any plans to expand the pilot project and areas that need to be addressed if the project is to be expanded into a large scale service delivery programme such as the CAB programme discussed in Section 4.1. The importance of addressing institutional coordination issues and increasing capacity where necessary is critical to the sustainability of the system – as is the importance of finding ways to deter vandalism and theft. There should also be a contingency plan if the solar panels are stolen or damaged, e.g. a backup power source.

An overview of various dimensions of sustainability and equity considerations for the CAB pilot are presented in Figure 4.25 and Figure 4.26. The Diepsloot facility was opened in October 2014, and as of August 2015, no major technical issues had been reported (Ncube, 2015, pers. comm., 20 August). While there can be many technical challenges to providing services in informal settlements, unpredictable social dynamics and institutional coordination challenges are often the most complex challenges that arise before and after facilities are built as demonstrated by the Diepsloot pilot project. Figure 4.25 depicts some of the various sustainability considerations that may support or hinder the sustainability of the Diepsloot recycled wastewater CAB system. Two features that favour the environmental sustainability of the system are the reuse of treated greywater and blackwater for flushing toilets and the use of solar energy to power the lighting and pumping system for the DEWATS. However, the wastewater reuse may potentially have negative health or environmental consequences if not monitored carefully given elevated levels of ammonia or higher than targeted E. Coli levels observed (Appendix R) indicating that additional treatment of effluent or dilution may be required prior to reuse.

There are also several issues that may threaten the sustainability of the pilot service as well as limit the potential to expand the service to other settlements. One of the issues is that the pilot project is not being assessed systematically by JW, e.g. monitoring monthly usage patterns, surveying users prior to the project implementation to use as a baseline for comparison to later assessments or regular effluent quality measuring. There are several aspects such as the ‘applicability, scalability and sustainability’ (Olschewski, 2013) of utilising a new technology in informal settlement environments that need to be assessed before deciding to implement a particular technology or system on a larger scale.

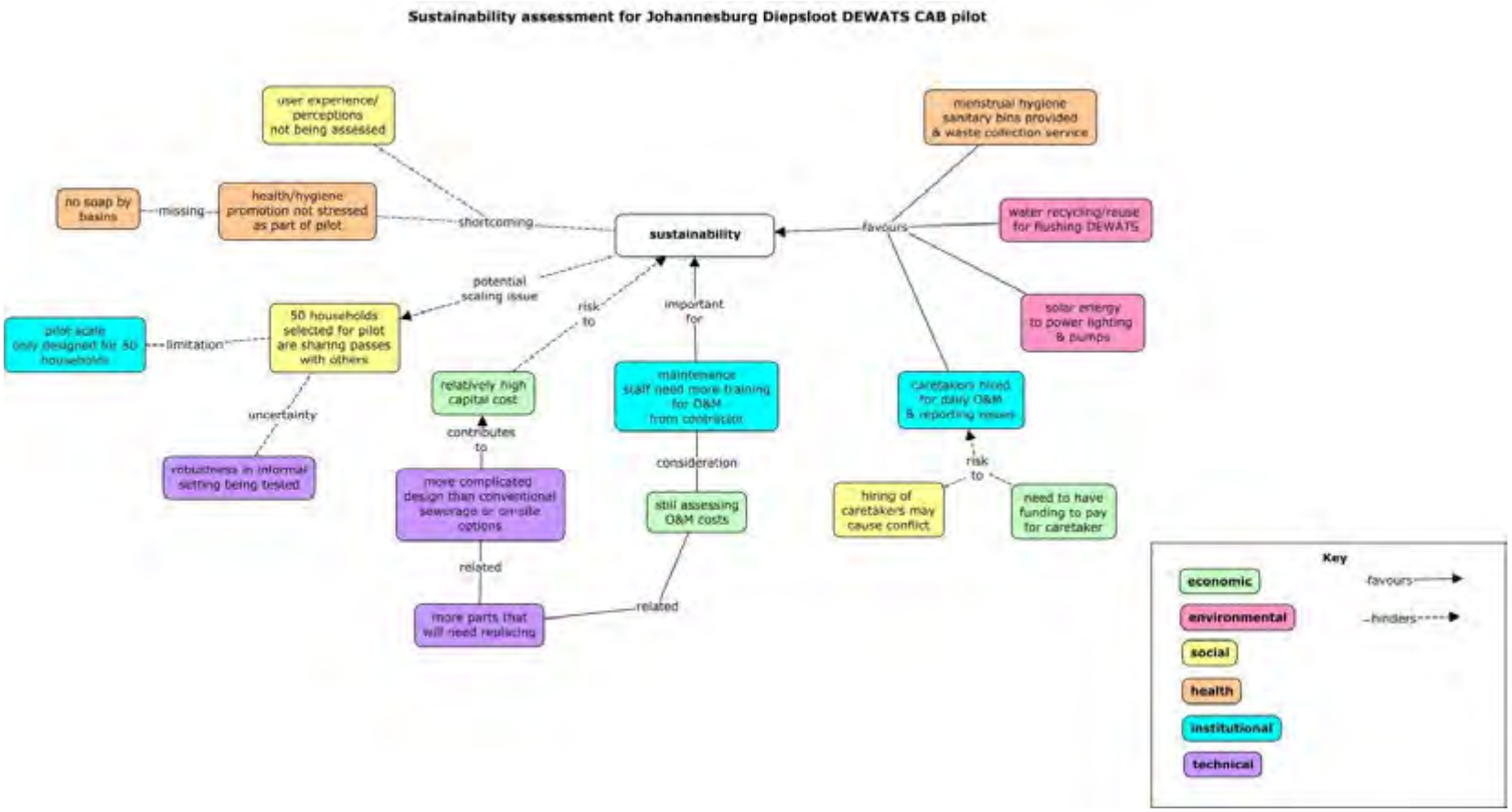

Figure 4.25: Concept map for sustainability assessment of Diepsloot pilot project in Johannesburg

Some of the sustainability related questions that still need to be evaluated include:

- How frequently does the settling tank need to be desludged[59]?
- How much water/energy is being used per month?
- What is the system's cost per user compared to alternatives?
- Are users satisfied with the service? [60]
- Can O&M skills be transferred from contractors to municipal employees or should it continue to be managed by contractors?
- How does the system fit into overall sanitation planning for the City as an interim service?

Three important institutional and financial lessons from the Diepsloot pilot project that affect its sustainability are the need to:

i) plan for O&M prior to the installation of any system whilst taking into account existing capacity and/or the need to train or hire staff,

ii) include skills transfer and training as part of any service delivery agreements signed with consultants and contractors, and

iii)budget for adequate M&E to provide feedback for decision-makers.

All three are important considerations regardless of whether a new technology is being tested or not, but they are especially critical if a decision is being made to expand from a pilot to full-scale programme.

With regards to equity of access, one of the issues detected during the author's field visit is that the caretakers indicated that the facility is closed during the evenings, and thus residents resort to using the adjacent chemical toilets or night soil buckets. It should be noted that even if facilities were open at night, it is unlikely that women and children would use the facilities given the risk of being attacked after dark en route to the sanitation facility. Provision for disabled users also has not been made, although the pilot design could be modified to accommodate disabled users if necessary. It was encouraging, however, that the female facilities have a MHM system in place with sanitary bins provided inside toilet cubicles (Figure 4.22). The Diepsloot pilot project is operating at a relatively small scale (one unit designed for only 50 households); thus, if the pilot project is not expanded it can become a potential equity issue amongst other Diepsloot residents.

[59] The supplier claims that desludging should only be necessary after approximately three years (WRC & DST, 2016), but as of 2016 the system had been in operation for less than two years so the claim was difficult to verify.

[60] A general comment on the pilot project, made by the JW Research and Innovation Manager was that there were several M&E gaps in the pilot project design, particularly with regards to social aspects such as assessing user perspectives and satisfaction (Ncube, 2015, pers. comm., 2 March).

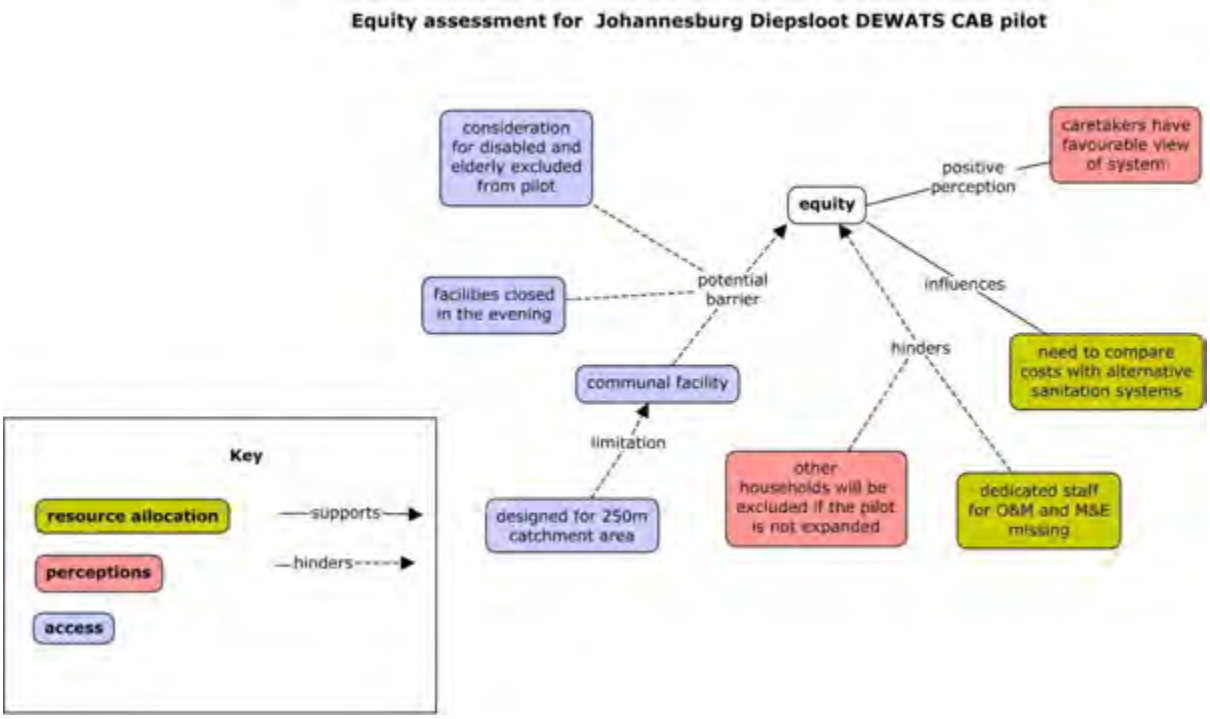

Figure 4.26: Concept map for equity assessment of Diepsloot pilot project in Johannesburg

As indicated by some of the uncertainties and lessons gleaned from the Diepsloot pilot project, it is important to consider multiple dimensions of sustainability and equity when assessing a sanitation service and whether or not to scale up a pilot. On the surface, for example, the water recycling system may make the DEWATS appealing from an environmental perspective (although the recycled effluent quality needs to be monitored carefully); however, if the system is very costly to maintain and/or adequate technical capacity is not available, then the system is technically unsustainable (Figure 4.25). Equity is particularly important not to overlook given the potential exclusion of vulnerable groups of people with a communal sanitation system. As mentioned in Section 4.1.5, communal systems that are located several hundred meters from people's homes may be considered unsafe to use by vulnerable groups of people at night, and those with physical disabilities need sanitation systems accessible within their homes. Perceptions are also important to consider. If multiple sanitation systems are used in the same settlement, comparison can affect people's perceptions of what is an acceptable system and result in perceptions of unfair or preferential treatment if one system is perceived as a better LoS. For example, although chemical toilets were still available adjacent to the CAB, some users asked to borrow access cards to use the CAB rather than the chemical toilets indicating a preference by some users for flush facilities. Equity implications for the LoS framework will be discussed in Section 4.4.

As a general commentary on testing 'alternative' or 'new' sanitation technologies in informal settlements or 'slum areas', the ethics of doing so always needs to be considered, as with any tests involving human subjects. If a pilot fails, what happens then? If it is successful in one area, can it be transferred to another? If it is removed, will a new (and better) system

be installed and at whose expense? Do people know that they are part of a pilot project testing a new technology? Being able to answer these questions can go a long way towards promoting the sustainability and scaling up of a system, and it is concerning that this was not observed in the Diepsloot pilot project.

Arguments can be made that providing something is better than nothing and that there are valuable lessons to learn from failures. However, informal settlement residents are especially vulnerable to the risks associated with a failed sanitation system such as environmental pollution (now concentrated in the vicinity of the system) or diseases associated with poor sanitation since they often have limited access to healthcare services. The risks of failure and how to mitigate them need to be carefully assessed. Therefore, any proposed sanitation 'solutions' should be carefully tested and evaluated in a lower-risk setting *prior* to implementing them in an informal settlement to ensure that they meet technical sustainability criteria. Various stakeholders' (e.g. government officials, service providers', researchers') biases towards wanting a technology to work regardless of the context often lead to demands or expectations that people change their behaviour, but the socio-cultural sustainability and peoples' perceptions need to be taken into account before a particular technological solution is recommended rather than as an afterthought.

4.3 Cape Town

4.3.1 Introduction

The City of Cape Town (CCT) is located in the Western Cape Province. As with EM and CJ CCT is also categorised as a metropolitan municipality. It is the second most populated city in South Africa. Population, household and sewerage access statistics are given in Table 4.11. The City's climate can be classified as warm and temperate with dry summers and wet winters and is described as a Mediterranean climate. The City faces significant concerns about preserving the unique 'natural assets', including several nature reserves within the boundaries of the municipality, which attract visitors as well as residents (CCT, 2013b).

Table 4.11: Basic statistics for Cape Town (Stats SA, 2012b)

Population	# of Households (HHs)	% Informal (HHs)	% Point Change in % Informal HH (2001-2011)s	Population growth (2001-2011) (% p.a.)	Unemployment rate (%)
3,740,025	1,068,572	22	3.2	2.57	23.9

The city has grown by an average of 2.57% per annum in the last 10 years as shown in Table 4.11, i.e. since 2001 has grown by over 25%. The rapid population growth faced by CCT, as well as the other metropolitan municipalities discussed, has put a significant strain on water and sanitation services. Water and sanitation service statistics for CCT are shown in Table 4.12. The number of sanitation facilities installed by CCT has increased over the last 10 years; however, due to a higher rate of growth in informal settlements than the rate of delivery, the backlog has grown, and city officials interviewed described it as a 'moving target'. More on the backlog and service delivery planning will be discussed in Section 4.3.2.

Table 4.12: Water and sanitation service statistics for the City of Cape Town (CCT, 2001[a]; CCT, 2011d[b]; StatsSA, 2012b[c];)

Water and sanitation coverage	Percentage (2001)	Percentage (2011)	# of HHs (2011)
In-house piped water supply (% households)[b]	69.4	75	801,429
Piped water within 200m of dwelling[a, c]	98	98	1,081,118
Unaccounted for water losses (%)[c]	23	14.5	n/a
Sewerage coverage (% households)[b]	85.4	88.2	942,481
Sanitation backlog (% hosehoulds below basic level)[a,b*]	7.3	8.7	88,305

Figure 4.27 shows the location of major WWTWs and informal settlements in CCT. The majority of informal settlements are located in an area known as the Cape Flats which is characterised by sandy soils and a high water table and was primarily a wetland area prior to residential development (Joubert & Martindale, 2013). The high water table and seasonal

flooding have impacted the choice of sanitation technology, e.g. VIPs are not used due to concerns over groundwater contamination. All faecal sludge collected from non-sewered informal settlements is transported to Borcherds Quarry WWTW, which is indicated on the map (Figure 4.27).

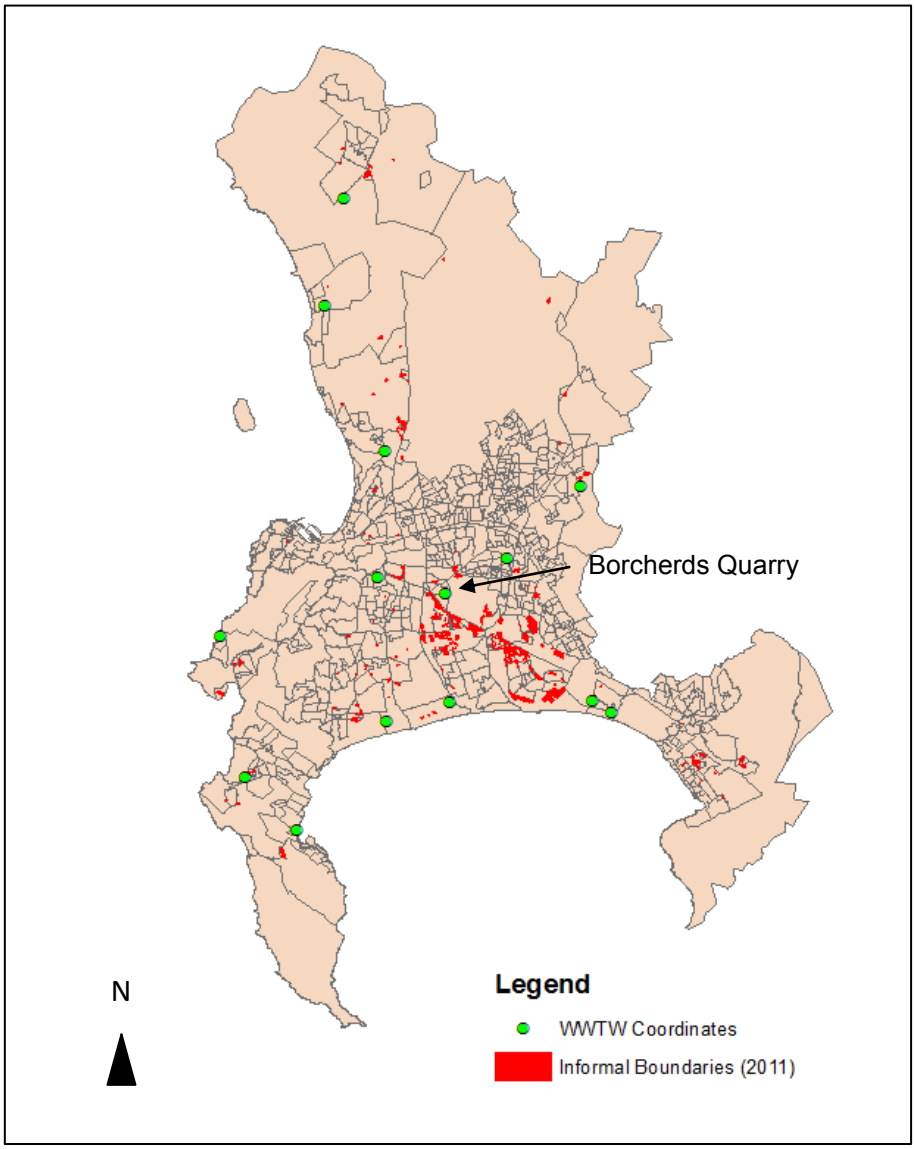

Figure 4.27: Map of Cape Town showing the location of informal settlements and major WWTWs (CCT, 2012b)

4.3.2 Service delivery planning

CCT participated in a long-term visioning process in 2012 to develop a vision for Cape Town in 2040, similar to the Imagine Durban and Joburg 2030 exercises, which was coordinated with the OneCape2040 vision and strategy for the entire Western Cape Province (EDP, 2012). The vision statement in OneCape2040, echoed in the CCT's City Development Strategy (CDS), is to be 'A highly skilled, innovation-driven, resource efficient, connected,

high-opportunity and collaborative society' (CCT, 2012a:10). The long-term CDS goal of delivering basic services optimally (Goal 7, CCT, 2012a) is discussed in relation to the medium-term IDP focus area of the 'well-run city' mainly in reference to governance and administration and the 'caring city' with regards to increasing access to basic services and social services (CCT, 2013b). Sanitation services to informal settlements are specifically referenced in the IDP Objective 3.4 to 'provide for the needs of informal settlements and backyard residences through improved service' (CCT, 2013b:72). A five year target for eradicating water and sanitation backlogs by the 2015/16 financial year was set, but will not be met, and there is projected to be a continued shortfall between the number of toilet facilities needed and the number delivered per annum during the next financial year due to budget shortfalls and on the ground delivery challenges.

The WSDP highlights some of the key sanitation service delivery challenges as:

- lack of space and the extreme densities of some settlements,
- resistance from the community[61],
- greywater ponding problems,
- settlements located on private land, closed landfill sites or other unsuitable land, and
- the [low] level of community acceptance of non-waterborne sanitation. (CCT, 2013g)

In terms of the rate of delivery, the average delivery rate of 3,100 sanitation units per annum, utilising a variety of different technologies, falls short of the average predicted annual informal settlement growth rate of 3,371 households[62] (CCT, 2013g). As observed in the other municipalities, there is some ambiguity in terms of how to calculate the sanitation service backlog. The 2014 estimated sanitation backlog, drops to 19,260 households or ~1.5% of all households in the city if a basic sanitation service level is broadened to include all forms of sanitation technologies provided by CCT as long as the service ratio is less than or equal to one toilet per five households (CCT, 2014c). However, given that the SAHRC (2014a; 2014b) deemed chemical toilets and other similar services as unacceptable for basic service standards, backlog figures cited in Figure 4.28 are higher than those cited by CCT (CCT, 2014c).

A conservative estimate of the number of households without access to a basic level of sanitation service is given in Figure 4.28. Actual backlog figures fluctuate since surveys generally do not take into consideration whether or not a sanitation facility is still functional. The majority of those without access live in informal settlements, which make up ~13.5% of the City's households (CCT, 2013b), but there are also backyard dwellers who lack sanitation access. Backyard dwellers, who make up ~7% of households in Cape Town (CCT, 2013b), often lack reliable access to water and sanitation services from the formal household owners

[61] Resistance often takes the form of protests relating to employment contracts that are linked to infrastructure construction. If some dwellings need to be relocated for infrastructure construction, then there can also be community resistance.
[62] N.B. This figure excludes backyard shacks, which also contribute to the sanitation backlog.

who act as landlords unless there is a familial relation between the backyarder and the owner (Madubedube, 2013, pers. comm., 8 May) and also contribute to the sanitation backlog.

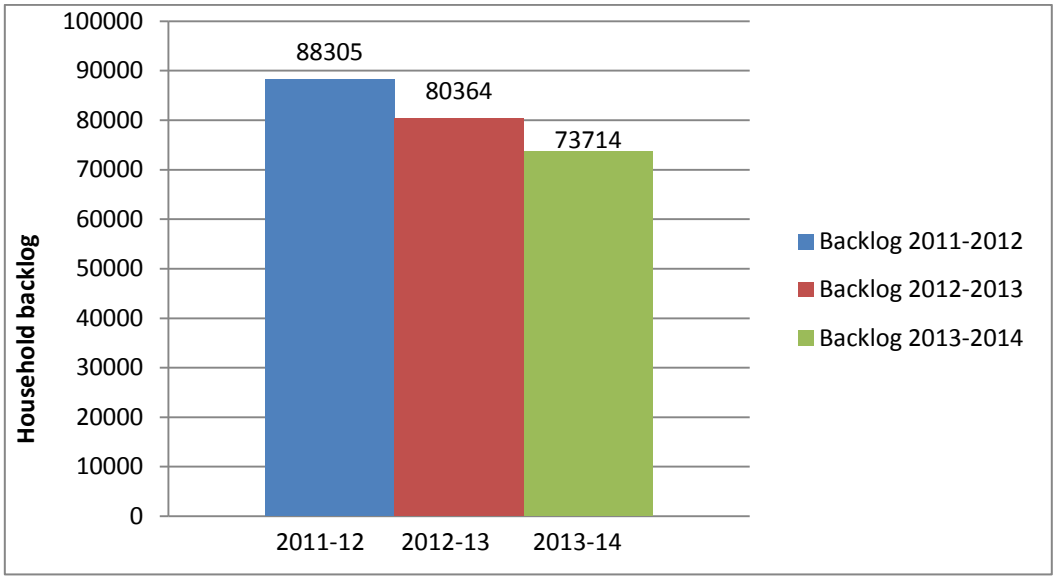

Figure 4.28: Household sanitation service backlog estimates from 2011-2014 for CCT (CCT, 2011d; CCT, 2012b; CCT, 2013b). (N.B. The estimated number of informal households was significantly reduced between 2012-2013.)

4.3.3 Institutional arrangements and expenditure on sanitation services in informal settlements

CCT is a metropolitan municipality governed by a 221-member City Council, which elects the mayor and several other political leaders. The Council and Mayoral Committee represent the political structure for the city, whereas the administrative staff members are led by the City Manager and an Executive Management team, similar to the other metropolitan municipalities (CCT, 2011a). Water and sanitation services fall under the Utility Services Directorate. The Human Settlements Directorate also has a significant influence on water and sanitation service development in informal settlements due to the presence of informal settlement departments in both directorates and the linkage between housing and water and sanitation service provision. Diagrams for both directorates are presented in Figure 4.29 with sub-departments relevant to sanitation services in informal settlements bolded.

The Water and Sanitation Informal Settlements Unit (WSISU) is responsible for O&M and M&E of water and sanitation services to informal settlements, whereas Human Settlements Informal Settlements (HSIS) plans for informal settlement upgrades linked to housing development; however, some of the programmes such as the reblocking programme, which will be described in Section 4.3.5, require a high degree of collaboration between departments. Even within the Water and Sanitation Department, coordination issues between sub-departments have been cited as a challenge, particularly during the handover after installation between the Design and Construction Department and Operation and

Maintenance Department (CCT, 2014b). Some issues with coordinating responsibilities between different departments and directorates have been observed by the author and described by NGOs as a barrier to effective service delivery (Bregman, 2013, pers. comm., 2 December; Kumar, 2013, pers. comm., 22 May). CCT has tried to address some of the internal coordination issues with the formation of an Urbanisation Department to act as an 'umbrella' for urbanisation-related challenges such as informal settlement growth and service delivery (Sims, 2013, pers. comm., 20 November).

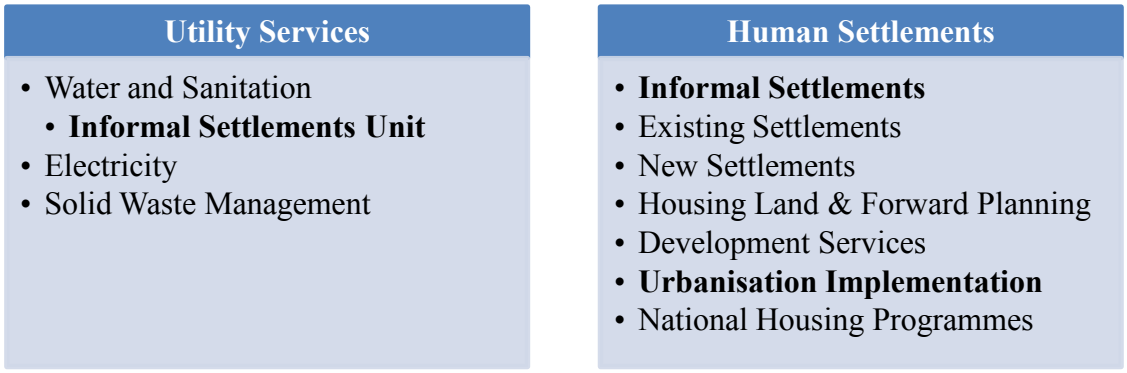

Figure 4.29: Departments in Utility Services and Human Settlements Directorate (CCT, 2014c)

The cost of providing FBW and FBSan as well as projected costs for upcoming budget years is presented in Table 4.13. Notably, spending on FBSan has increased annually since 2011 at an average rate of 15.4% (excluding inflation adjustment) per annum over six years (a higher rate than either EM or CJ).

Table 4.13: Revenue costs for FBW and FBSan in CCT (CCT, 2012; CCT, 2014a; CCT, 2015b)

Description	2011/12	2012/13	2013/14	2014/15	2014/15 Medium Term Revenue & Expenditure Framework		
Revenue costs (R'000)	Outcome	Outcome	Outcome	Adjusted Budget	Budget Year 2014/15	Budget Year 2015/16	Budget Year 2016/17
Free Basic Water	498,367	544,359	667,256	674,724	730,125	818,543	917,669
Free Basic Sanitation	314,203	384,410	440,786	554,040	605,330	667,129	735,722
% Difference previous year	--	22.3	14.7	25.7	9.3	10.2	10.3

4.3.4 Level of service and O&M for sanitation services in informal settlements

CCT is using a development matrix, developed by the CCT HSIS to help categorise informal settlements based on a variety of factors including inter alia (CCT, 2013e):

- land type,
- availability of bulk infrastructure,
- availability of distributed space, and
- recommended levels of service.

A complete list of factors considered for the development matrix can be found in Appendix 1L. As shown in Table 4.14, levels of service have been recommended according to the category of informal settlement. The different levels of water and sanitation services linked to the development matrix categories in Table 4.14 are described in Table 4.15.

Table 4.14: Development matrix categories and recommended levels of water and sanitation service in informal settlements (CCT, 2014c)

Cat.	Land Type	Bulk Infrastructure	Space available w/in settlement	Recommended Level of Service
A1	Government land, occupation permitted	Available within economical distance	Adequate	1
			Inadequate	2
		Not available within economical distance	Adequate	3
			Inadequate	4, 5
A2	Private land, occupation permitted	Not applicable (no capital investment on private land)	Adequate	3
			Inadequate	4, 5
B	Adverse physical conditions, occupation permitted	Not applicable	Adequate	3
			Inadequate	4, 5
C	Occupation prohibited	Not applicable	Adequate	3
			Inadequate	4, 5

Table 4.15: Proposed levels of water and sanitation service linked to informal settlement development matrix for the City of Cape Town (CCT, 2014c)

LoS	Water	Sanitation	Servicing frequency
1	Ratio of 1:25 communal standpipes per household	Waterborne sanitation with ratio of 1:5 toilets per household	Reactive maintenance upon report of defective infrastructure
2	Taps and basins included at 1:25 ratio	Sewered ablution facility (toilets, showers, wash basins) with a janitorial service to be supplemented by porta potties on demand for night-time use	Reactive maintenance upon report of defective infrastructure.
3	Ratio of 1:25 communal standpipes per household	Communal container or dehydration toilets to technology-specific household ratios	• Reactive maintenance upon report of defective infrastructure. User ratio is technology dependent. • Containerised technology serviced three times /week. • Dehydration toilets serviced monthly. • Conservancy tank serviced monthly.
4	Taps and basins included at 1:25 ratio	Conservancy tank ablution facility with janitorial service, supplemented by portapotties on demand, to be used in the dwelling at night	Reactive maintenance. Conservancy tank serviced weekly.
5	Ratio of 1:25 communal standpipes per household	Portapotties or single use dehydration toilets allocated at a ratio of 1:1, each with specified cleaning arrangements and usage training	Reactive maintenance. Regular emptying/cleaning service of three times per week.

Figure 4.30 shows the breakdown of sanitation technologies used in informal settlements between 2010-2014, which are predominantly communal with the exception of bucket toilets, Portable Flush Toilets (PFTs or Portapotties), and Afrisan (urine diversion dehydration) toilets. Approximately 14% of households do not receive a sanitation service that meets the basic minimum standard ratio as set by CCT of 1 toilet to 5 households (CCT, 2013e). With respect to O&M responsibilities, the municipality hires contractors to assist with cleaning, emptying and transporting faecal sludge for container based systems such as the chemical, container, bucket and PFTs described in Appendix C. The frequency of cleaning and emptying varies depending on the size of the system and contract arrangements ranging from several times per week to once a month (Table 4.15). Anecdotal evidence indicates a wide variety of cleanliness levels for facilities depending on the number of people using a particular facility, and the informal cleaning arrangements made between households. Workers who empty toilets and/or clean are usually hired from the settlement receiving the service or neighbouring settlements; the City also maintains a database of job seekers using the local ward system for administration, but there is often employment related conflict

during basic service delivery projects given high competition for limited job opportunities in informal areas that have high levels of unemployment (Taing et al., 2013).

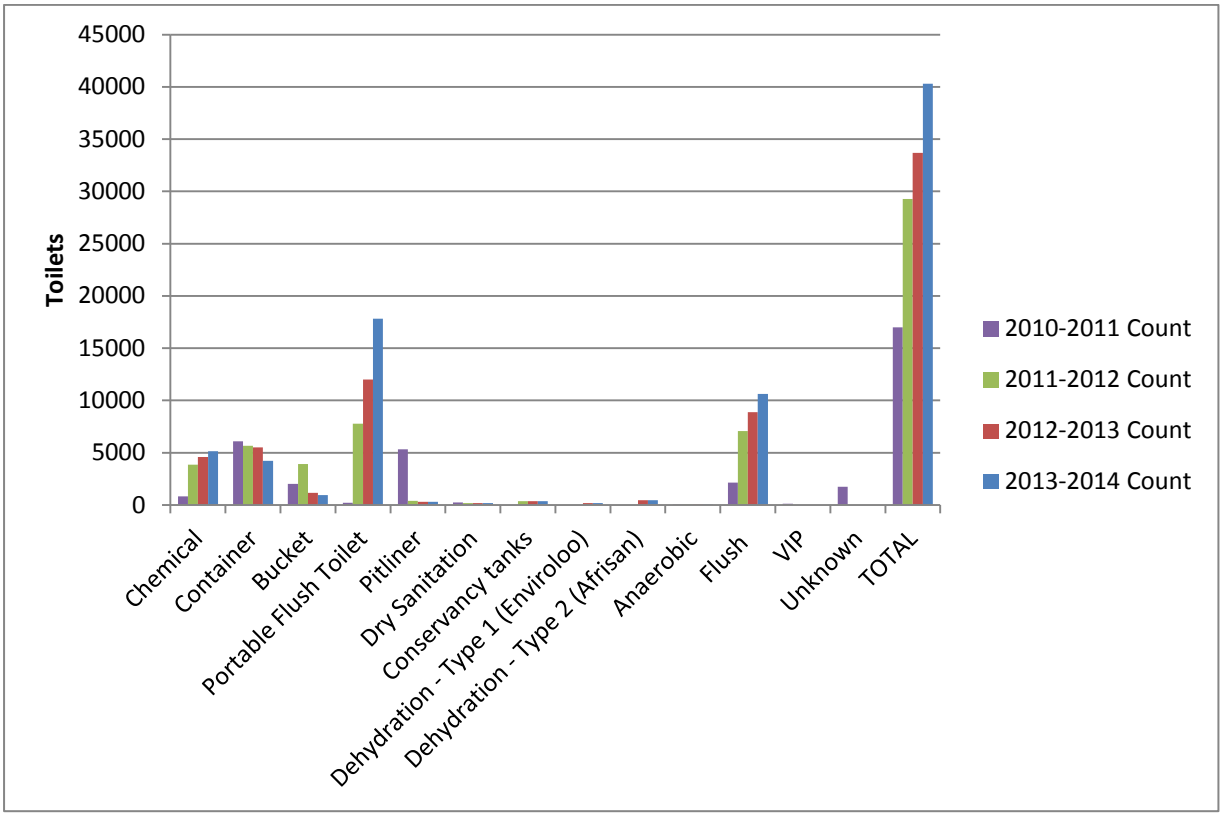

Figure 4.30: Toilet counts from 2010-2014 water service development plans. N.B. data comes from the preceding year. (CCT, 2009; CCT, 2011d; CCT; 2012; CCT, 2013e)

Although the majority of sanitation systems used in Cape Town are container based, there are also several other systems utilised including pitliners[63], pour flush toilets linked to conservancy tanks, anaerobic toilets and full waterborne (flush) toilets that are either for individual households, clusters of households, or part of CABs. VIPs were phased out after 2010, although the use of sealed or lined VIPs is being considered for future implementation in addition to settled sewerage and toilets linked to bio-digesters (CCT, 2014c). With regards to dry sanitation systems, several have been tested such as Enviroloos and Afrisans (Appendix 1S). However, with the exception of conventional sewered systems, all of the sanitation systems require costly desludging services, or in the case of the Afrisan, manual removal of bags used to contain the faecal sludge. All of the sludge, either in containers or in vacuum tankers, is then transferred to Borcherds Quarry WWTW, which was upgraded during 2013-2014 to accommodate the trucks unloading waste from container based systems (Figure 4.31). Containers require manual emptying into a faecal sludge disposal point and the waste is mixed with water so that the contents can enter into the wastewater stream for

[63] See Appendix S for a brochure describing various sanitation technologies used in informal settlements in Cape Town.

treatment and disposal. Some of the major treatment challenges are that many of the container based systems have wide openings, which results in users using the containers for general refuse disposal leading to major problems for the treatment works. Common items that cause problems include floatable items such as plastic bottles, bags and food packaging as shown in Figure 4.32 (Vice, 2014, pers. comm., May 23).

Figure 4.31: Truck bringing PFT containers to Borcherds Quarry WWTW (Pan 23/5/2014)

Figure 4.32: Worker hosing contents into faecal sludge disposal point (Pan 23/5/2014)

Some of the most common issues with waterborne systems provided by the city are presented in Table 4.16. The most common maintenance issue is blocked toilets. Based on the author's fieldwork, the issue of toilets being used for refuse disposal requires improved refuse removal services and more frequent ongoing engagement with user groups to prevent inappropriate usage and to encourage the use of biodegradable anal cleansing material. For communal

waterborne systems, users are provided with toilet paper at CABs to prevent blockages (CCT, 2014c). CABs also have the advantage of having janitorial staff to regulate toilet paper use and assist with cleaning and reporting blockages.

Table 4.16: Most common water and sanitation service maintenance issues in informal settlements in Cape Town (CCT, 2014c)

Informal Settlements Maintenance	Cumulative Statistics City Wide			
	Apr-13	May-13	Jun-13	% of Total
Blocked toilets cleared	2288	2400	2535	38.7%
Burst pipes repaired	267	373	401	5.6%
Defective cisterns replaced	610	712	763	11.2%
Defective sewer lines repaired	242	254	263	4.1%
Defective standpipe leadings replaced	254	264	264	4.2%
Defective taps replaced	1 080	1263	1339	19.7%
Toilet upgrades	116	138	138	2.1%
Toilets Replaced	173	188	205	3.0%
Vandalized taps	368	561	561	8.0%
Vandalized toilets	151	246	246	3.4%
TOTAL	**5549**	**6399**	**6715**	**100%**

Consumer satisfaction with levels of sanitation service in Cape Town is significantly lower in informal residential areas than in formal areas (CCT, 2012d; CCT, 2013f), *e.g.* only 39% of informal domestic consumers as compared to 77% of formal domestic consumers were satisfied with water and sanitation services in 2009 (CCT, 2012d). Reasons posited by the municipality for low levels of satisfaction included that residents may 'not understand the reasons for a basic level of service as opposed to a full level of service' and will not be satisfied without a full level of service, or, that satisfaction levels will remain low due to problems associated with communal toilets (CCT, 2012c:52). A critique of the technology-based LoS model used in South Africa is given in Chapter 5. The implications of low levels of satisfaction with sanitation services are considered in the next section.

4.3.5 Sustainability and equity assessment for Mtshini Wam reblocking

CCT has approximately 193,000 households in 204 informal settlements (CCT, 2013a), the majority of which are serviced by container based systems (Figure 4.30). Container based systems are mobile, provide at least an emergency level of service, and can be installed relatively quickly given existing agreements that the municipality has with various contractors. They are, however, some of the most expensive systems to operate (Appendix 1A). Furthermore, with the exception of PFTs, they do not hygienically separate users from excreta, especially when nearly full. Additionally, workers are at risk of exposure to pathogens when transporting, emptying and cleaning units if personal protective equipment

(PPE) is not worn properly (or at all). Part of the challenge that the City has faced is trying to transition from providing temporary (i.e. likely to be replaced in the short-medium term) services to planning for permanent services in alignment with housing plans (Tsatsire, 2013, pers. comm., 5 December). Earlier housing and service delivery policies were aimed at eradicating backlogs within a relatively short time frame, e.g. between 2004-2010, but rapid growth in the number of people living in informal settlements and backyard dwellings has added to the backlog. Moreover, poor maintenance of facilities has created 'second generation' backlogs in some cases (Tyers & Mbatha, 2010).

Given the challenge of providing sustainable sanitation services to informal settlements, CCT has tested a number of different technologies, shown in Appendix 1S. One of the realisations, however, is that similar to EM and CJ, some of the major service delivery challenges are often of a non-technical nature; thus, a different approach or model for service delivery is as, or more, important than a plethora of alternative technologies. One of the approaches to service delivery that CCT is piloting is an incremental upgrading method known as reblocking which was developed in conjunction with local NGOs, the Informal Settlement Network (ISN) and the Community Organisation Resource Centre (CORC). Reblocking represents a form of co-production of service delivery and upgrading which relates to the 'reconfiguration and repositioning of shacks in very dense informal settlements in accordance to a community-drafted spatial framework' with the aim of 'better [utilising space] to allow for better service provision' (SASDI, 2013). Residents contribute in terms of volunteering time towards planning the reblocking, conducting household surveys and funds toward part of the capital costs. The reblocking is done in clusters of willing residents and shacks are spaced around a communal 'courtyard'. The size of shacks is limited to allow for larger access ways and to enable the installation of water and sanitation services. Reblocking is intended as a 'paradigm shift' away from centralised top down slum eradication to a community-driven process that empowers residents to self-organise (SASDI, 2013).

One of the pilot reblocking sites is Mtshini Wam informal settlement. Mtshini Wam has approximately 250 households and is adjacent to the formal settlement known as Joe Slovo in Milnerton. According to residents, the settlement was established in 2006-07. One of the first steps towards reblocking is a 'community-based enumeration'[64] conducted by residents with assistance from NGO staff, which includes counting and numbering shacks, mapping of the settlement, household demographic surveys, and a presentation of results to be shared in a public forum which can be used as an advocacy tool to engage with government. Table 4.17 presents a summary of the data that was collected during the enumeration exercise prior to reblocking.

The community-based enumeration exercise revealed that improving the water and sanitation situation in the settlement was a high priority. The number of facilities was below

[64] In the context of the method used by CORC, an SDI affiliate, it generally refers to mapping, and conducting a survey as a way to gather information that can be used to build a development agenda for negotiating with local governments. Questionnaires are developed in consultation with communities to identify needs and demographic information. It is seen as a bottom-up approach to data collection, with surveying being conducted by a trained enumeration team drawn from residents within the community and support from the NGO (SASDI, 2012a).

the CCT standard of 1 toilet to 5 households (or 15 people) and was insufficient to meet residents' needs.

Table 4.17: Self-enumeration summary prior to reblocking for Mtshini Wam (ISN et al., 2012)

Settlement name	Mtshini Wam
Suburb	Milnerton
Age of settlement	From 2006
Type of structures	All shacks
Population	497
Number of shacks	250
Land ownership	City Council
No. of individual toilet blocks	None
No. of individual toilet blocks	16 chemical toilets with 1 toilet: 31 people
Water taps	3 standpipes with single water tap: 166 people
Most urgent needs	• Reblocking • Electricity, water taps and toilets

Although not initially part of the reblocking aims, after the reblocking layout was proposed (Appendix 1T) CCT officials proposed that toilet facilities could be provided on a nearly 1:1 basis instead of as a communal service given the increased space available (Jack, 2013, pers. comm., 4 October). Chemical toilets were replaced (Figure 4.33) with full flush toilets in concrete cubicles, and additional water taps were installed. Although some facilities are shared, most of the toilets are used by only a single household. Residents are responsible for cleaning their own toilets, obtaining their own anal cleansing material and dealing with toilet blockages, but the City's water and sanitation department is still expected to provide maintenance if there are repairs to be made such as fixing leaks or replacing plumbing (Powell, 2015, pers. comm., 10 June), i.e. similar to a landlord tenant arrangement, in addition to unblocking sewer pipes and/or replacement.

Table 4.18: Financial contributions for Mtshini Wam reblocking (CORC, 2014)

Financial contributions for reblocking	
Community contribution	R146,440
CORC contribution	±R800,000[65]
Government contribution (USDG)	±R2,900,000-R3,500,000

[65]Exact costs for these contributions were difficult to obtain and only estimates were given. The higher range for government contribution likely includes EPWP payments as opposed to the lower value given in the CORC report (Fieuw, 2014, pers. comm., 5 December).

In addition to the community-based enumeration and needs assessment, residents also assisted with moving and rebuilding shacks according to the reblocking layout, and contributed with labour and money. Funds allocated to the Expanded Public Works Programme (EPWP) were used to pay residents who constructed some of the reblocked shacks and dug trenches for the new water and sanitation system installations. Estimated costs and contributions from different partners in the reblocking process are presented in Table 4.18. A method promoted by CORC, an affiliate of Slum Dweller's International (SDI), for community organisation and empowerment is the promotion of savings groups willing to make contributions towards improved services, particularly sanitation. In the Indian model, which is where SDI originated, residents usually contribute towards constructing a CAB and are responsible for paying for the O&M, including wages for a live-in caretaker. In the South African context of subsidised Free Basic Services, however, how much and how communities should contribute is murky and often contested. For the reblocking, residents were expected to contribute 20% towards purchasing the materials for rebuilding shacks as well as labour (Bolnick, 2013, pers. comm., 21 May), but contributions towards water and sanitation improvements were less explicit. Although most households fell short of the 20% financial contribution, catalyzing savings groups to empower residents to invest in infrastructure improvements as 'co-producers' rather than passive recipients of government subsidies was seen as a major success in Mtshini Wam and subsequent reblocking projects elsewhere (Bolnick, 2013, pers. comm.., 21 May).

Figure 4.33: Pre-reblocking chemical toilets along the main road (left) (Pan 27/8/2013); Post reblocking waterborne facilities and water tap (right) (Pan 28/2/2014)

The reblocking in Mtshini Wam has been hailed as a success locally and nationally (Macleod, 2013), and helped lead to the development of a policy to adopt reblocking as an informal settlement interim upgrading strategy included in the IDP (CCT, 2013c). Anecdotal evidence indicates that residents are pleased with the improvements in the levels of service for water and sanitation, a stronger sense of community and a safer environment due to the spatial

reconfiguration creating communal 'courtyards'[66] shared between clusters of households. Waterborne sewered sanitation was the preferred choice of residents, and the majority of households now have their own waterborne toilet facilities, which are viewed as the highest level of service. Sewage is reticulated to sewers located alongside adjacent roads and gravitated to the nearest treatment works (Potsdam WWTW).

Several service gaps remain however. One of the major service gaps that was not addressed was how to deal with stormwater. Although the layout of settlements helped create communal spaces, wider access routes (Figure 4.33 on right) and enabled the installation of a sewered sanitation system, the topography of the settlement is such that there are still low-lying areas which become waterlogged after rainfall (C2C, 2012; Fieuw, 2014, pers. comm. 5 December). Subsequent reblocking projects in other informal settlements included grading of the settlements and the installation of drainage infrastructure, which was one of the lessons learned after Mtshini Wam (Poleman, 2015, pers. comm., 12 May). Another gap observed was hygiene promotion, which was not included as part of reblocking, but assumed to be addressed through other programmes. Additionally, although residents are expected to be responsible for 'minor repairs' or unblocking toilets, during a walk around of the settlement it appeared that most households did not own equipment to assist with unblocking such as plungers and gloves for PPE. The majority of challenges described by city officials and NGO members related to the social dynamics of the settlement, especially with regards to conflicts between leaders of the settlement as well as resistance from the Mtshini Wami leaders to 'external influence' from NGOs or city officials, which resulted in construction delays and concerns over the misappropriation of community savings. Challenging social dynamics, trust and communication issues tend to be some of the primary barriers to participatory approaches to sanitation improvements (Tiberghien et al., 2011). These challenges can be overcome, but additional time and resources need to be dedicated to social facilitation outside of 'typical' engineering construction timelines and budgets, particularly if social equity is going to be prioritised.

The scale of the project was confined to the settlement boundaries (Figure 4.34) and took approximately a year to complete between May 2012 – March 2013, although it should be noted that the process of mobilising residents and organising savings groups started in 2010 (SASDI, 2012b). Initially, mobilisation around improving water and sanitation services was a major motivation for reblocking. However, interviews and conversations with municipal officials, Mtshini Wam residents and NGO workers indicated that some of the greatest challenges and opportunities presented by reblocking were not primarily related to the improved water and sanitation facilities, or technical concerns, but rather to the institutional and socio-political aspects required to address tenure issues, clarifying roles and responsibilities for O&M (Lagardien et al., 2010), (mis)trust between different stakeholders, and shifting informal settlement upgrading policy. A socio-political and institutional context that supports sustainable sanitation service delivery has been described as an 'enabling environment' by Lüthi et al. (2011a; 2011b), and the need to foster an enabling environment

[66] Two advantages of the courtyard layout are the creation of a semi-enclosed safe space for residents to wash/hang laundry and to allow children to play whilst still under their parents' surveillance.

as well as ways in which to do so through a participatory process are some of the major lessons from the reblocking in Mtshini Wam.

Conceptual maps assessing the sustainability and equity of the sanitation services provided post-reblocking are shown in Figure 4.35 and Figure 4.36 and depict connections between some of the sustainability and equity challenges and benefits of reblocking in Mtshini Wam. For example, one of the major institutional sustainability benefits of the reblocking project was to create a platform for collaboration between multiple stakeholders transforming residents from passive beneficiaries to active participants (Figure 4.35).

The reblocking process supports equity in terms of resource division and allocation in ensuring that all households that want to be part of it contribute time and financial resources. The break down into cluster level teams and door to door surveys also assists in identifying individual household needs. For example, one of the major benefits of reblocking was the opportunity to improve the LoS since more space was available to provide sanitation facilities for almost every household on a 1:1 basis. Households could also have a say in where they wanted the facility to be located in relation to their dwelling. A perception that is a recurring theme mentioned by local government officials and a potential challenge with regards to not only reblocking and sanitation services in Mtshini Wam, but also to service delivery in informal settlements in general is the notion of 'interim solutions' (Figure 4.36). The underlying implication is that these services are temporary until permanent formal housing with all associated services (electricity, water, sanitation, access roads) are provided by the government, even if the LoS achieved meets the criteria for a 'full' or highest level of service as in Mtshini Wam. As also noted in EM and CJ, however, there is a great deal of uncertainty associated with if and when formal housing opportunities will be provided. Therefore, a shift away from treating sanitation service delivery in informal settlements as a temporary or emergency response is important for stakeholders involved with sanitation programme development to encourage further investment in those areas even prior to the provision of formal houses. Reblocking is one potential way to improve the LoS in informal settlements outside of the formal housing process which can help improve the equity of services to informal settlements by improving household access and including perspectives of informal settlement residents.

There are some limitations to reblocking however. As a CT official pointed out, a reblocked informal settlement is often improved through the increased services and communal spaces added, however, at the end of the day it is still an informal settlement (Poleman, 2013, pers. comm., June 2013) with limited tenure security for residents. There can still be a property conflict if at some point residents are required to relocate by the municipality. Additionally, given the amount of time and skills required to facilitate and build consensus for reblocking and cost involved, the scale at which it can be reproduced and impact on the overall sanitation backlog has been questioned by some municipal officials (Faure, 2013, pers. comm., 8 August).

Figure 4.34: Pre- (left) and post-reblocking (right) aerial images of Mtshini Wam informal settlement

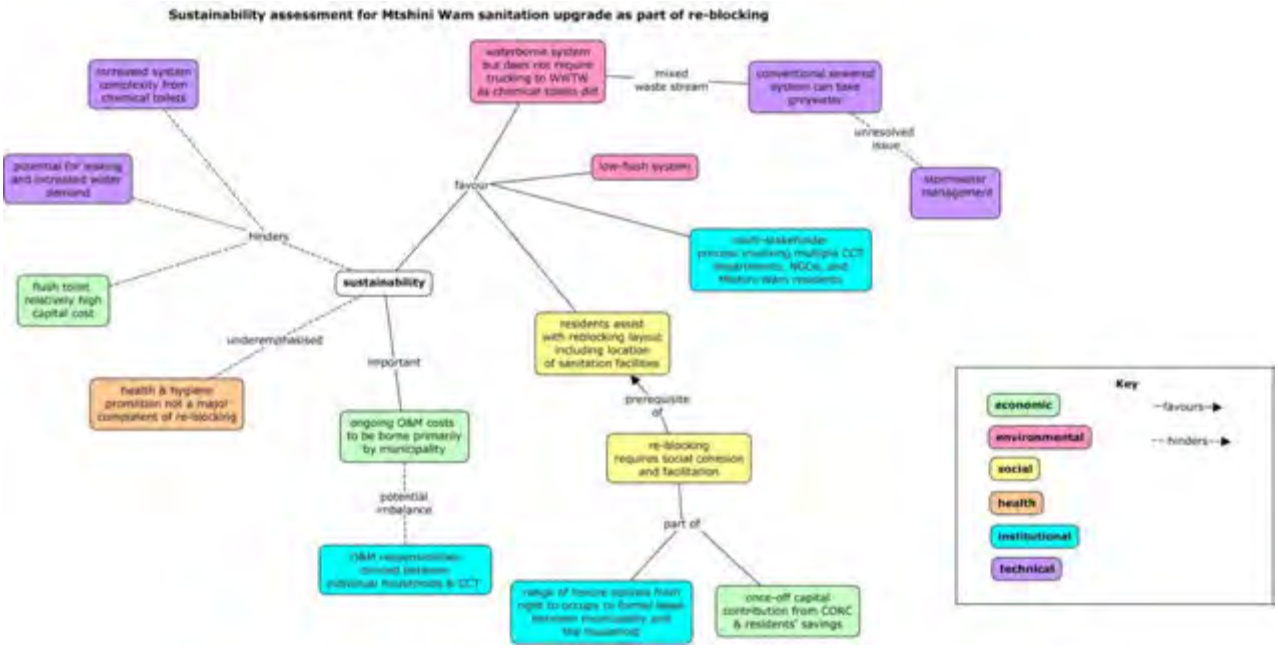

Figure 4.35: Concept map for the sustainability assessment of the sanitation upgrade as part of Mtshini Wam reblocking

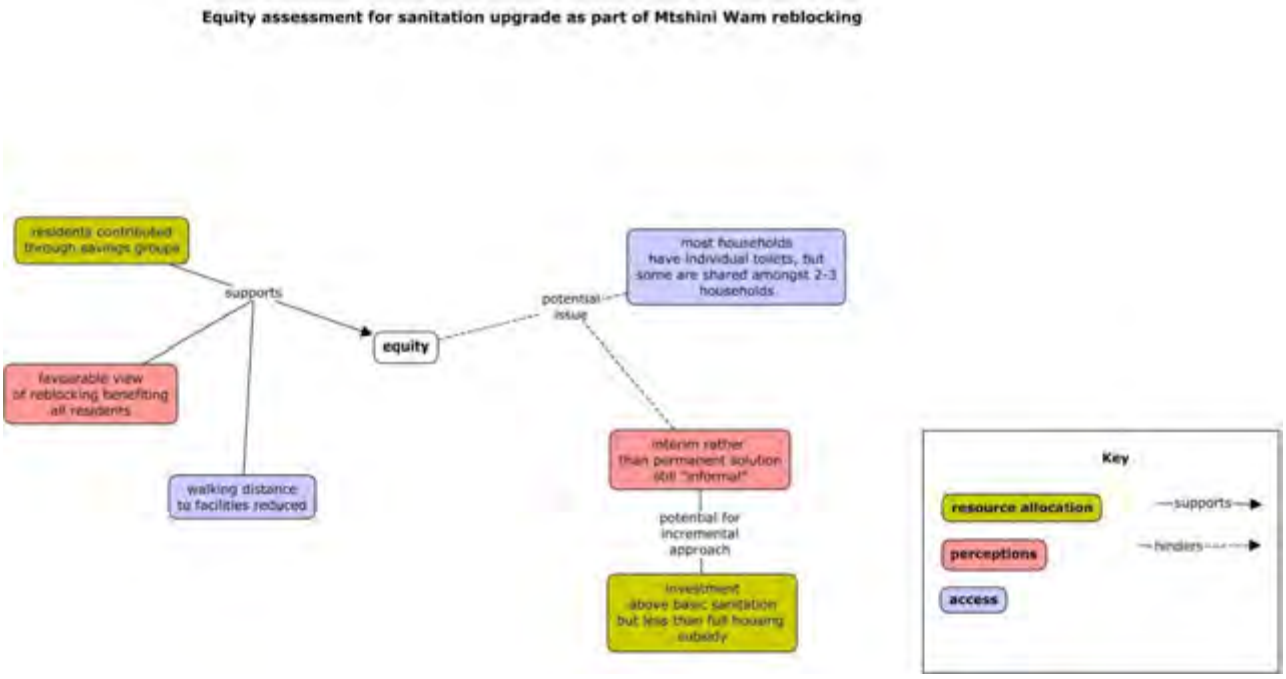

Figure 4.36: Concept map for the equity assessment of the sanitation upgrade as part of Mtshini Wam reblocking

4.4 Summary of case studies

Each of the municipal case studies highlighted some of the contextual challenges for providing sanitation services to informal settlements and EM, CJ and CCT's approaches to addressing some of the challenges. Additionally, planning frameworks and institutional arrangements for delivering water and sanitation services were discussed. Conceptual maps evaluating the sustainability and equity of selected embedded case studies were also presented. In EM, the embedded case presented related to the UDDT and CAB programmes and highlighted some of the challenges to sustainability for the UDDTs such as increasing densification and inequities in access between individual and communal facilities. In CJ, a pilot wastewater recycling CAB facility was selected as the embedded case study. Some of the issues with institutional arrangements for managing, accessing the facilities and perceived differences between different types of sanitation systems were discussed. Finally, in CCT, an example of the reblocking in situ upgrading method to improve services was presented, the ambiguity of 'interim' solutions and the need to shift away from temporary services was discussed. The LoS framework was similar for each municipality, i.e. some level of rudimentary or emergency level of sanitation, followed by some 'basic' or interim LoS and a 'full' LoS, which was a full flush toilet connected to a sewage system for each municipality. A critique of the technologically based level of service framework, a comparison of the municipal approaches, an analysis of sanitation backlogs and service delivery gaps and a discussion on synergies and trade-offs between dimensions of sustainability and equity are presented in the following chapter.

5 Critique of technology-based level of service approach

In this chapter, a critique of the LoS approach used in South Africa which perpetuates inequities between formal and informal areas, a comparison of the levels of sanitation service provided in informal settlements in each municipality and a discussion on trade-offs between different aspects of sustainability and equity will be presented. One of the weaknesses of the LoS used is that they are linked to specific ratios and sanitation technologies as opposed to functions provided by the service, which will be discussed in Section 5.1. While specifying the types of technology provided at each LoS supports administrative clarity, linking levels of service to specific technologies implies that a 'full' level of service will only be achieved when conventional waterborne sewerage is supplied. Furthermore, linking the LoS to technologies limits discussion on the equity of different types of sanitation systems and reinforces perceptions that waterborne sewerage is the 'ideal' system. Another issue is that the LoS models used by all three municipalities represent a top-down approach to service delivery that does not incorporate meaningful participation from non-governmental stakeholders regarding what appropriate services are, and runs the risk of preventing discussions about alternative long-term development possibilities (Huchzermeyer, 2011; Sutherland, 2013). (N.B. The reblocking project in Cape Town represents a break from this, but still needs to be implemented on a larger scale.)

According to Huchzermeyer (2011:245):

> the new urgency of the interim services rollout [in eThekwini] has largely prevented any bottom-up definition of what might be considered appropriate levels and forms of interim services, and any consideration of whether communities could be involved in their implementation.

Huchzermeyer (2011) highlights a tension between the urgency of meeting delivery targets, and the value of often lengthy participatory processes in service delivery. Including community (users) stakeholders in the decision-making process around what appropriate levels and forms of interim services are, and what functions are most important to users as part of an inclusive design process, is missing from most municipal service delivery projects to informal settlements. The aim of most projects is primarily to install facilities as quickly as possible.

While having a sufficient number of facilities is important, focusing mainly on the number of toilets provided or the number of households serviced, i.e. quantity, does not give an indication of the quality of the service provided and if the design is meeting people's needs, users' levels of satisfaction with the service or hygiene improvements. Relatively low levels of customer (user) satisfaction with sanitation and water supply services are reported in informal settlements as compared to formal areas (CJ, 2010; CCT, 2013e; Sutherland et al., 2013). The results indicate a need to apply a more 'demand-responsive' approach as advocated by the national White Paper on sanitation (DWAF, 2001b) regarding the LoS that are supplied in informal settlements.

One of the major challenges, however, with respect to improving informal settlements residents' satisfaction levels is the gap between residents' expectations of eventually getting full flush toilets and the ability of municipalities to deliver full waterborne sanitation to every household, especially as part of a FBSan service (CCT, 2009; Sutherland et al., 2013). The conventional sanitation ladder promoted within national and municipal policies, presents full waterborne sanitation (for individual households) as the top rung of the ladder, which perpetuates expectations for waterborne services and highlights service inequalities between 'rich' and 'poor' areas of cities. This is despite findings that indicate '[that] model is not sustainable in the South African context as it is not possible for [all] municipalities to provide full waterborne sewerage services to all citizens across the country, given the resources available and the backlogs in basic service provision that exist' (Sutherland et al., 2013:52).

Furthermore, unrealistic national targets for eliminating service backlogs, e.g. by 2010 which was not met, then extended to 2014 (also unmet), have likely been detrimental rather than beneficial as evaluated by Mjoli et al. (2009:54) '[promoting] a supply-driven approach and [working] against local innovation and community involvement'. An example of detrimental effects is the controversy produced by the South African Human Rights Commission (SAHRC) findings that the long-term use of chemical temporary or emergency sanitation technologies in informal settlements in CCT, e.g. chemical toilets, is a violation of the rights of residents and perpetuates discrimination, particularly against black residents (SAHRC, 2014a). Nevertheless, given the pressure on municipalities to rapidly deliver services and to reduce backlogs, and the unclear legal status of most informal settlements, using rented chemical toilets becomes a logical if not sustainable or desirable sanitation option. Estimated delivery time frames to meet basic sanitation service delivery backlogs given available national subsidies, municipal funding and projected annual delivery rates are given in Table 5.1.

Table 5.1: Estimated time frame to meet basic sanitation service backlog in eThekwini, Johannesburg and Cape Town (EM, 2015; CJ, 2014c; CCT, 2013b)

Municipality	**eThekwini**	**Johannesburg**	**Cape Town**
Estimated time frame to meet basic sanitation backlog*	18-23 years (from 2015)	11-16 years (from 2015)	10-14 years (from 2015)

*Assuming delivery rates remain consistent with 0-3% growth rates in informal settlements and not accounting for slippage.

Ambiguities also exist within the definition of a basic facility and service defined by national policy as compared to municipal service levels, particularly when it comes to services for informal settlements. Results from the case studies imply that communal sanitation facilities do not provide a 'basic' equitable level of service, particularly for vulnerable users, which is also in line with the SDG-linked exclusion of communal facilities from the improved sanitation definition (UNDP, 2015). An issue with most sanitation systems used in informal settlements, with the exception of waterborne facilities, is that they are not designed to handle black and/or greywater, and thus do not qualify as a basic sanitation service according to the

definition laid out in the Strategic Framework for Water Services (DWAF, 2003) and reiterated in the Free Basic Sanitation Implementation Strategy (DWAF, 2008). This means that the LoS provided to many informal households technically does not meet basic sanitation service criteria despite being counted as such by municipalities.

Settlements with different LoS within the same settlement may face particular equity challenges, e.g. overloading or vandalism of facilities and/or protests over perceived unfairness that can impact on the sustainability of sanitation services. For example, in the Diepsloot case study presented in Section 4.2.5 for CJ, residents outside of the pilot area borrowed access cards to use the CAB despite other types of sanitation facilities being available. Field observations from settlements in CCT and EM also indicated residents' sensitivity to perceived differences to different types of sanitation facilities, especially if they were located within the same settlement or in an adjacent settlement. This was also confirmed as an issue by EM and CT staff that people would compare their services to other settlements in the area:

> The people whose shacks are along the road, those guys are enjoying flush toilets, but the people at the back [of the settlement], because you can't bring services like [that] to those because they live very close to the wetland, we can't install flush toilets, then maybe chemical toilets or container toilets or sometimes porta-pottis. So people like to think that uh… they are not given, like [an] equitable service as it were, but really, we are giving a service that, uh, we can at that point in time, depending on the external factors (Gangatele, 2013, pers. comm., 16 May).

With regards to testing new sanitation systems, if a pilot project is initiated, there should be plans and funds prepared to either expand the pilot to the rest of the settlement or to provide an alternative equivalent level of service. The difficulty is establishing what an equivalent level of service is. There is also the underlying question of what is equitable not just within a particular settlement, but across an entire municipality with differentiated levels of service, e.g. the majority of residents in all three metropolitan cities have access to waterborne systems, with the exception of those living in informal settlements, backyard dwellings or traditional areas (in the case of EM) (Table 4.2, Table 4.6 and Table 4.12). An alternative function based sanitation ladder developed by Kvärnstrom et al. (2011) is discussed in the context of South Africa in Section 5.1.

5.1 Alternative sanitation ladder or levels of service

It is unlikely that sanitation development will happen in discrete orderly steps or that an ideal integrated resource system is possible or the only desirable outcome. The reality of urban sanitation in South Africa is a variety of co-existing service levels, but a function-based rather than technological option-based sanitation ladder is a potentially useful tool for facilitating and guiding the direction of gradual or incremental improvements as promoted by

various national programmes (CCT, 2011d; DHS, 2011a). Furthermore, it is useful as a monitoring tool to assess whether or not a transition to increased functionality is occurring as more households gain access, or whether development is stagnating at a particular functional level. One shortcoming of the model shown in Figure 5.2 is that a uniform state of development at the onset is implied in the model; how to reconcile social equity issues if there are co-existing different levels of service to different segments of the population correlating to race and/or income is not addressed, which is one of the major challenges in the South African urban context. The functional based ladder also requires more information to assess and analyse than a technology-based ladder, and some of the top rungs may be considered 'more academic than pragmatic' (Graham, 2015). Therefore, the functional ladder needs context specific modifications in order to be implemented by practitioners. Ideally, functionality, LoS and affordability should not be linked to specific technologies, but rather be assessed more holistically as discussed in the municipal case studies.

Some additional equity criteria to consider are shown in the dotted lines in Figure 5.2 in Level 2 and 5: the inclusion of MHM, ensuring access to information about sanitation options and ways to upgrade, and redistributing benefits of nutrient reuse to invest in improvements to services for individuals with services lower down on the ladder. A complementary tool to the sanitation ladder that would help identify inequalities in progress in South Africa would be to consider the proportion or number of households in a municipality (or another scale) who are at a particular level, which could then be disaggregated even further to identify if there are inequalities in accessing services between different categories such as gender of head of household, type of dwelling, settlement type, or income bracket, which is the type of data collected in the census (Figure 5.1).

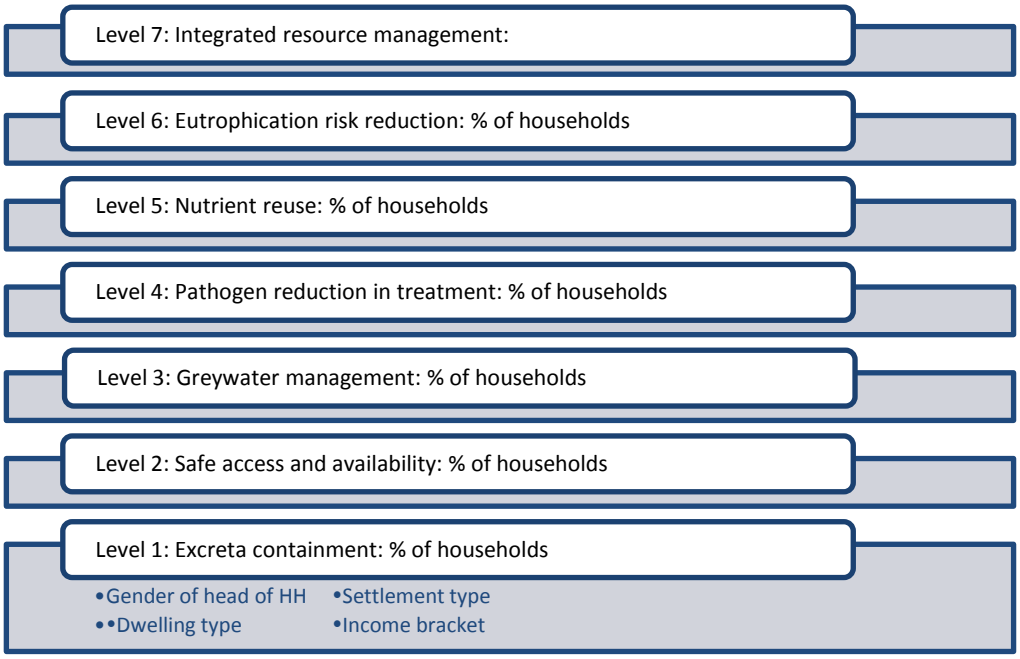

Figure 5.1: Complementary tool for measuring progress along functional sanitation ladder

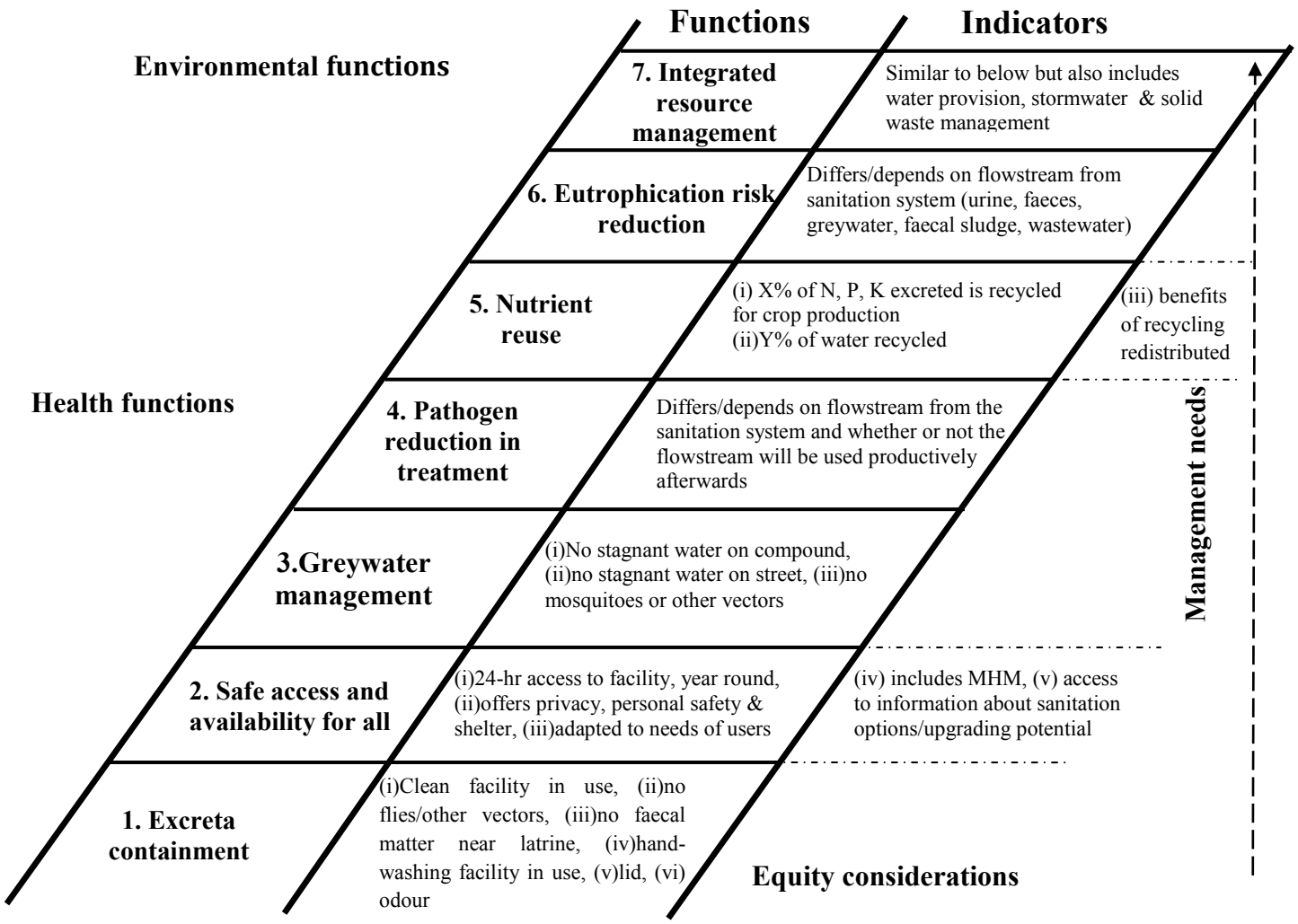

Figure 5.2: Suggested function-based sanitation ladder where each step up the ladder indicates that the functions below have been meet (after Kvarnström *et al.*, 2011)

Notwithstanding some shortcomings to a function-based LoS framework, using functionality of sanitation services as a way to assess and compare city-wide progress provides an alternative to the 'basic needs approach' to sanitation service delivery, which has the potential 'to entrench a social differential in African towns that not only creates inherent political instability but also defines the majority of residents in those towns as second-class global citizens' (Abbott, 2012:134). Therefore, to avoid promoting both unsustainable and inequitable sanitation services to low-income residents in informal and peri-urban settlements, sanitation service delivery in these areas needs to be incorporated into the overall infrastructure development of the municipality rather than seeking separate and/or temporary solutions. For example, CORC, which was involved with the reblocking in Mtshini Wam is lobbying with CCT to adopt reblocking as an incremental upgrade approach where the water and sanitation infrastructure upgrade can be seen as an investment to build around rather than only an interim solution (Fieuw, 2014, 5 December).

As mentioned in Section 2.3.4.2 and in the case studies, issues related to land tenure and housing underpin some of the temporary and interim approaches to sanitation service delivery taken by the three municipalities discussed. One of the tools used to link sanitation service levels to planning for human settlements is the development matrix that has been developed by CCT to categorise informal settlements by upgradeability according to various criteria such as: availability of bulk infrastructure, location and accessibility, topography, etc. (Appendix L). According to data used to compile the development matrix, the majority of informal settlement clusters identified (283 of 437) are 15 years or older (CCT, 2015a). Furthermore, as noted in Table 5.1, a rough estimate of the minimum time frame it will take to eliminate sanitation backlogs, not even accounting for slippage, will be greater than 10 years (from 2015) given the average annual delivery rates for Cape Town, which has the smallest backlog, more than 11 years for Johannesburg, and more than 18 years for eThekwini which has the largest backlog of the three municipalities.

Therefore, treating sanitation services for informal settlements as 'temporary' or an emergency level of service is a misguided approach, and a missed opportunity to invest in services that provide multiple health and environmental functions. Of EM, CJ and CCT, all three aim to meet the first and second functions on the ladder with regards to basic sanitation services; however, most of the dry on-site systems that are used by the municipalities (Appendix 1C) do not deal with greywater (Level 3), which is then typically disposed of untreated on-site or into stormwater channels along the roadside where available. Treatment requirements (Level 4) depend on the type of sanitation technology used and the characteristics of the waste, e.g. faecal sludge requires different treatment processes to wastewater that is already relatively diluted. With regards to pathogen reduction, WWTWs and regulations for dealing with wastewater are fairly well established in South Africa, although there is a risk of reduced performance as services are expanded and if systems are not maintained (DWA, 2012a). The other challenge with pathogen reduction from excreta collected from sanitation systems in informal settlements and peri-urban areas is that alternative systems such as the UDDTs in eThekwini or the container based systems used in Cape Town require different management practices than for wastewater collected from centralised sewer systems including overland transportation to off-site treatment works if it is

a dense settlement. Alternative collection systems require investment in alternative treatment systems to add onto or modify conventional WWTWs, e.g. the pilot BSF facility being constructed in EM or the expansion of the sludge disposal facility in Borcherds Quarry in CCT. For Levels 5-7 on the functional ladder, there are indications that the three municipalities are taking them into consideration, particularly eutrophication risk reduction at treatment works, but nutrient reuse and integrated resource management are a challenge to implement and not necessarily a high priority as compared to reducing basic sanitation service backlogs.

Again, however, it is important to reiterate that in order to improve sanitation services in informal settlements with increased functionality, i.e. a higher LoS, inadequate sanitation services cannot be seen as a problem limited to informal settlements, but rather as an issue integral to the development of the municipality (city) as a whole worth investing in. Furthermore, efforts to improve the environmental sustainability of sanitation services and social equity of sanitation services will require 'the behavior, habits and expectations of full-service users [to] be reformed alongside those on the bottom rung' (Penner, 2010).

5.2 Backlogs and sanitation technology versus services

Although as mentioned previously, backlogs fluctuate and only give a rough picture of sanitation service levels, estimating the size of the backlog, i.e. those without a basic level of sanitation service according to municipal standards, is an important measure of progress. In terms of the size of the sanitation service backlog, EM has the highest number of households that still do not have access to a basic sanitation service level as defined by municipal and national standards for reasons which were discussed in Section 4.1; however, EM is reducing its backlog at the fastest rate of the three case study municipalities through the CAB and UDDT programmes as shown in Figure 5.3 and Table 5.2

.

Table 5.2: Percentage change in backlog from the baseline measurement year

Municipality	Percentage change (from baseline)
Cape Town	-16.5%
Johannesburg	-11.5%
eThekwini	-21.2%

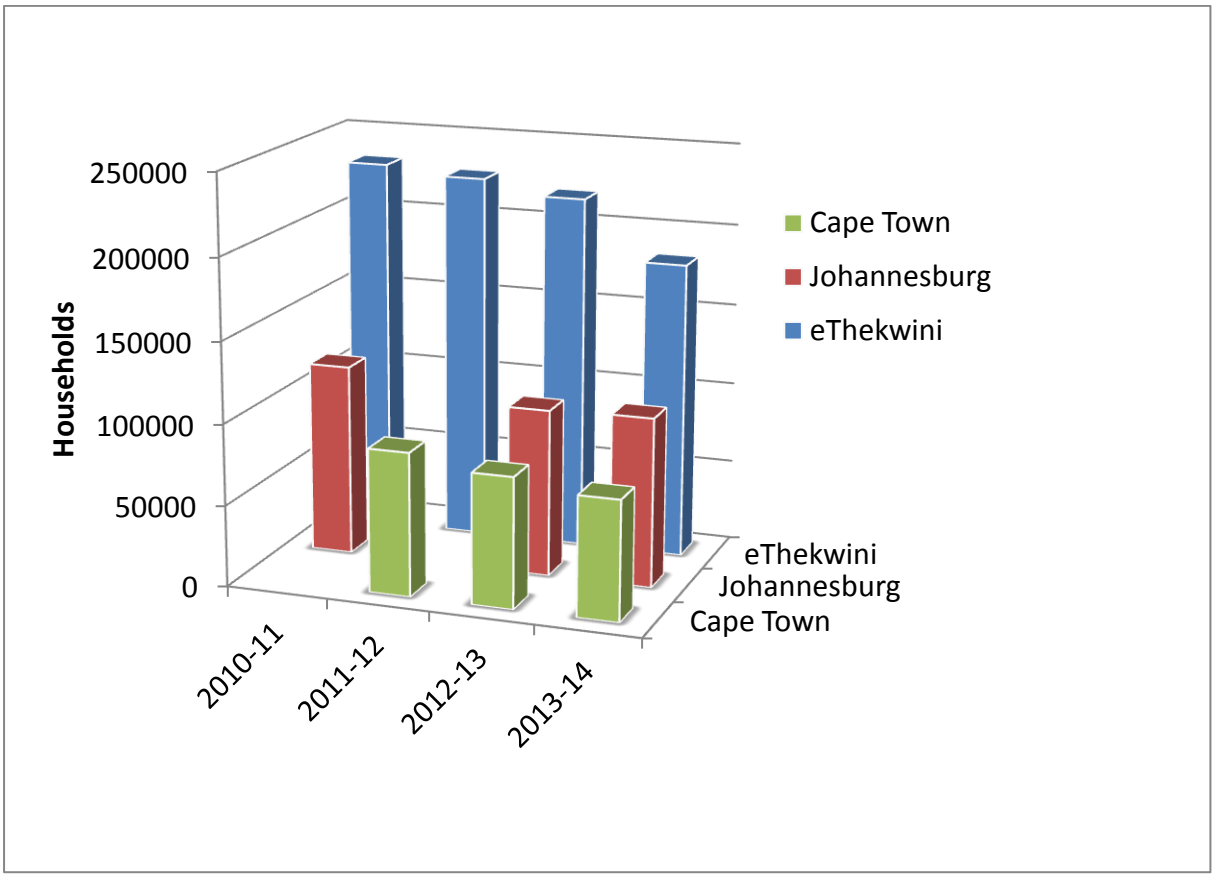

Figure 5.3:Comparison of municipal sanitation backlogs from 2010-2014 (CCT, 2013g; CCT, 2014a**;** EM, 2014a; Kunene, 2010; CJ, 2014c)

The scale of the sanitation backlog, the large proportion of the municipality's population living in rural and peri-urban areas located far from existing WWTWs and the need to reduce O&M costs were reasons that the UDDT programme was developed by EM. In areas that are considered to be more urban in characteristic, EM has also provided waterborne services in the form of the CABs, which is similar to the approach adopted by CJ and CCT. Predominantly due to the high water table in areas where the majority of informal settlements are located, CCT has steered away from installing VIPs on a large scale, which has resulted in the adoption and trialling of a much wider variety of sanitation technologies (see Appendix 1S) compared with CJ and EM.

The LoS developed by each municipality have been adapted for each context, but have a similar structure as mentioned earlier. While the emergency and basic/intermediate levels of service differ for each municipality, an in-house waterborne sewered sanitation system is implied to be a full level of service in all three municipalities, which aligns with national policy trends and users' perceptions of what a dignified or 'proper' form of sanitation is as discussed in Section 2.3.4.2. Promoting an alternative approach to levels of service based on increasing functionality as proposed in Section 5.1 and wider acceptance and improvement of alternative sanitation systems, i.e. not conventional waterborne sewerage, would thus require policy shifts as well as a massive shift in public perceptions around sanitation services. These shifts are unlikely to occur if alternative sanitation systems

are promoted exclusively or primarily for informal settlements. For example, one of the reasons that EM has invested so heavily in the UDDT programme including developing alternative treatment technology is that it was developed primarily for formal households, albeit in rural areas, and thus is viewed as relatively permanent infrastructure as compared to temporary emergency services such as chemical toilets.

There is a risk, however, of reinforcing infrastructural inequalities if alternative technologies only address the management of human excreta without including wastewater. While dry systems such as the UDDTs or VIPs can help contain excreta and provide hygienic separation from waste, one of the remaining concerns with respect to non-sewered sanitation systems is how to address stormwater and greywater management as population density increases, and/or household water usage increases. Thus, investment in some sort of on-site greywater treatment system where there is adequate space is required in addition to stormwater drainage/storage infrastructure. Where space constraints, soil and groundwater conditions prevent on-site treatment and storage, or settlement density is too high[67], piped systems to transport greywater to off-site treatment and stormwater drainage need to be incorporated into the basic/intermediate level of service for informal settlements. (N.B. Once piped systems are required, installing waterborne sanitation systems becomes a more practical option.)

While EM has steered away from installing more VIPs due to the high cost of emptying and transporting faecal sludge from VIPs, CJ is continuing to construct them as part of its basic sanitation programme despite similar concerns over O&M costs and desludging challenges. One of the issues is that the municipality is still searching for a viable on-site alternative to VIPs as UDDTs are not considered to be appropriate in the more urban CJ context for both social and technical reasons (Manus, 2014, pers. comm., 24 March). Enviroloos (dry composting system) and Aquaprivies (similar to a septic tank that can be used with pour flushing), which are both on-site sanitation systems were piloted and discontinued due to operational issues (Kunene, 2010; Mudau, 2015, pers. comm. 13 April). Waterborne solutions such as the wastewater recycling CAB facility with a janitorial service, similar to EM's, are being piloted in Diepsloot as a potential way to provide basic sanitation services in dense urban informal settlements as an alternative to VIPs and chemical toilets. CCT is also looking for viable less costly and socially acceptable alternatives to chemical toilets, and as of 2015 was providing a wide array of container based systems (chemical toilets, buckets, container toilets and portapotties) which require frequent emptying and cleaning (several times a week). There are, however, high O&M costs associated with container based systems (Appendix 1A), which leads to concern over financial sustainability. Additionally, as a long-term sanitation service there is cause for concern over their sustainability in other respects, e.g. portapotties were designed for short-term use as camping or caravan toilets and chemical toilets are usually used for events or construction-sites. From a social equity perspective there is a strong perception that container based systems are

[67] Mara (1996) also makes the economic argument that at a certain density (160 persons/ha) shallow sewerage or low-cost sewerage becomes more cost-effective than on-site systems.

inferior, leaving streets filled with containers of excreta and a lack of privacy for users (Meyer, 2014).

Regardless of the type of technology selected, as emphasised previously and in literature, sustainable sanitation is as much about users' day to day experience and the daily delivery and functioning of services relating to social, financial and institutional issues as it is about the facilities used for sanitation and hygiene (Mitlin, 2015). Two areas where EM has distinguished itself from other municipalities is by considering the entire 'sanitation value chain', moving beyond focusing on finding the 'perfect' technological solution, but rather adapting one to the context and developing management strategies for collecting, transporting and treating the waste and promoting hygiene education. Although some of the innovations have been developed more reactively rather than from a proactive planning process, the other distinguishing characteristic to EM's approach is the use of M&E to improve and modify its sanitation services over time, e.g. the evolution of the UDDT programme and iterative CAB design (Crous, 2014). Rather than abandoning a particular pilot technology or project, researching user experiences and dedicating resources towards improving basic sanitation services through research collaborations and integrating informal settlement services into the general water and sanitation departmental activities has proved beneficial in terms of developing internal capacity amongst staff and fostering an enabling environment for sanitation service provision. Although, EM has not solved the sanitation problem, the support for reflexive engineering practices (Robbins, 2007) helps foster an enabling institutional environment for sustainable sanitation service delivery that extends beyond a particular individual or project.

An important part of ensuring that services continue to function as intended and to meet health, environmental protection and social objectives will be to incorporate and assess multiple dimensions of sustainability and equity (Sections 2.3 and 2.4). Assessment guidelines that were developed as a result of the literature review and case study analysis were presented in Chapter 3 and were intended to be used in conjunction with existing M&E tools such as the Municipal Benchmarking Initiative or the Sustainability Index for Urban Water Management (Appendix V).

5.3 Service delivery gaps

Although the case studies indicated measurable progress in sanitation service delivery since 2001, several gaps in service delivery to informal settlements still exist. With respect to physical infrastructure, as mentioned in Section 5.2, one of the major challenges with dry sanitation services is how to deal with greywater. Field observations indicate that informal settlement residents typically discharge greywater into adjacent water bodies, wetlands, or into the road and stormwater channels where they exist. Some residents also dig their own soakaway pits for greywater drainage, but the pits are usually not dug or constructed according to any standards and can quickly fill or affect adjacent households, especially in dense settlements. Drainage is a particular issue during the rainy season, ponding in roads and flooding poses a significant threat to residents' safety (Joubert & Martindale, 2013), and it

makes it difficult for residents or O&M teams to access sanitation facilities. Although on-site greywater disposal is feasible in low-density areas with well-drained soil, municipalities are struggling to deal with the issue of greywater management in non-sewered areas that are rapidly densifying. The need for off-site disposal represents an important shift from the primarily household level responsibility for on-site disposal to a municipal level responsibility for off-site treatment and disposal. If on-site disposal is an option and/or necessity, research in non-sewered informal settlements has indicated that greywater disposal is typically the best option rather than trying to recycle and reuse it given high pathogen loads in greywater that could be a health hazard and contribute to environmental pollution without adequate treatment (Winter et al., 2010). Neighbourhood and household level greywater treatment systems for low and middle-income countries are discussed in Morel and Diener (2006). One caveat is that systems requiring community-level management are typically not sustainable without significant external support from local authorities or NGOs (Winter et al., 2010); therefore, off-site (sewered) greywater treatment and disposal are preferable in most urban informal settlement contexts.

Data management and information flow relating to informal settlement services is also an area that needs strengthening. One of the issues is the challenge of keeping information up to date given the dynamic conditions that exist in informal settlements, e.g. in a single year the number of households frequently fluctuates in high growth settlements. Modelling informal urban growth can be a useful tool for high-level urban planning (Hill & Lindner, 2011), however, it requires sufficient and accurate land-use, demographic, and economic data at various temporal and spatial scales, which is often housed in different institutions and difficult to access (Shoko & Smit, 2013). As mentioned in previous chapters, one of the institutional sanitation service delivery challenges is coordination between various institutions within the municipality as well as with other stakeholders, one of which relates to data synchronisation, e.g. the number of households per settlement or even settlement boundaries may differ between different departments' databases. Advocacy NGOs such as SJC (CCT based) and Abahlali baseMjondolo (EM based) have complained about municipalities' reluctance to share data related to services in informal settlements, which has also been experienced by the author during the research process, e.g. two of the three case study municipalities declined to share GIS data for the location of informal settlement water and sanitation services; although backlog figures were shared. Part of the issue is that municipalities want to ensure that data is accurate and has been audited prior to sharing, but there is also a reluctance to share data for fear of political backlash and biased analysis for personal or political agendas, which makes collaboration between different stakeholder groups difficult. The failure to publish reports related to sanitation infrastructure, such as the Green Drop report (unpublished since 2012), is an issue that needs to be addressed if service delivery is to improve (Muller, 2016). Insufficient access to information can also be considered as a general equity concern, which has been noted by non-government stakeholders as a concern.

Data collection alone is insufficient if it is not analysed and applied to addressing service delivery issues. One of the challenges mentioned by municipal interviewees in CCT and CJ regarding M&E for sanitation services was not only inadequate capacity in terms of

numbers of staff, but also insufficient financial support to implement remedial actions or to apply feedback to strategic planning. Much of the M&E activity at the water and sanitation department in CCT and CJ relates to monitoring contractors for outsourced services or enumerating tap stands and toilets rather than evaluating the quality of the level of service. While environmental health practitioners are often tasked with the responsibility of assessing the status of water and sanitation services in informal settlements, they frequently struggle to get Water and Sanitation departments to follow-up on problems (Andrews, 2014, pers. comm., 3 September).

Another challenge that remains with regards to services for informal settlements is what an 'acceptable' sharing ratio is and how to assign responsibilities for managing shared facilities. For example, each municipality defines its own toilet facility to household ratio, CCT (1:5), CJ (1:6), EM (1:10) (DWS, 2014). CAB facilities have caretakers, but some other services such as container toilets often become smelly and dirty in between the weekly emptying and container replacements, and users must arrange their own cleaning schedules (which sometimes fail if users disagree on sharing cleaning duties). The distance required to walk to CABs[68] is also another issue that discourages people from using CABs (Crous, 2014), particularly when there is inclement weather.

Two shortcomings from a hygiene perspective are the general absence of menstrual hygiene management (MHM) programmes and soap. Observations from site visits to 17 urban and peri-urban informal settlements visited between 2012–2015 indicated that only one communal facility site included visible support for MHM (Diepsloot pilot project in Johannesburg) within toilet cubicles; although most sites did have a solid waste bin outside of the toilet facilities[69]. Privacy concerns as well as cultural preferences may lead women to deal with MHM at home rather than at communal facilities (Sommer et al., 2015). Soap was also absent from all of the communal facilities visited. Results from a survey of residents in informal settlements in Khayelitsha in Cape Town indicated that most users do habitually wash their hands after using communal toilets, but only with water (Norvixoxo, 2015, pers. comm. 24 November). Hand washing with soap was typically only practiced at home as most users do not bring soap to communal facilities and soap does not appear to be provided, with the exception of two pilot facilities visited by the author (the Mobisan in Cape Town (Naranjo, 2009) and Langrug in Stellenbosch). The general impression from site visits, however, was that MHM and soap provision seem to be the exception rather than the rule, which potentially reduces the health and hygiene benefits of sanitation services. Therefore, while the basic function of excreta containment may be provided by the basic LoS provided in most informal settlements, other functions such as safe access for all users (including vulnerable groups), greywater management, etc. are not being provided consistently. Inadequate attention to hygiene programmes and unsafe and unreliable access to services that fail to meet the needs of different user groups is a particular equity concern.

[68] Although EM strives to locate CABs no more than 250m from households, that is not always possible. Crous (2014) indicated that the primary factor for non-usage of CABs was perceived distance required to walk to the facility.

[69] N.B. Outside of the Cape Town informal settlements, site visits were only visited once, therefore a longitudinal study was not possible in all cases.

5.4 Comparison of municipal approaches to basic sanitation service delivery and perspectives of different stakeholders

Each municipality has implemented service delivery differently based on their own context, as aforementioned. There are of course common issues such as: settlement on land that is considered unsuitable for occupation (Category C in Appendix 1L), illegal occupation and tenure issues, rapid urbanisation, high density and the challenge of relocating people to install services, politicisation of sanitation, vandalism and theft of materials from facilities to name a few. Distinctive and common concerns and approaches related to the sustainability and equity of sanitation services for informal settlements in the three case study municipalities drawn from municipal data, interviews and field observations are presented in Table 5.4. A (+), (-), (0) rating system was applied to each point mentioned to indicate whether there was observed progress towards this (+), slow or no progress (-), or insufficient information or something that is neutral in terms of progress towards sustainability or equity. In addition to different municipal approaches, there are also various perspectives on which components of sustainability and equity are most critical that relate to stakeholders' experiences and their position, which influence their decisions around what a sustainable and equitable sanitation service should include. Without making gross generalisations, statements from group discussions and interviews that indicate representative key concerns and attitudes from various stakeholder groups involved with sanitation service delivery projects in informal settlements in South Africa are presented in Figure 5.4.

Table 5.3: Key for sustainability and equity dimensions used in Table 5.4

Sustainability	Equity
Technical	Resource allocation
Environmental	Perceptions
Social (including health & hygiene)	Access
Institutional/political	
Economic/financial	
General	

A comparison of the resources available to EM, CJ and CCT for providing services to informal settlements can help explain some of the variability in the backlog reduction rate and ability to operate and maintain services (Table 5.4). The financial, institutional and technical capacity of each municipality has significant bearing on the ability of municipalities to deliver sustainable sanitation services. CCT has the highest number of staff per capita of

the three municipalities. EM, however, has the highest number of registered professional engineers in water services of all the metropolitan municipalities (Group A) and was rated the highest of all Group A municipalities in terms of senior technical staff with the appropriate skills (SALGA & WRC, 2014). EM also allocated the most funds to support FBSan services in terms of ZAR/household. CJ has the fewest resources dedicated to FBSan services; some of the reasons for this were discussed in Section 4.2. Investing in and developing comprehensive M&E protocols for sanitation services in peri-urban and informal settlements is another area that has made EM stand out from the other two municipalities investigated. For example, the Human Science Research Council (HSRC) and University of Kwa-Zulu Natal (UKZN) were commissioned by EWS to assist with conducting household surveys and evaluating community acceptance of their basic water and sanitation programme (Gounden et al., 2006). Additionally, research to improve the CAB and UDDT programmes is ongoing. The linkage between research to improve sanitation programmes and actual modification of programmes was not as visible in CJ and CCT.

In terms of the budget allocated to FBSan services, it should be noted that the figure shown in Table 5.4 for eThekwini included the budget for CABs, which was considered to be part of FBSan by the author, but may have caused the budget for FBSan appear higher in eThekwini than in the other municipalities. It was not possible to attain the budget specifically allocated to sanitation in informal settlements from any of the municipalities; therefore, it is possible that some of the funds for sanitation services provided to informal settlements in Cape Town and Johannesburg were excluded. In terms of areas of dissatisfaction in each municipality, the author was unable to obtain customer survey reports for multiple years in all case studies, thus 2010, which was available for all, was used.

Table 5.4: Comparison of municipal levels of sanitation service (CCT, 2009; EWS, 2010; CJ, 2010; Crous, 2014; EWS, 2014a[a]; CJ, 2014c[b]; CCT, 2014c[c]; EM, 2015[d]; JW, 2015c[e])

Municipal characteristics	**eThekwini**	**Johannesburg**	**Cape Town**
2013-2014 Informal settlement estimate (HHs)	265,542[a]	196,391[b]	143,823[c]
Estimated 2014 sanitation backlog for informal settlements* (HHs)	182,271[d]	104,240[e]	73,714[c]
Median informal settlement density (HH/ha)	57	n/a	176
Levels of Service & Technologies	Emergency: Chemical toilet Interim/Inter-mediate: CABs, UD toilets, or waterborne w/ conservancy tanks or septic tanks Full: Conventional waterborne sewerage	1: VIP for each site 2: Waterborne connection connected to either a municipal sewer or a shallow communal sewer system; or a pour flush toilet 3: Conventional waterborne drainage installation connected to the Council's sewer	Essen-tial: Shared service, ratio determined by technology option, subject to densities Basic: Shared service, ratio determined by technology option Full: One flush toilet per household
Water/sanitation dept. staff size (staff/capita)	9:10,000	6:10,000	11:10,000
2013/14 Estimated budget allocated to FBSan (ZAR/HH)	1,486.28	253.39	386.32
2010 Areas of customer dissatisfaction	Poor communication on water and sanitation issues Poor service from call centre	No proper sanitation (especially in Region G) or flush toilets Toilet blockages/burst pipes	Gaps between provision and expectation for flush toilets Clean and safe toilets and education

*No service or below basic sanitation level as defined by municipality

Table 5.5a: Distinctive concerns and approaches to sustainability/equity of sanitation services

Municipal characteristics	eThekwini	Johannesburg	Cape Town
Distinctive concerns and approaches to sustainability/equity of sanitation services	 •Developing and investing in treatment and recycling technologies for faecal sludge from VIPs and UDDTs (+) •Very steep topography for some informal settlements makes them difficult to access and service (-)  •Concern that groundwater and soil in UDDT sites may be overloaded with nitrogen and phosphorus from urine and greywater because the density of settlements has grown at higher than anticipated rates (-)  •As households become wealthier they tend to convert from dry to waterborne sanitation systems, but may not pay rates due to location on tribal land (-)  •Development on tribal land complicated by policy that prevents the municipality from collecting rates on tribal authority land, but they are still obligated to provide free basic services (-)	 •Dolomitic soils in some informal settlement areas make them difficult to service due to susceptibility to erosion and potential sink holes (-)  •Mayor is promoting green infrastructure across the city including off-grid solutions for informal settlements (+)  •Transient and highly mobile population makes promoting alternative systems like UDDTs less viable given the high level of ongoing engagement required with users (-) •Insufficient meaningful community engagement (-)  •Given pressure on Johannesburg Water to be self-financing and profitable, delivering free basic water and sanitation services are not necessarily a priority (-)	 •High water tables in many areas of CT where informal settlements are located prevents wider spread use of dry sanitation because pits must be lined to prevent groundwater contamination (-) •All informal settlement waste from various container based and dry sanitation systems are treated at a single WWTW for quality control (0)  •Concern that sanitation service protests are linked to political motives to cast the municipality in a negative light as the only metropolitan municipality where the dominant political party (ANC) is a minority in city council (-)  •Struggle to determine who should lead in planning activities for water and sanitation services given separate informal settlement departments in different directorates (human settlements and utilities) (-)  •Provide portable flush toilets to individual households as a supplementary service to communal services for households upon request (+)

Municipal characteristics	eThekwini	Johannesburg	Cape Town
Distinctive concerns and approaches to sustainability/equity of sanitation services	•Using Urban Development Line as a guideline for where it is cost-effective to extend networked municipal services like sewerage (0) •UD toilets developed as an alternative to VIPs that were not considered a sustainable solution and to assist with bucket system eradication (+) •Modifying UD programme and UDDT design over time using feedback from consumer surveys and continued research collaboration (+)		

Table 5.5b: Common concerns and approaches to sustainability/equity of sanitation services

Municipal characteristics	eThekwini	Johannesburg	Cape Town
Common concerns and approaches to sustainability/equity of sanitation services	•Providing interim/ temporary services until housing opportunities are provided, but there is not enough well-located land available to resettle all informal households (-) •Short term planning dominates over long-term environmental consequences (-) •Servicing privately owned land can be the most difficult due to legal restrictions (-) •Need to avoid 'fruitless expenditure' (+) •Chemical toilets are not sustainable due to high O&M costs, but may be necessary in the short-term (-) •O&M costs are most important consideration for financial sustainability of the service (+) •Seeking social acceptance from users (0) •User education and hygiene programmes are important (+) •Dry sanitation systems have a higher maintenance burden for users than waterborne systems unless the municipality takes on the responsibility for collecting and transporting, treating and disposing/recycling of waste (+)		

Municipal characteristics	eThekwini	Johannesburg	Cape Town
	•Need to develop viable alternatives to waterborne systems (+)  •Need to find ways to reduce water used for flushing and to recycle wastewater (+)  •High-income users need to change their water consumption patterns to free up resources for users who do not have access to water and sanitation services (-)  •Dry sanitation is perceived as inferior to waterborne sanitation by most informal settlement users, and waterborne systems would be preferred if given the option (-) •Need to consider decisions from the point of view of the users not decision-makers who may never have used alternative sanitation systems before (-) •Providing different sanitation systems in the same or neighbouring settlement can lead to tension between residents and perceived as unfair (-)  •Night-time access to facilities outside of the dwelling place can be limited due to shared facilities being locked, and safety concerns for women and children (-) •Information about sanitation access and decision-making procedures is not transparent (-)  •Impossible to plan for informal settlements because of uncertainty and unregulated development (-)		

The thematic analysis of interviews, group discussions and field observations with key stakeholders revealed both distinctive and common concerns and values relating to sustainability and equity in each municipality. Although each municipality had unique technical concerns relating to service delivery challenges, e.g. the steep topography in eThekwini, dolomitic soils in Johannesburg and the high water table in Cape Town, many of the institutional and financial concerns tended to overlap. A comparison of the municipalities showed that amongst the sustainability dimensions evaluated, institutional sustainability was one of the weakest areas. One of the main institutional sustainability challenges is the coordination and linkage of sanitation services to housing development and the concept of developing interim solutions. There is, however, a great deal of ambiguity with regards to how long an interim service should be designed for given the relatively long time frame anticipated to meet sanitation backlogs (Table 5.1). According to Crous (2014), municipal officials in eThekwini designed CABs as interim services designed for approximately five years, but some CAB facilities have already been in use for longer than this. Furthermore, the interim period, i.e. until people receive formal housing opportunities is likely to be much longer for a large proportion of the urban poor. Therefore, interim services straddle the line between temporary and permanent services and with respect to technical sustainability should be robust enough to last for longer than five[70] years. Institutions should also distinguish

[70] Many of the interim services may be in use for much longer than five years, but five years is generally recognised as the maximum for a short-term time frame.

between emergency service delivery for immediate disaster relief, e.g. fires or natural disasters, and medium to long-term development of services for informal settlements and backyard dwellers.

One of the common financial concerns mentioned by municipal stakeholders was the need to avoid 'fruitless and wasteful expenditure[71]', which is regulated by the Public Finance Management Act (PFMA) (RSA, 1999), which defines it as 'expenditure which was made in vain and would have been avoided had reasonable care been exercised'. Application of the PFMA and related Municipal Finance Management Act to sanitation services in informal settlements has been used as a rationale for providing temporary sanitation systems such as PFTs and chemical toilets to informal settlements on private land[72] or in areas where occupation is prohibited in CCT (Appendix 1L) (De Lille, 2013). There are, however, questions about the economic sustainability of using contracted emptying and cleaning services for a prolonged period of time. For example, some settlements have been serviced by chemical toilets for years at a high operational cost, which could have been used to invest in a better level of service.

Although environmental or technical sustainability may be promoted by dry sanitation systems, the socio-cultural sustainability of promoting dry 'alternative' sanitation systems in South Africa as a solution primarily for low-income households remains dubious given negative associations with the 'bucket system' and aspirations for a flush toilet as 'a sign of modern citizenship' (Robins, 2014). Dry sanitation systems can be viable in the right context, but to increase social acceptability, dry systems need to be dissociated from the bucket system and lower social status. However, with increasing settlement density, draining both greywater and urine onsite with dry systems like the UDDTs becomes less technically feasible and leads to a higher risk of environmental pollution.

Overall, two dimensions of sustainability that all three municipalities were performing relatively well in compared to other dimensions related to technical sustainability and financial sustainability. All municipalities had plans to address the entire sanitation service chain (from collection to treatment) in their services to informal settlements, although the quality of service was not always guaranteed. There were also several examples of developing or testing a variety of sanitation systems to try and find those best suited to the informal settlement context. Again, however, this needs to be balanced against some of the socio-cultural and equity criteria. While it is beyond the scope of this thesis to do a full economic evaluation of FBSan or to assess whether it will always be financially viable for municipalities, there is a significant emphasis from municipal stakeholders on this dimension of sustainability (see Figures U.1-2 in Appendix U), particularly on the need to allocate sufficient budget to O&M.

[71] At a meeting with the Western Cape provincial government (11 Jan, 2016), some attendees suggested that the National Health Act and the need to protect human health can trump the 'fruitless expenditure' argument, but the author could not uncover any recent court cases relating to this.

[72] There is not much guidance for municipalities on how to deal with informal settlements on private land. At a recent meeting (14/01/2016) that the author attended with the Western Cape Government, relating to sanitation services for informal settlements, the possibility for purchasing land or appropriating land when the owner has abandoned the property for a number of years was discussed, in addition the need to protect public health as trumping the "fruitless expenditure" argument.

Municipalities were weaker in addressing dimensions of equity than some of the sustainability dimensions previously mentioned. For example, while 'low-cost' alternatives to conventional waterborne sanitation have been widely promoted in informal settlements, the reasons for why these alternatives are installed or if and when it will be possible to upgrade to a higher LoS is not generally explained well to informal settlement residents (Gangatele, 2013, pers. comm., 16 May). This has had a noticeably negative impact in relation to people's perceptions of alternative sanitation systems. In relation to resource allocation, there needs to be greater emphasis on modifying the water consumption patterns of high-income households. This could help free up limited water resources for a higher LoS for water and sanitation services to low-income households, which will be discussed further in Section 5.5.

A worrying trend that emerged during the course of the research was the inaccessibility of data pertaining to water and sanitation services for informal settlements. While initially when the author began the research in 2012, municipal officials (except for in Johannesburg) contacted were willing and able to share data such as GIS files relating to the location, type and condition of water and sanitation facilities in informal settlements. However, by the time the majority of field work had been completed in 2015, officials were unable to share the same data for that year due to political changes in administration and fear that the information would be used for sensational media fodder. The politicisation of sanitation services and service delivery in general in South Africa has thus served as a double-edged sword for progress in equity. On the one hand, public attention and pressure has forced high-level authorities to address the sanitation crisis in informal settlements and to allocate funds for service delivery, but on the other hand, it has made sanitation in informal settlements such a sensitive issue that it is difficult to share information or to discuss shortcomings without fear of political backlash, which has negative implications for equity.

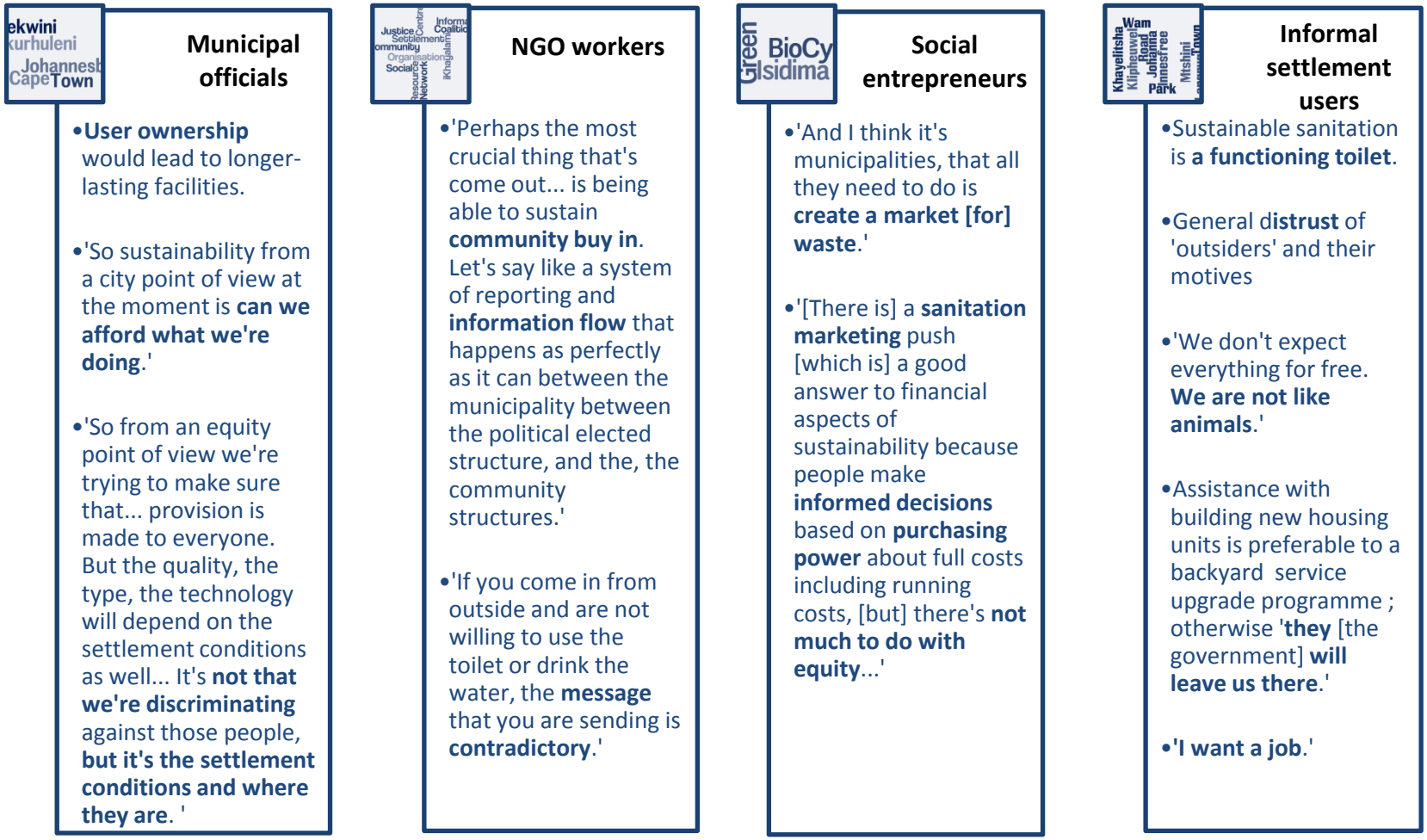

Figure 5.4: Quotations from various sanitation stakeholders relating to their perceptions of sustainable and equitable sanitation services

Not surprisingly, another element of the thematic analysis revealed that different stakeholder groups tend to emphasise different aspects of sustainability and equity. Quotations which highlight some of the common themes that emerged from interviews, group discussions and field observations with various stakeholders demonstrated some of the different concerns and perspectives that different stakeholder groups find most salient (Figure 5.4). In EM and CCT, the financial sustainability of O&M activities, which are paid for by the municipality not users, was one of the key sustainability concerns. Interestingly, the financial sustainability of O&M services did not come up as frequently in interviews with municipal officials in CJ, where social sustainability concerns relating to the transient population and land ownership issues were more prominent in the nodal frequency analysis (Appendix 1U). The approach to equity from municipal employees tended to be pragmatic, as indicated in Figure 5.4, acknowledging that there will be a different quality of service depending on the settlement conditions and the location.

NGO workers discussed themes primarily around socio-cultural sustainability through increased communication between the municipality and informal settlement dwellers. In contrast to municipal employees, NGO workers generally expressed a more idealistic view of equity and how there should be less of a difference in the level of service between informal and formal areas despite different socio-economic conditions. Furthermore, advocacy oriented groups such as SJC and Ndifuna Ukwazi in Cape Town have taken on a monitoring role and question the local government's commitment to improving services in informal settlements and low prioritisation of sanitation services (Kramer, 2015). Other NGOs such as CORC, which is linked to SDI, have taken a more collaborative approach with local governments. They have tried to engage local government as a partner in service provision as well as to shift informal settlement residents towards self-empowerment through processes such as reblocking (Section 4.3).

In interviews with sanitation entrepreneurs, discussions gravitated towards the need to develop a 'sanitation market' in South Africa (Figure 5.4), i.e. demand for the beneficial reuse of waste and for sanitation products (Kotze, 2013, pers. comm.., 26 June; Schaub-Jones, 2013, pers. comm.., 2 September). Furthermore, the need to encourage users to make informed decisions based on what they need and what they can afford was mentioned (Schaub-Jones, 2013, pers. comm., 2 September), although it was noted that equity is not easily addressed by the private sector and market based approaches. In the South African context, since the government subsidises FBSan services and is the primary decision-maker in relation to sanitation service delivery to low-income areas rather than users, different market models from other countries where users finance their own sanitation services are required. One of the challenges in South Africa is to promote greater investment in sanitation services for informal settlements from residents themselves and to encourage greater private sector investment in the development of sanitation services in low-income areas.

Users in informal settlements tended to focus on localised issues (Figure 5.4), and as one focus group participant succinctly stated, 'sustainable sanitation is a functioning toilet', regardless of the type or what happens to the waste after it leaves the settlement. Those types of comments are consistent with Tayler et al. (2003:3), who note that: 'Householders living in

areas with poor sanitation and drainage tend to focus on their own local environment and are understandably less concerned about the needs of the wider environment.' In addition to less concern, generally, with wider environmental issues than other stakeholder groups, a lack of sanitation is also conflated with other needs. Discussions about sanitation services or the status of facilities, location, cleanliness, odour, etc. often led to discussions about housing and a desire for job opportunities. In terms of social equity, there was a strong sense of not wanting to be treated differently than any other people regardless of living in a backyard or informal settlement, 'We don't expect everything for free. We are not like animals,' one community leader emphasised, which speaks to the importance of perceptions in equity.

Incorporating different perspectives to promote sustainable sanitation services with an emphasis on equity is important because sustainability and equity are broad issues requiring input and participation from a wide variety of stakeholders. Furthermore, getting buy-in from different groups of people requires understanding what appeals to them as well as to ensure that responsibilities at every stage of service delivery are distributed according to interest and ability. For example, a study of the acceptance of EcoSan toilets in the Northern Cape highlighted that the success of the programme was largely attributed to 'marketing to people's [users'] aspirations rather than promoting the reuse of excreta' (Holden et al., 2003). Whereas environmental protection and health promotion may be more important to government officials, other stakeholder groups may be more concerned with promoting a human rights agenda, or addressing private concerns for convenience and prevention of odour; thus their roles with regards to promoting different elements of sustainability and equity will be different. Including various perspectives in the assessment of sustainability and explicitly addressing equity concerns relating to resource allocation, perceptions and access to sanitation services can help different stakeholders find common ground and ways to compromise when trade-offs are necessary.

5.5 Discussion on trade-offs and intersections between sustainability and equity: 'some, for all, forever'

It is important to consider where there may need to be trade-offs between general sustainability and social equity goals. In the South African context, informal settlement residents do not generally pay for sanitation services. Sanitation services are provided as part of a Free Basic Services package, which was discussed in Section 2.3.4.2 that is premised on a 'basic needs approach'. Arguably, the provision of FBSan services should automatically support equitable sanitation services in urban areas, but the provision of sanitation hardware for free does not automatically lead to an improved use of sanitation facilities (de Albuquerque, 2012); nor does the provision of facilities ensure that they are accessible to all. Furthermore, a major consideration is 'whether [the choice to provide free services] is sustainable in the long run or whether, in the near future it will give rise to a financially unsustainable situation that will inevitably lead to a deterioration of services and infrastructure' (de Albuquerque, 2012:91). Although it is beyond the scope of this thesis to explore financial models and the economic impact of FBSan in depth, the economic

sustainability of providing free basic sanitation services is one that will keep arising, and multiple funding sources, including user contributions should be considered.

There are trade-offs between meeting various sustainability and equity criteria given the breadth of dimensions to consider and competing demands for limited resources as demonstrated in the case studies. Equity primarily relates to social and economic dimensions of sustainability, therefore environmental, technical or institutional sustainability issues are not necessarily addressed by equity objectives. Sustainability may encompass considerations for intergenerational equity, but inter- and intra-regional or socio-economic disparities relating to intra-generational equity may be overlooked, if for example, the primary objective of project decision-makers is economic sustainability. This development conflict is frequently encountered in choosing a sanitation system. Can a sanitation service be equitable without being sustainable, or vice versa? An example scenario where sanitation services may be equitable without being sustainable would be to promote conventional waterborne sanitation services for an entire city in a water scarce region without considering implications on water usage. Universal access might be achieved in the short-term, but insufficient funding, water resources or technical capacity would make it difficult to operate the system over the long-term. On the other hand, there could be an equity argument that supports the use of sewered systems to address inequities in the status quo in the South African context. For example, Fisher-Jeffes *et al.* (2015) conducted research indicating the significant impact of swimming pools on residential water demand (the largest source of demand) in Cape Town, which can increase those households' water demand by 7-8%. Pools should be considered a less essential usage than for sanitation services, and as argued by Fisher-Jeffes *et al.* (2015) the usage of potable water for swimming pools should be better regulated. Another argument for a sewered system is that flush water can be of a lower quality than drinking water or water used for swimming pools, e.g. greywater could be used for flushing. Given competing demands for a limited supply of water, equitable distribution of water and fair usage should be considered prior to making the argument that there is not enough water to support waterborne systems for informal and peri-urban settlements.

Another potential trade-off is between individual and communal household services. For example, in EM UDDTs are designed for individual household usage whereas CABs are communal systems. In terms of economic and technical sustainability, a communal system may be the most feasible option, but individual household services are more aspirational and likely to be accessible to all household members, which supports equity objectives and social sustainability. The notion of equity with regards to access to sanitation inherently invites comparison between different groups of people whether from an intra- or inter-urban perspective. It is unlikely, therefore, that a sanitation service could be considered sustainable if it was perceived as inequitable by many users, which is the dilemma with the LoS model used in many South African urban informal settlements.

There is a spectrum for determining sustainability and equity, and in many cases it is easier to say what is or is not sustainable or equitable through comparison rather than to have an absolute standard; although there are guiding principles which can be used to assess sustainability and equity as was discussed in the comparison of municipal approaches to

sanitation service delivery. The slogan adopted by the Department of Water Affairs and Forestry (now DWS) in the 1990s succinctly summarises the goals for sustainability and equity to ensure that there are 'some [services], for all, forever' (Figure 5.5).

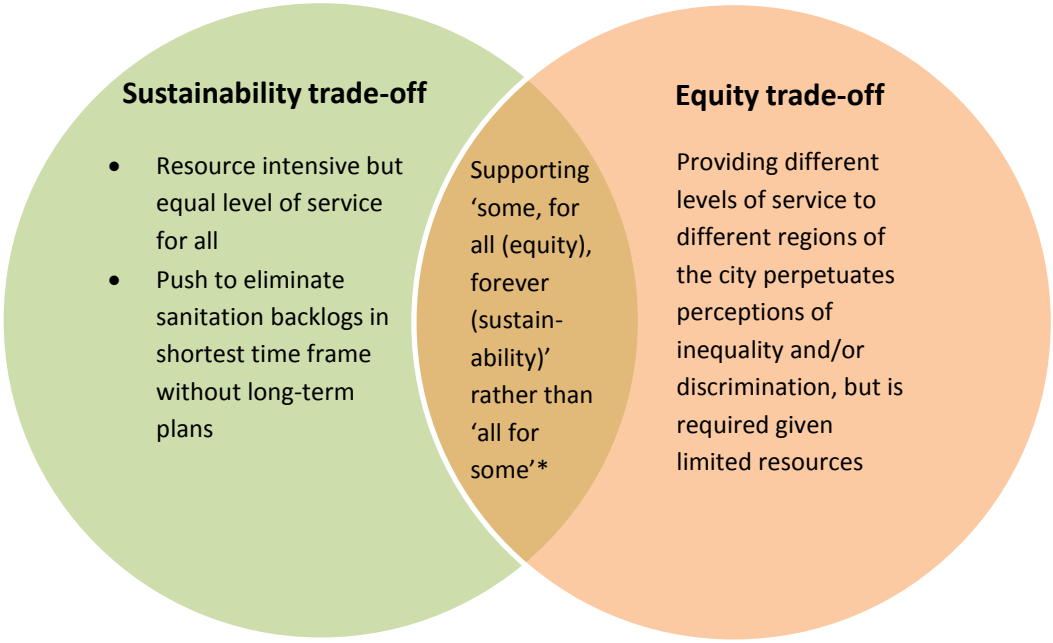

Figure 5.5: Summary of underlying trade-offs and the theme of 'some for all'

*N.B. The principle of 'some, for all, forever' versus 'all for some' is a core theme of South Africa's post-1994 water management policies (DWAF, 1994; RSA, 1997b).

When various dimensions are explored by multiple stakeholders in sanitation service delivery, it becomes relatively subjective as to what criteria become most important whether they relate to trade-offs between sustainability and equity or between different aspects within sustainability. For example, as mentioned in the case study analysis, financial sustainability was often described as the most important aspect of sustainability by municipal officials in line departments; whereas environmental sustainability may be more important to an official working in environmental affairs, or social sustainability for NGO workers, or the proximity of facilities (equity of access) to informal settlement residents (Crous, 2013), as noted during site visits and interviews. Determining what an adequate level of sanitation service to informal settlements should be is often contested (Taing, 2015), but it can also provide an opportunity for communication and collaboration between local government, private sector service providers, NGOs and informal settlement residents (Bradlow, 2013). Thus, where trade-offs need to be made it is useful to incorporate the perspectives of multiple stakeholders. One way to do so is to evaluate how an existing technology or programme is performing to identify which areas need the most improvement or pose the most risk of failure, e.g. using a Technology Assessment Framework (Olschewski, 2013 Appendix 1G)

As mentioned earlier, equity primarily supports social and economic dimensions of sustainability but can also affect environmental and institutional dimensions of sustainability if equity is connected with decisions around resource allocation. For example, as mentioned in Section 2.4.2, to ensure equitable allocation of resources towards improving sanitation services in informal settlements it may be necessary to redistribute resources in the form of redistributing staff responsibilities within or between municipal departments, which can affect institutional arrangements. Or with regards to information dissemination and decision-making and equity of access or what Haughton (1999) referred to as procedural equity, institutional sustainability is important.

As indicated by the case studies, an equity trade-off is being made in service delivery based mainly on financial resource limitations (although technical constraints are also noted), i.e. different levels of service are being provided to different regions of cities (Figure 5.5). The problem with providing different levels of service to different regions of the city, in the South African context of visible socio-economic disparity, is that it perpetuates perceptions of inequality and/or discrimination based on historic racial and spatial differentiation patterns. Different levels of service are a necessary trade-off at present and framed as a pragmatic decision, but given the long-term aims of sustainable and equitable services, the aim should still be to provide sanitation services as high up the 'sanitation ladder' (Figure 5.2) as possible in informal settlements even if they are considered as interim solutions. A starting point would be to ensure that all people, even those in vulnerable groups, can access a safe and reliable sanitation service 24 hours a day, ideally per household. Where communal services are the only option, facilities should be: well-lit, within reasonable walking distance, fitted with hand washing facilities with soap, accessible to disabled users, include MHM systems, attended by janitors and designed with night soil bucket disposal points that people can use in the morning.

6 Conclusions

Achieving universal access to sanitation services, both in South Africa and globally, will require long-term planning that addresses multiple dimensions of sustainability and equity. This thesis analysed the approaches taken by three South African municipalities to meeting the challenge of providing sanitation services to residents in informal areas and examined how various dimensions of sustainability and equity were applied and potential trade-offs between sustainability and equity objectives. While the three case study municipalities cannot be taken as representative of the whole country, each municipal case study represented not only important contextual issues, but also demonstrated some of the issues shared across different municipalities through comparison of some of the better if not 'best' practice approaches to support the related concepts of sustainability and equity in sanitation service delivery to informal settlements. Furthermore, although the focus was on South African metropolitan municipalities, there are also lessons that can be applied to smaller municipalities or other countries with differentiated service levels that are facing multi-dimensional challenges in providing subsidised sanitation services to informal settlements. Sustainability and equity have been promoted within Free Basic Service policies in South Africa and the SDGs internationally as essential to the provision of services; thus this thesis aimed to clarify some of the ambiguity around how sustainability and equity concepts can be applied to assessing the quality of sanitation services as opposed to emphasising the quantity of facilities provided to informal settlements.

The literature review and analysis of the case studies revealed a common thread of inequity at different scales as a major threat to the sustainability of sanitation services in informal settlements, particularly given the South African context of extreme socio-economic inequality. Six dimensions of sustainability (environmental, economic, technical, institutional, socio-cultural, health and hygiene) and three dimensions of equity (resource allocation, access and perceptions) were identified and utilised to evaluate sanitation services in the case studies. As noted in the literature review, statistically significant inequalities in access correlated to race and gender remain, e.g. Black African and female headed households are the most likely to lack access to sanitation facilities (Figure 2.7 and Figure 2.8).

In relation to meeting the needs of as many people as possible, one of the identified dimensions of equity that needs greater attention during planning and design stages relates to access for vulnerable groups such as children, the elderly, people with disabilities and pregnant women. They may struggle to access facilities due to physical and social barriers, such as the distance required to walk to facilities, social marginalisation and general safety concerns. Furthermore, the full range of health and hygiene benefits cannot be realised if hand washing facilities (with soap) are not located close to toilet facilities or if MHM is not included as part of sanitation service delivery programmes. Only two of the communal facilities visited by the author included both soap and MHM services, indicating that general hygiene and MHM are often overlooked in sanitation service delivery. With the exception of the reblocking process described in the CCT case study, there were very few examples where inclusive design principles were used for the design and planning of sanitation services

mentioned by any of the interviewees. Again, including the perspectives of vulnerable groups can help address barriers to access for vulnerable groups and to improve the equity of sanitation services.

In terms of equitable allocation of resources to sanitation services in informal settlements, EM has earmarked the most per household. While detailed budgetary figures could not be attained for M&E costs, based on municipal interviews and field visits to each municipality, one of the reasons that EM is reducing its sanitation backlog at the fastest rate is due to both more financial resources dedicated to FBSan per household (Table 5.4) and the inclusion of informal settlement services as part of general water and sanitation department services. The inclusion of informal settlements indirectly helps to dedicate more staff members to informal settlements, as opposed to the arrangements in CJ and CCT where informal settlement responsibilities are delegated to separate 'informal settlement' units or divisions. Furthermore, including informal settlements as part of the general water and sanitation department responsibilities facilitates the inclusion of informal settlement services as part of overall water and sanitation service delivery for the municipality as a whole rather than fragmenting plans for formal versus informal areas. Again, while the distinction appears minor, equity and inclusion are closely linked. Thus, institutional arrangements that promote or hinder equitable distribution of human and financial resources should also be scrutinised alongside other dimensions of equity mentioned previously (Table 5.3).

Institutional issues around gaining property rights to well-located land or how to deal with settlements on private land are also major underlying challenges to the promotion of equitable sanitation services in informal settlements. Tools such as the informal settlement development matrix proposed in CCT (Table 4.14) can assist stakeholders with planning water and sanitation services and identifying land-use related issues. However, a shortcoming of the tool is the top-down approach used to determine upgradeability. A lack of engagement with non-government stakeholders and unwillingness to share information undermines those stakeholders' trust that the municipality will incorporate the perspectives of representatives from informal settlements. As mentioned throughout this thesis, perceptions can be considered as a dimension of equity, and thus it is important for service delivery providers to incorporate the perspectives of multiple stakeholders. One of the major equity challenges for municipalities is to move away from implementing services in informal settlements as temporary services that are perceived by users as 'sub-standard', i.e. poor people receive poor quality services while rich people receive better services. Services should be considered temporary only if there is a clear action plan to relocate residents in a particular area within the short-term (<5 years). As a compromise between 'temporary' and 'permanent' services, interim services have been introduced in the three case study municipalities. Interim implies until informal settlements can be 'formalised', either through relocation to subsidised housing units, rental apartment stock or through in situ upgrading. The interim period remains undefined; however, it is clear that the majority of informal settlements will remain 'informal' in the short to medium term (>5 years) as defined in Figure 4.2.

Applying or operationalising sustainability and equity is difficult because of the interwoven and subjective nature of some principles and criteria for assessing them.

Furthermore, as Campbell (1996) concisely described, there are often conflicts between different sustainability goals, of which equity is one of the pillars. As was mentioned throughout the thesis, the property conflict between economic development and social equity and development conflict between environmental protection and social equity frequently emerge in bringing sanitation services to informal settlements. Where trade-offs are necessary between meeting different areas of sustainability and equity, looking at sanitation services from a functional (Figure 5.2) rather than technology based LoS can assist with ensuring that at least the core functions of a sanitation service to protect human health and reduce environmental pollution are being met for as many people as possible; i.e. get the basic functions right for as many people as possible before focusing on technological sophistication and higher level functions such as resource recovery or integrated water management. As mentioned in South African policies (DWAF, 1994; RSA, 1997b) 'some for all, forever' is a core tenet of water and sanitation services, but the 'some' needs to meet locally defined sustainability and equity criteria. There should also be a vision to progress 'all' up the sanitation ladder. Priority should be given to bring those lower down up to the level of those higher up, again from a functional rather than technological perspective. A caveat, however, of the basic service approach is the risk of locking poor residents into a lower LoS while excluding them from 'premium networked areas' (Jaglin, 2008). A primary goal of sanitation services across the municipality should be to reduce intra-generational and geographical inequalities in the dimensions of equity described. It is not enough to promote 'alternative' sanitation systems to reduce water usage and spending in low-income areas without returning to the question posed earlier 'what is to be sustained, and for whom?' (Campbell, 2013). Ensuring that the costs and benefits of sustainable and equitable services are shared requires changes not only from informal settlement residents, but from all residents and how urban development is planned, e.g. could policies be changed so that 'alternative' sanitation systems are promoted in higher-income developments, or could informal settlement residents be relocated to 'premium networked areas' instead of on the outskirts of cities or on marginal land?

6.1 Knowledge contributions, areas for further research, and final recommendations

This thesis provided a critique of how sanitation services are provided to informal settlements in EM, CJ and CCT, specifically focusing on the sustainability, equity, and sometimes lack thereof, in each municipality's approach. In particular it added to the body of knowledge relating to the importance of equity in connection to sustaining sanitation services in informal settlements, and identified various dimensions of equity that should be considered during assessments. Sustainability and equity criteria as defined in this thesis were assessed at both project and programme scales using municipal case studies. While several sustainability assessment methods and criteria were identified in the literature review, there was less literature available relating specifically to equity assessments and the important connection between social equity and general sustainability. Three important dimensions of equity to consider that emerged from this research are: resource allocation, access to services and

perceptions of different stakeholders (Table 5.3). Some proposed ways to measure equity of resource allocation included both financial and human capacity assessments. Regarding access to services, the need to give greater attention to eliminating barriers to access (including access to information) for vulnerable groups during the design and planning stages of sanitation service delivery programmes was highlighted. An additional finding of the research is the importance of planning for services and post-implementation assessment of the quality of services using multiple stakeholders' input, which linked to the perceptions dimension of equity discussed. A proposed methodological framework developed through the case studies to assess the sustainability and equity of sanitation services was presented in Chapter 3. The emphasis needs to be on sustaining the quality of services and ensuring that every individual can access them, as much as on the quantity or type of facilities provided. It is important, therefore, for those responsible for regulating sanitation services to assess sustainability and equity in sanitation services and to ensure that feedback is used, not just collected, to make adjustments to existing services and policies and to inform future sanitation service projects.

Specific findings and recommendations include the following:

- municipalities need to move away from the use of temporary services such as chemical toilets except in areas that are clearly scheduled to be relocated (land is earmarked, funds are secured) or upgraded within less than five years;

- major lessons learned from EM's basic sanitation programme are not primarily about replicating the technologies employed such as the UDDTs or CABs, but rather their approach to scaling up services and emphasis on investment in O&M, M&E and ongoing participation with a wide variety of stakeholders;

- if urine diversion and dry sanitation systems are going to be promoted, cost-effective treatment and resource recovery systems need to be developed concomitantly and promoted not only in low-income housing developments, but also in middle-high income developments;

- regularly assessing services post-implementation, then acting on assessment recommendations is crucial even if the municipality does not do this directly, but uses intermediaries such as consultants, NGOs or researchers;

- sustainability and equity assessment results focused on service quality should be shared between different municipalities and made publicly available for greater knowledge transfer through new or existing M&E tools such as the Municipal Benchmarking Initiative;

- to promote greater equity in sanitation services across a municipality and water conservation, the LoS framework should be re-evaluated with a greater emphasis on the functionality and accessibility of services rather than the type of technology used;

- local governments need to include marginalised communities in the process of service delivery, for example through an inclusive design process and to continue to engage with communities even after infrastructure is installed, particularly with vulnerable groups, e.g.

improving the incorporation of MHM in communal facilities by engaging more women during the planning and design stages;

Recommended areas for further research include:

- addressing water and sanitation services for the growing number of backyarders who do not receive services from landlords;
- exploring alternative funding mechanisms for FBSan including potential revenue from resource recovery and user payments for at least part of the O&M costs;
- investigating the potential to scale up the enumeration, reblocking and inclusive design methods developed by SDI/CORC and assessing the resources necessary to develop it further as a means to improve sanitation service delivery;
- modelling the life cycle costs of providing various levels of sanitation services under different urbanisation scenarios for all municipalities;
- linking local monitoring indicators to international monitoring programmes such as the JMP, which will be used to assess progress for SDG Goal 6.
- testing the M&E assessment method recommended in Section 3.3.1 and the potential to improve the feedback loop between M&E findings and corrective actions.

The overarching theme that emerged through the research is that while there may be necessary trade-offs between meeting various sustainability and equity criteria in sanitation services in the short to medium term, in the long term, the two aims are intertwined. Equity is a critical component of the broader notion of sustainability. Moreover, in the context of extreme socio-economic inequality, equity can be viewed as both a means to sustainability and an important end in and of itself.

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Appendices

A. Capital and operating costs for selected sanitation systems in Johannesburg and Cape Town municipalities

Table A.1: O&M costs for chemical and VIP toilets in Johannesburg (Nelson, 2015, pers. comm. May 14)

Sanitation type	Service Cost (ZAR)		
	Weekly Hire	Weekly Servicing	Emptying VIP with vacuum tanker
Chemical toilet	12.50	50.76	n/a
VIP	n/a	n/a	213.87 - 240.33

Table A.2: Expected service ratios, capital costs and annual operational costs for sanitation technologies in Cape Town (Naranjo, 2009; Jooste, 2011)

Sanitation type	Service ratio (toilets: households)	Capital cost per Unit*	Annual operational cost per unit
Chemical	1:5	R 0.00	R 11,520.00
Porta-potti	1:1	R 1,100.00	R 1,180.80
Bucket	1:1	R 3,100.00	R 1,920.00
Container	1:5	R 3,500.00	R 1,920.00
Flush**	1:5	R 5,200.00	R 72.83
Pitliner	1:5	R 6,000.00	R 900.00
Anaerobic (NOWAC)	1:2	R 6,600.00	R 450.00
Dry Sanitation***	1:5	R 6,800.00	R 120.69
MobiSan	N/A	N/A	R 5,397.38
Conservancy Tanks	1:5	R 8,500.00	R 1,174.00

*Values are assumed to be in 2009 ZAR and exclude professional fees.

** This is an estimated average cost for installations where there is an existing bulk reticulation network.

*** The figures for dry sanitation exclude Afrisan installations and the MobiSan, which includes a full-time janitorial service.

B. Unit Costs for Domestic Sanitation by Province

Table B.1: Average unit capital costs for domestic sanitation in South Africa by province in 2009 rand values (COGTA, 2010:72)

Province		VIP toilets/equivalent (single pit fixed top structure)	VIP toilets/equi-valent (double pit fixed top structure)	VIP toilets/equivalent (single pit movable top structure)	VIP toilets/equivalent (double pit movable top structure)	Onsite UDS	Septic tanks (full level of service)	Full water-borne sanitation (full level of service)
		R/ Household	R/ Household	R/ House-hold	R/ House-hold	R/ House-hold	R/ House-hold	R/ House-hold
Limpopo	**Min**	6,247	6,518	6,587	6,858	6,125	9,388	7,247
	Max	6,941	7,242	7,319	7,620	6,806	10,431	8,052
	Avg	6,594	6,880	6,953	7,239	6,466	9,910	7,650
Gauteng	**Min**	5,614	5,860	6,216	6,462	5,515	8,476	6,611
	Max	6,238	6,511	6,907	7,180	6,127	9,418	7,346
	Avg	5,926	6,186	6,562	6,821	5,821	8,947	6,979
North West	**Min**	6,326	6,604	6,916	7,194	6,185	9,229	7,179
	Max	7,028	7,337	7,684	7,993	6,872	10,254	7,977
	Avg	6,677	6,970	7,300	7,593	6,528	9,741	7,578
Free State	**Min**	5,608	5,863	6,300	6,555	5,487	9,075	6,933
	Max	6,231	6,514	7,000	7,283	6,096	10,084	7,703
	Avg	5,919	6,188	6,650	6,919	5,792	9,580	7,318
Kwazulu Natal	**Min**	5,302	5,536	6,140	6,374	5,086	8,274	6,464
	Max	5,891	6,152	6,822	7,082	5,651	9,194	7,183
	Avg	5,597	5,844	6,481	6,728	5,369	8,734	6,823
Mpuma-langa	**Min**	6,234	6,503	6,697	6,966	6,115	9,160	7,087
	Max	6,926	7,225	7,441	7,740	6,794	10,178	7,875
	Avg	6,580	6,864	7,069	7,353	6,454	9,669	7,481
Northern Cape	**Min**	6,502	6,791	6,925	7,213	6,406	9,885	7,448
	Max	7,225	7,545	7,694	8,014	7,118	10,983	8,276
	Avg	6,864	7,168	7,309	7,614	6,762	10,434	7,862
Western Cape	**Min**	6,107	6,374	6,684	6,950	5,971	9,300	7,245
	Max	6,786	7,082	7,426	7,723	6,635	10,333	8,050
	Avg	6,447	6,728	7,055	7,337	6,303	9,817	7,648
Eastern Cape	**Min**	6,231	6,531	6,776	7,077	6,014	9,477	7,389
	Max	6,923	7,257	7,529	7,863	6,682	10,530	8,210
	Avg	6,577	6,894	7,153	7,470	6,348	10,003	7,800
National	**Avg**	6,353	6,636	6,948	7,230	6,205	9,648	7,460

C. Introduction to sanitation technologies used in informal settlements in South Africa

One of the major factors discussed in relation to what is considered a sustainable or equitable sanitation relates to what type of sanitation technology is used to provide a sanitation[73] service. This section provides an overview of technologies that are used in South African informal settlements classified according to whether or not they use water and if waste products[74] are disposed of on or off-site. It should be noted that it focuses on the 'front-end' or user interface for sanitation systems, which are primarily related to the storage/collection related components, given the relative importance placed on this component in the informal settlement context and the ongoing debate between the merits of 'wet' versus 'dry' systems; whereas sanitation systems should include not only storage/collection and conveyance systems, but also treatment, disposal and reuse systems[75]. The potential for recovering resources from faecal sludge and wastewater and challenges to resource recovery are, however, briefly discussed in the final section of the chapter.

Part of the challenge with developing policies to regulate sanitation services and with choosing context appropriate technologies is the wide variety of sanitation technologies available that range in technical complexity and cost. One of the major discourses developed over a period from 1978 to 1988 was described as the 'appropriate technology phase' with an emphasis on developing 'low-tech' low-cost technologies (Black, 1998:11-12) for developing countries, much of which was influenced by the publication of the book *Small is Beautiful* in 1973 (Schumacher, 1973). The main thrust of the appropriate technology argument is that the choice of technology should be influenced by the context and situation in which it is being used (Kalbar et al., 2012) including the developmental goals of the country making the choice (Kalbermatten et al., 1982). A variety of tools exist to support decision-making in selecting the most context appropriate water supply and sanitation systems, which are presented in Appendix D.

In South Africa, achieving at least a 'basic' level of water and sanitation for all is one of the major national development goals. A definition for what qualifies as a 'basic sanitation facility' is:

> The infrastructure necessary to provide a sanitation service which is safe, reliable, private, protected from the weather, ventilated, keeps smells to a minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating appropriate control of disease

[73] The author recognises that sanitation services also need to encompass consideration for stormwater and municipal solid waste management as promoted in the definition of 'environmental sanitation' (Lüthi *et al.*, 2011a), but the scope of this research is primarily limited to sanitation services in reference to dealing with human excreta and domestic wastewater.

[74] Depending on the type of sanitation technology waste products can be: blackwater, greywater, sludge or some combination of urine, faeces, flush water and anal cleansing material. For more specific details on terminology used, see Tilley *et al.* (2014).

[75] The emphasis on reuse and resource recovery is promoted particularly in relation to the idea of a 'sanitation value chain' where productive usage of faeces/urine is promoted and has a potential market value (van Dijk, 2012).

> carrying flies and pests, and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner. (DWAF, 2003:46)

The type of technology to be employed, however, is not specified in the Free Basic Sanitation implementation strategy[76] (DWAF, 2008) as long as the environment and public health are protected to enable adaptation for local conditions.

The World Bank developed a system of sanitation classification for different technologies in the 1980s (Kalbermatten, et al, 1982), which is primarily based on whether or not excreta disposal is done on or off-site or both. The secondary classification is based on whether or not water is used to flush, i.e. wet or dry. However, as the majority of urban informal settlements, regardless of whether they are wet or dry systems, require off-site disposal due to hydrogeological conditions and population density, the classification hierarchy (Figure C.) recommended by the South African *Red Book* guidelines (CSIR, 2000) will be used in this thesis where the groups are:

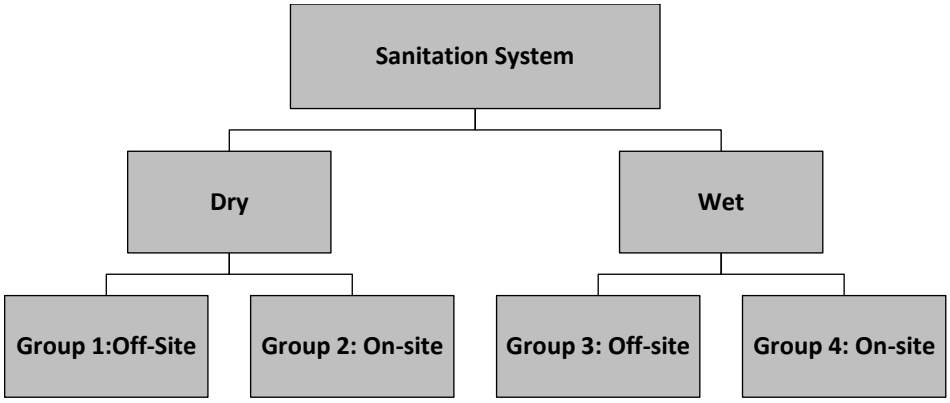


Figure C.1: Revised classification of sanitation systems using Red Book categories (CSIR, 2000; Graham, 2003; Pan, 2011)

- Group 1: No water added—conveyance to off-site facility
- Group 2: No water added—no conveyance
- Group 3: Water added— conveyance to off-site facility
- Group 4: Water added—no conveyance.

Some systems fall in between the groups, but they are categorised according to which group they best fit into and focus on the user interface and O&M requirements. For greater detail on a broader range of system configurations, technologies and how they function *The Compendium of Sanitation Systems and Technologies* (Tilley et al., 2014) is a useful

[76] The Free Basic Sanitation policy is discussed in Section 2.3.4.2 and relates to the provision of a 'basic level' of sanitation services for free to qualifying indigent households.

resource. Conveyance and treatment options are considered separately, and are included as different functional groups in Tilley et al. (2014).

C.2 Dry sanitation

In the Group 1 category of dry sanitation, there are a variety of options being used by South African municipalities. It should be noted, however, that some of these options do not meet basic sanitation criteria because they do not hygienically prevent human contact with faecal matter. Furthermore, anecdotally, some of them have been referred to as a 'glorified bucket system'[77], which has historically negative connotations and are associated with the apartheid-era; although the bucket system has the advantage of generally servicing only one household per bucket as opposed to other systems which are shared at a higher ratio. Essentially, these toilets are used to collect and store excreta until it is conveyed to a treatment facility off site. Some of the Group 1 options include container toilets and chemical toilets.

Figure C.2: Container and chemical toilet units (Pan 2011/2/8 and Pan 2010/10/19)

Container toilets are made from plastic and hold a volume of 100 litres. Ten litres of odour-inhibiting chemicals are poured into the container. The toilets are usually distributed at a ratio of one toilet to five households similar to other communal sanitation options like the chemical toilet. Liquid and solid excreta are not separated and drop directly into the container under the seat. Container toilets are the simplest form of sanitation, but are generally one of the least hygienic of all sanitation systems since users can still come in contact with excreta (Graham, 2003) and flies are a major problem, particularly during the summer (Pan, 2011).

Each container is replaced by a clean one, emptied and cleaned by contractors, notionally, thrice a week. The emptied containers are sometimes rinsed on-site, but are supposed to be disinfected at the wastewater treatment works (WWTW) (CCT, 2010). The

[77] See Glossary of terms for explanation.

waste is collected by a truck and brought to the WWTW. The collection typically takes place between once and thrice a week, but anecdotally, residents report that service quality varies widely and that containers are not always emptied according to schedule.

Chemical toilets are recommended only for temporary or emergency use within the *Red Book* (CSIR, 2000), a widely used South African infrastructure design guide book. Within the City of Cape Town and Johannesburg, however, since being introduced as an emergency public health solution, they have become a standard option for areas which cannot be serviced by any other means. They are usually rented from a contractor, and are mobile units which are easily relocated; therefore, they are often used as a way to quickly service an area and to improve the ratio of toilets to households. The toilets and exterior are prefabricated plastic units with a ventilation pipe included (Figure C.2, right). Excreta is stored in a small vault beneath the pedestal with a layer of chemicals (includes *inter alia*, formalin, an emulsifier, a coloured dye and fragrance, Graham, 2003) to prevent odours and to help with partial digestion of the excreta. The system typically uses either a dry flush mechanism or recirculation of chemicals to assist with cleaning the toilet pan; although most of the chemical toilets used in informal settlements do not include the flush mechanism. The holding vault needs to be emptied periodically, which can be done manually or with a vacuum tanker, and taken to a WWTW. Within the Cape Town context chemical toilets are targeted at a ratio of one toilet to five households and one toilet to seven households in Johannesburg. In Cape Town, toilets are supposed to be cleaned a minimum of three times per week by contractors, but as with the container toilets, service quality varies. Group 1 sanitation options are likely to be the least sustainable systems in terms of meeting environmental, social and health criteria; however, their advantage is that they are relatively robust, and are the easiest to implement. With respect to equity for different users, since they are generally pre-fabricated standardised units, there is little opportunity to include users in the design process or to cater to different needs.

Group 2 are dry on-site sanitation systems. One of the most commonly used systems in South Africa is the pit latrine, which includes a number of variations such as: ventilated improved pits (VIPs), double vaulted and lined pits. Since it is the most widely promoted, only the VIP will be described, but all variations function on the same basic principles (Figure C.3). VIPs were developed in the 1970's at the Blair Research Institute in Zimbabwe as a more hygienic pit latrine because there is ventilation to the toilet unit as well as a firm area for either sitting or squatting depending on whether or not a pedestal or squat pan is used. The units can be constructed entirely of locally sourced materials, but in South Africa it is more common to use commercial products for the vent and pedestal. Superstructures are also commercially available or can be made using local materials and labour (CSIR, 2000). A key component for the superstructure design is to try and keep it dark enough to prevent flies from exiting the pedestal or squat hole (Graham, 2003), but to still allow enough lighting for users' convenience. VIP latrines have a reinforced concrete slab with two holes placed over a pit. One hole is for depositing excreta and the other is for a vent that extends vertically beyond the roof of the structure. The vent is covered with a mesh at the top to act as a fly screen. Air passing across the vent creates a low pressure pocket. Air is drawn into the pedestal through the pit, and up and out the vent pipe (Graham, 2003). Ventilation helps

eliminate odours and discourages flies from entering. Detailed instructions on the design of VIPs are available in the publication *Building VIPs* by Bester and Austin (1997).

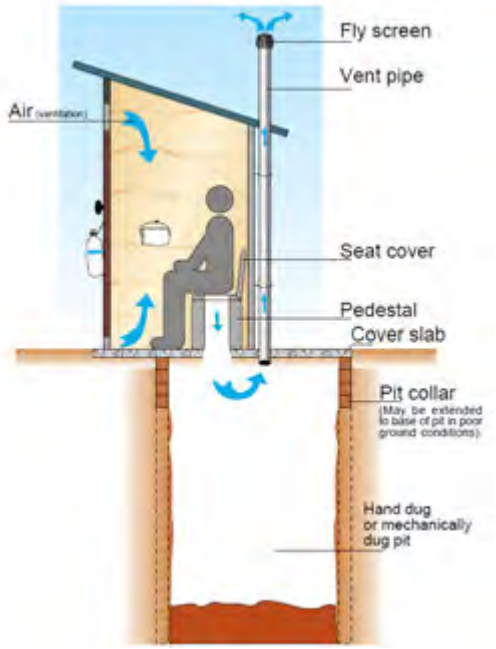


Figure C.3: VIP cross section
(DWAF, 2002c)

In the VIP, excreta drops directly into the pit as depicted in Figure C.3. The pit can be un-lined or lined. Solids accumulate in the pit and decompose anaerobically. Liquid percolates into the ground if the pit is unlined. Lined pits fill more quickly than unlined pits, thus requiring more frequent emptying (CSIR, 2000). However, in densely settled areas or areas with high groundwater tables such as in many parts of the Cape Flats in Cape Town, lining the pits for easier emptying and to stabilise walls with brickwork or other reinforcements is recommended. Lined pits are one of the sanitation options being utilised by the City of Cape Town (CCT) as of 2015. The pits serviced by the CCT are mechanically emptied on a monthly basis, but in some informal settlements some residents have constructed their own latrines which are not being emptied by the CCT. These latrines are usually unlined and dug manually and are not emptied but sealed off or abandoned when full.

Urine diversion (UD) toilets separate urine from faeces through a special pedestal. The toilet pedestals are placed over a vault or pit into which faeces, anal cleansing material, and bulking agents are dropped. The front of the pan has a dished cover with a small hole which diverts urine into a soakaway while faeces drop into the back of the pan into a vault below. Alternatively the urine can be collected in a container and used as an agricultural fertiliser (CSIR, 2000; Jönsson, 2001). Ash, wood shavings or other dry organic matter (bulking agents) need to be added to help absorb moisture and assist with the biological decomposition process if the urine diversion is combined with composting. The vaults are designed to be shallow and accessible because composting material needs to be mixed

manually or with a mechanical device. At least six months of storage is required for the urine to be used. The minimum period required for the faeces to be stored is longer. While the *Red Book* (CSIR, 2000) suggests that 6-12 months of storage may be sufficient, depending on the conditions in the 'dry box' (CSIR, 2000), research indicates that certain helminth eggs can survive for longer than one year depending on temperature and humidity conditions (Chong, 2003; Murray et al., 2005). Therefore, ideally faeces should be stored for longer than one year, and further treatment may be necessary if it is going to be used as compost.

Separating urine and faeces can make it easier to recycle nutrients if so desired given the different nutrient and pathogen loads in different waste streams. Additionally, diverting urine means that smaller vaults can be used for storing the solids since urine is diverted, and should make handling the faecal solids easier (Buckley et al., 2008). In EM, urine diversion is typically combined with a double vaulted pit latrine, and the solids can be removed manually or mechanically from the back of the vaults and buried or taken off-site for further treatment. Having two vaults means that the pedestal can be moved from one vault to the other when the first vault fills, allowing for less frequent emptying and for the faeces to be stored for the recommended period for safe handling. In CCT, urine diversion dehydration toilets have also been piloted in several settlements. Attempts have been made to combine urine diversion with composting, such as with the Mobisan pilot project[78] (Naranjo, 2009), but to date none of the UDDTs in CCT are functioning as composting toilets. Instead, urine and faecal waste are taken off-site for treatment.

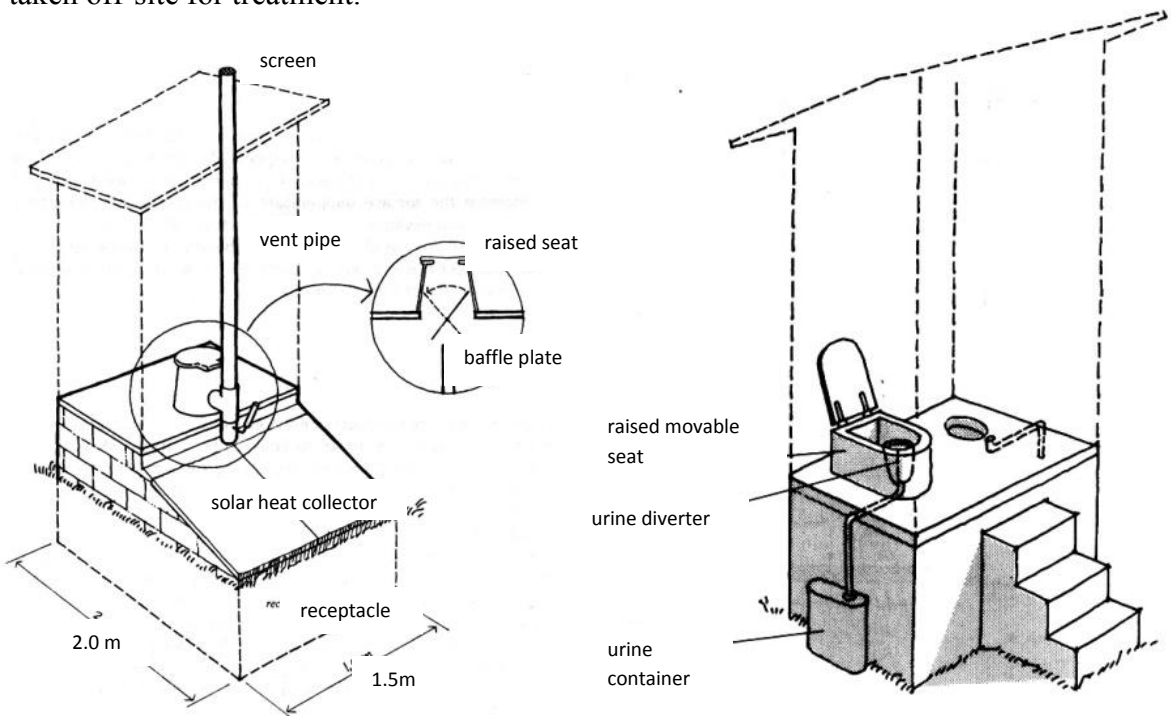


Figure C.4: On left toilet with double compartments for storage, and on right urine diversion pedestal with urine collection tank (Winblad and Kilama, 1985)

[78] The Mobisan is a communal dry sanitation facility that uses urine diversion pedestals. It was installed in Pook se Bos informal settlement and was intended to function as a composting facility, but the composting was unsuccessful.

Another lesser known dry sanitation option used in Cape Town municipality is a 'No Water Consumption-NOWAC' or 'anaerobic toilet[79]', which utilises anaerobic digestion to decompose waste. Toilets are built over 1000ℓ underground plastic tanks filled with water (DWAF, 2002). They do not require water for flushing but small volumes of water can be used to clean the toilet bowls. Units are designated on a one toilet to two household to toilet ratio. The tanks operate similarly to septic tanks with heavy solids settling at the bottom of the tank and partially decomposing while lighter particles float to the top forming a scum layer with an outlet to a soakaway. Some on-site treatment is provided in the anaerobic and aerobic chambers. The anaerobic chamber is accessible through a top hatch which is left above ground for inspection and emptying, and the toilet can be connected to a vent to release odours which extends vertically out the back of the enclosing structure.

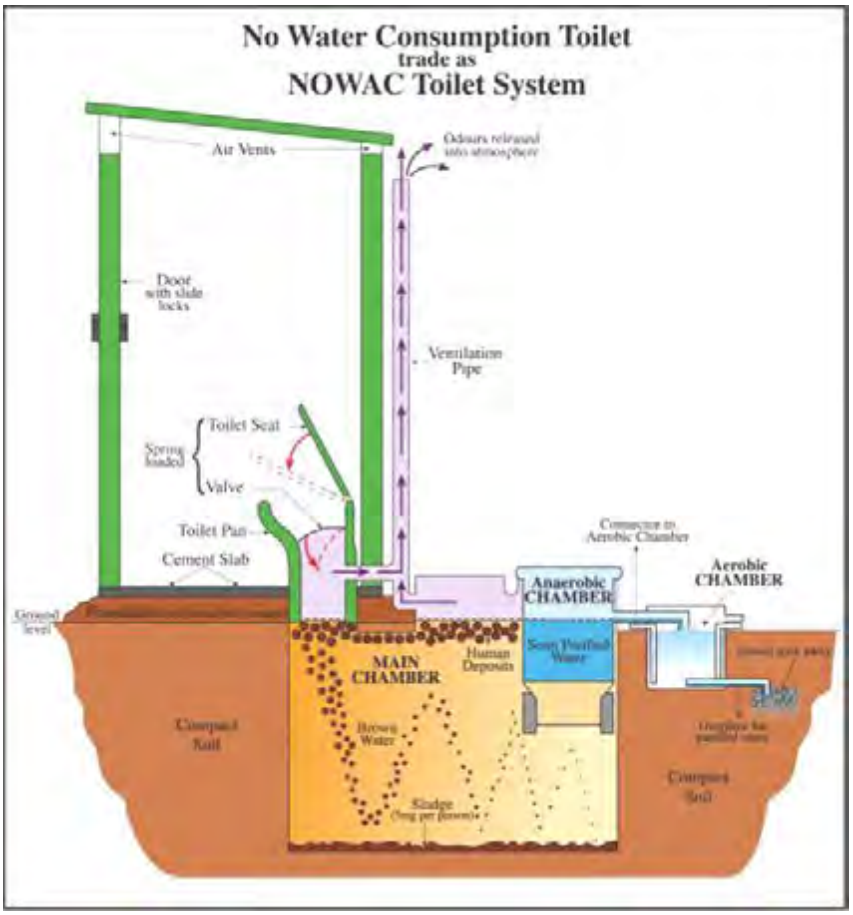


Figure C.5: Cross-section of anaerobic (NOWAC) toilet (DWAF, 2002)

Group 2 toilets, similar to Group 1, have the environmental advantage of not requiring water to convey wastes off-site, although it should be noted that even "on-site" systems in urban areas eventually require off-site treatment of waste given limited space for on-site burial or treatment systems. If well-designed, they potentially offer additional benefits such as the

[79] There were only 22 anaerobic toilets in Cape Town as of a 2013 survey commissioned by the WSISU. A pilot project was started in 2011 to test the use of anaerobic toilets for informal settlements, but due to several operational issues the pilot was not expanded.

potential for nutrient recycling on or off-site. Dry sanitation systems, however, are often not designed to handle large volumes of grey-water, which is a major issue in dense urban areas. There is also a health risk if people need to handle faecal matter on-site. In South Africa, there is also evidence that users often perceive dry sanitation systems as 'inferior, backward and unsuitable for modern urban areas' (Matsebe & Osman, 2012:10), which is a potential barrier to social acceptability that needs to be considered when planning sanitation projects in urban areas. There is also often a greater burden on households to manage dry sanitation systems than with wet sanitation systems, which should be considered as part of equity criteria when selecting a sanitation system.

C.3 Wet sanitation

Group 3 systems rely on water to convey waste to an off-site facility, which includes conventional waterborne sewer systems, i.e. flush toilets. Conventional flush toilets come in a variety of designs, but they all require an on-site water supply source as well as either a septic tank or sewered connection. Typically between 6-10ℓ of water are used per flush with a standard cistern and bowl (CSIR, 2000), but lower-volume flush mechanisms can reduce the water demand, e.g. newer toilets have dual or multi-flush mechanisms which can reduce the volume of water used per flush to for the half-flush to ~3ℓ (Hauenstein et al., 2013). Waste is conveyed with water to either a septic tank, conservancy tank (Group 4 configuration) or into sewer lines. Conventional flush toilets are generally perceived as the highest level of service by residents and on the conventional technology-based sanitation ladder (see Chapter 4 case study discussions on level of service), but capital costs can be prohibitive. Additionally, in a water-scarce country like South Africa, there are also environmental resource management issues that should factor into deciding whether waterborne systems are appropriate sanitation technologies, and design modification such as using non-potable water for flushing should be considered.

Many different types of sewage systems exist; each has advantages and disadvantages. Mara provides a detailed description of alternatives to conventional gravity sewer systems focusing on low-cost alternatives in *Low-cost Sewerage* (1996). Ashipala and Armitage (2010) describe some of the impediments to alternative sewerage in South African informal settlements in greater detail. Given the variety of texts available, only a brief overview of the various alternatives employed in South Africa and how the systems function will be described.

Shallow or simplified sewerage, like conventional sewerage, operates using gravity to transport waste, but with modified design standards. Simplified sewerage was developed in the 1980s to provide a lower-cost waterborne sanitation service to densely populated urban and peri-urban settlements in Brazil (Mara, 1998). Simplified sewerage is considered to be most appropriate in 'high-density, low-income housing areas which have an on-plot level of water-supply and no space for on-site sanitation pits or for solids interceptor tanks of settled sewerage' (Mara, 1998). From a technical standpoint, the main differences between shallow and conventional sewerage is that the pipe network relies on narrower pipes, the layout

differs (as shown in Figure C.), and can be laid using shallower gradients reducing the overall cost of the system. The network can be laid with smaller diameter pipes (50-100mm) than conventional sewer systems (Mara, 1996), which can be laid under pedestrian areas on either side of the road as opposed to the middle of the road (Figure C.). Construction and excavation costs can be reduced by using shallower gradients (1:167-255, instead of 1:150), and simplified manholes or inspection chambers rather than conventional manholes (Mara, 1996; Graham, 2003).

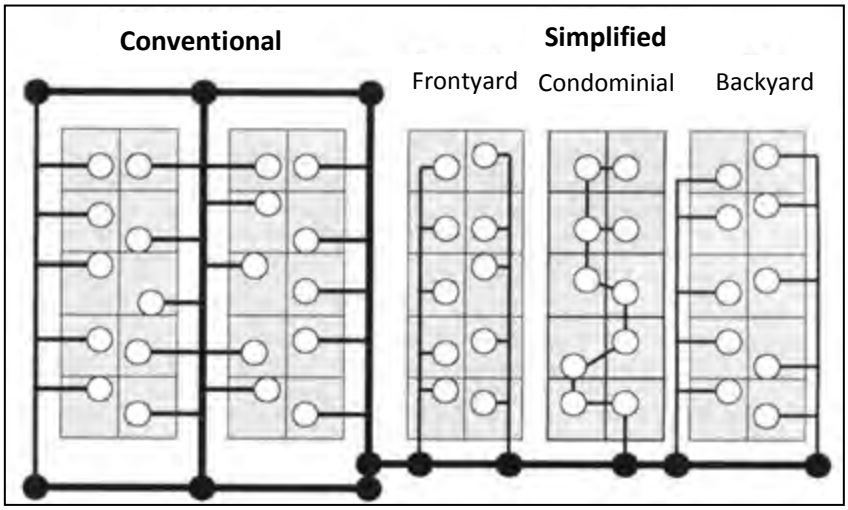


Figure C.6: Comparison of pipe layout for conventional and simplified sewers (CAESB, 1999)

From an institutional standpoint, a major component of implementing simplified sewerage involves community engagement and partnerships between municipal authorities and residents who take on greater responsibility for operation and maintenance than with conventional systems because household connections are interlinked before connecting to the main sewer (Mara, 1998; Graham, 2003). Household blockages affect upstream households and need to be dealt with immediately by the household assigned to the affected pipe section, which is especially important using a condominial layout; whereas with conventional systems, blockages may not be detected until they reach the main sewer, at which point municipal authorities are expected to take responsibility for unblocking the sewer line[80].

In the eThekwini municipality of South Africa, two simplified sewer systems were installed in low-income residential areas, but were replaced by conventional sewerage due to communication break-downs between different stakeholders, and social and political resistance linking sanitation to failed housing developments in the area (Eslick & Harrison, 2004). While the lack of success with this pilot project does not rule out shallow sewerage for low-income areas in South Africa, it does indicate some of the hazards of direct technology transfer from one country to another. Additionally, the unsuccessful simplified sewerage pilot

[80] Shallow sewerage does not need to follow the condominial system. It can also be operated with municipal utility departments taking responsibility for managing sewer line blockages, as with the conventional system.

project indicates the need to address institutional and socio-political barriers before implementing alternative sanitation technologies.

Settled sewerage is another alternative to a conventional waterborne offsite sanitation sewer system. The first settled (small bore) sewage systems were designed and installed in Zambia in the 1960s. Settled sewerage, similar to conventional and simplified sewerage, also relies on gravity to convey wastewater to WWTP via a reticulated network. The difference is that wastewater goes through an interceptor tank before connecting to the main sewer line. The original Zambian systems made use of aqua-privy tanks (see CSIR, 2000:10.11) which were drained by sewers with a 100mm minimum diameter that were designed to flow partially full reaching a minimum daily peak self-cleansing velocity of 0.3m/s (Otis and Mara, 1985).

Settled sewerage is usually considered as a service upgrade to areas with existing septic tanks given that the interceptor tanks used for settling solids are often essentially septic tanks, which have been modified to connect to sewer lines. The main purpose for including the interceptor tank is to allow large, i.e. settleable solids, to settle in the tank before entering the sewer pipes while floatable solids float to the top. The majority of effluent is liquid drawn from the middle of the tank, which allows for the use of smaller diameter pipes, similar to shallow sewerage. More flexibility in pipe layout and fewer manholes are also advantages of settled sewerage. Pipes do not require a uniform gradient with straight alignment between manholes. An inflective gradient, i.e. some dips allowed so that sewer is full under static conditions, and curves to avoid obstacles are permissible (Otis & Mara, 1985), which is not possible with conventional gravity sewers. The main disadvantage, however is that an interceptor tank is required before connecting to the sewer, which can incur a high capital cost, and the tank needs to be desludged periodically. One of the major implementation concerns in informal settlements is that of illegal connections to the sewer without first going through an interceptor tank, which would likely result in sewer blockages. To date, the only documented settled sewers in South Africa are in formalised suburbs, *e.g.* Hermanus (a resort town), although CCT officials have expressed interest in piloting a settled sewerage project in informal settlements where conditions allow for sewerage (CCT, 2014c).

Vacuum sewerage is a third alternative sewage system that was tested in one informal settlement in Cape Town, albeit unsuccessfully. Vacuum sewerage is not a new technology globally, but it is relatively new in South Africa and has not been widely used. Unlike the previous sewer systems described, which rely mainly on gravity to transport wastewater, vacuum sewerage uses differential air pressure to propel sewage through the main sewer network (USEPA, 1991). Vacuum sewage systems are not considered a 'low-cost' alternative to conventional gravity sewers, but are considered more cost effective than other sewered systems under certain conditions, such as unstable or rocky soil, a high water table, a flat terrain or restricted construction conditions (Water Environment Federation, 2007), which were all reasons for selecting vacuum sewerage in Kosovo informal settlement in the Phillippi suburb of Cape Town.

Vacuum sewer systems consist of three major components: the collection chamber (consisting of a sump, vacuum valve, and a sensor unit), the collection mains, and a centrally

located vacuum station (which houses the vacuum pumps, vacuum vessels and discharge pumps) (USEPA, 1991). A conventional gravity line carries wastewater from the property or group of properties to the service where the wastewater temporarily accumulates at the bottom of the sump. When a predetermined volume of sewage has accumulated in the sump, the pneumatically driven sensor unit triggers the opening of the vacuum valve, which is normally closed. The vacuum interface valve is usually closed to maintain a seal between the sump which is open to the atmosphere and the collection main which is under negative pressure.

Vacuum sewerage, however, because of its reliance on maintaining a negative pressure compared to atmospheric pressure is vulnerable to failure if there is a vacuum loss in the sewer mains, which can be caused by damages in the sewer line, sump overflows (Figure C.), pump station failure, excessive sewer surge flows, etc.

Figure C.7: Overflowing sump in Kosovo requiring the collection chamber to be desludged (Taing, 2010)

The system in Kosovo informal settlement was installed with expensive monitoring equipment to ensure that adequate pressures are maintained and centralised management, but CCT employees were not trained how to operate and maintain the system, which failed shortly after commissioning. Attempts were made to revive the vacuum sewage system with assistance from the contractors who installed the system, but eventually the vacuum system was abandoned. In an informal environment where toilets are shared amongst high numbers of people resulting in higher than estimated peak flows, and users who may use bulky anal cleansing material and/or tamper with some of the mechanical components, vacuum sewage systems are easily disrupted and may fail without adequate management as occurred in this case (Taing et al., 2011).

Communal ablution blocks (CABs) have been installed in CCT, CJ and EM as a sanitation service that is shared between large numbers of users (50+ households), with the

number of households sharing varying by settlement. They are typically waterborne facilities which include hand washing and laundry washing facilities, as well asshowers in some cases. Janitorial services are provided by the municipality to assist with toilet paper distribution and cleaning. The facility design varies by site, e.g. some are in shipping containers while others have brick and mortar top structures (Figure C.8). Not all CABs are connected to the sewage system, but the majority of CABs reviewed were connected to the sewage system rather than septic or conservancy tanks.

Figure C.8: CAB facilities in Parkington Grove in eThekwini Municipality (Pan 2015/5/20)

Portable flush toilets (PFTs) or caravan toilets, i.e. porta potties, are portable container toilets. They are container based systems, but use water for flushing, and therefore can be considered a form of “wet” sanitation. The upper portion of the toilet contains a small water tank (15 litres) and flush mechanism while the lower tank (21 litres) is used for storing waste (Figure C.).

Figure C.9: Porta potti toilet (Zille, 2013)

The units are serviced on a weekly basis by a contractor who swaps the full lower tank for a clean empty tank and brings the full tank to the wastewater treatment plant for cleaning in CCT. Porta potties are being used in CCT in dense settlements, which are still using the bucket system (Zille, 2013), difficult to service with other forms of sanitation systems or to supplement the number of toilets available in a particular area when the ratio of households to toilets is too high, and to assist women, children and the elderly (upon request) to avoid the need for nocturnal visits to communal facilities (Gangatele, 2013, pers. comm., 16 May). While porta potties allow individual households to each have their own toilet, similar to chemical and container toilets, they can become malodorous when full, are relatively small in size in comparison to conventional toilets making it difficult for larger individuals to use, and are not designed for use as a permanent sanitation service.

Group 3 sanitation systems are generally considered to have the highest capital costs, but may have lower operational costs than dry sanitation systems which require waste to be transported to off-site facilities for treatment. The use of potable water for conveyance, however, is a significant environmental disadvantage. In the case of porta potties, wastewater stored in the portable tanks needs to be transported by truck to the WWTW, which also has an environmental cost. In terms of user convenience, they are likely to be considered the most convenient given that the majority of management responsibilities will fall on the municipality in the South African context, and anecdotally waterborne systems are considered to be the most prestigious.

Group 4, on-site waterborne sanitation has also been used in urban informal settlements. The main system configuration has been either a conventional flush toilet or pour flush toilet linked to a conservancy or septic tank[81]. Pour flush toilets do not have cisterns for water storage thus water has to be poured in manually to clean the bowl and flush contents into the conservancy tank, and greywater collected from hand washing or laundry can be used for flushing. A water seal is maintained in the pour flush bowl preventing odours from the conservancy tank from rising. Pour flush toilets are designed to utilise less water for flushing than conventional flush toilets, typically 1-3ℓ per flush as compared to 6-10ℓ for conventional flush toilets (CSIR, 2000; Graham, 2003); in addition, greywater can be used instead of potable water for flushing. While two litres are adequate to flush urine out of the bowl, cleaning the bowl after defecation may require more water to flush, which can become a cumbersome task if users need to transport water from remote communal standpipes to the toilet, particularly for the disabled, elderly or children (Figure C.10).

A pilot study of pour flush toilets installed in three informal settlements conducted in the Western Cape indicated that the toilets were working well during the first three months of monitoring with few reported blockages and lower capital installation costs than a full waterborne system, partially due to the design which avoided inspection chambers and only included rodding eyes at bends to prevent disposal of unwanted waste such as food scraps into the system (Maluti, 2013). Using greywater for flushing provides an environmental benefit by reducing the use of potable water, but the potential health risks of handling

[81] Portable flush toilets (porta potties) introduced in Cape Town are notionally considered a form of on-site waterborne sanitation, although the contents need to be emptied weekly off-site.

greywater, social acceptability, and the need to redesign toilets that are pour flush and use greywater also need further research before trying to implement them on a large-scale in informal settlements. With regards to selecting a sanitation technology, several decision-making support tools exist, and can be used to assess the suitability of a particular technology for the context of informal settlements (Appendix G).

Figure C.10: Young boy pouring water into a pour flush toilet (Pan, 2011)

D. Stages of service delivery and responsibilities and risks for different stakeholders

Table D.1a: Stages of service delivery and various responsibilities and risks (after Taing et al., 2013)

Stage of service delivery	Stakeholders	Responsibilities	Risks
Needs assessment	Users	Identify relevant stakeholders within targeted beneficiary group	Divergent interests
	NGOs/CBOs	Agree on responsibilities, particularly for who will coordinate and manage overall	False information provided to achieve aims
	Municipal & ward authorities	Identify boundaries of the project, including physical boundaries of area to be serviced	Lack of willingness to participate
	Social facilitator	Identify problem areas around sanitation	Lack of trust between different stakeholders undermining collaboration
	Project support	Form a steering committee and sub-committees as needed	
		Gather information on socio-political, technical, cultural, environmental and economic constraints	
		Map the area	

Table D.1a: Stages of service delivery and various responsibilities and risks (after Taing et al., 2013)

Stage of service delivery	Stakeholders	Responsibilities	Risks
Conceptual Design	Users	Prioritise problems, particularly around sanitation issues	Risk of failure of sanitation problems are not identified as a high priority by users
	NGOs/CBOs	Conduct feasibility assessments of key stakeholders' (users, municipal authorities) abilities and willingness to contribute time and money	Political interference, *e.g*. refusal to consider non-sewered options
	Municipal & ward authorities	Brainstorm ideas for solutions	Feasible options do not meet users' expectations
	Social facilitator	Identify feasible sanitation options given both technical and non-technical constraints	
	Project support	Select feasible design	O&M is not accounted for in design or action plan
	Steering committee	Gather necessary information to complete design	Users' preferences/needs may be marginalised given tendency to use standardised design guidelines/pre-fabricated units
	Consultants	Finalise technical design: including drawings, schematics, budget , consider existing service arrangements and infrastructure	Prolonged process because of conflicts and lack of capacity can lead to stakeholders losing interest

Table D.1c: Stages of service delivery and various responsibilities and risks (after Taing et al., 2013)

Stage of service delivery	Stakeholders	Responsibilities	Risks
Design and action planning	Users	Prepare an action plan for implementation	
	NGOs/CBOs	Develop tasks	
	Municipal & ward authorities		
	Social facilitator		
	Project support	Assign roles and responsibilities -- pay special attention to O&M responsibilities	
	Steering committee	Develop a project timeline	
	Consultants		

Stage of service delivery	Stakeholders	Responsibilities	Risks
	Project manager		
Implementation	Users	Procure supplies and financing	Dissatisfaction with labour selection, e.g. users unhappy with community-liaison officer selected
	NGOs/CBOs	Prepare site and get required legal approval	Labour disputes
	Municipal & ward authorities	Technical training and education as required -- discuss employment and capacity building opportunities	Inadequate supervision resulting in poor construction
	Social facilitator	Construction	Unforeseen project delays, *e.g.* inclement weather, theft or vandalism of construction materials, resulting in project cost increases
	Project support	Monitor progress	Corruption in allocation of tenders
	Steering committee	Commissioning facilities	
	Consultants/ Contractors		
	Project manager		
O&M	Users	Daily operation of the system	O&M responsibilities neglected and facilities deterioriate
	NGOs/CBOs	Routine and unexpected maintenance	Lack of adequate budget for O&M resulting in delayed repairs or lack of equipment
	Municipal & ward authorities	Adaptive management	System capacity is exceeded if number of

Stage of service delivery	Stakeholders	Responsibilities	Risks
			users grows at unexpected rate
	Contractors	Continued training and education	
M&E	Users	Monitoring health and environmental indicators	Lack of budget for M&E
	NGOs/CBOs	Evaluation and measurement of project objectives	Information is not collected or shared
	Municipal and ward authorities		Recommendations are ignored
			Changes are needed but cannot be made due to inflexible institutional arrangements or technical constraints

E. Draft water and sanitation Key Performance Indicators for local government

Table E.1: Proposed water and sanitation indicators from COGTA (2014)

Local Government KPA	National/ Provincial Indicators	Municipal Indicators	Minimum Performance Standards	Legislation	Linkage to Outcomes
KPA: Service Delivery and Infrastructure Development	Number of households with access to basic Water Supply by target date	• Approved water master plan by target date	• Develop/ review water master plan • Pump station reservoirs treatment works • Maintenance and development of new Boreholes • 25 per Capita per day per household • % of water losses • Water reserve should be 48 hours • Duration of water interruptions should be resolved within 73 hours	• National Water Act, No 36 of 1998 • Water Services Act, No 108 of 1997	
		• % improvement on blue drop status by target date	• Compliance to the 27 activities of the Blue drop status. • Duration of water interruptions should be resolved within 48hrs		

Local Government KPA	National/ Provincial Indicators	Municipal Indicators	Minimum Performance Standards	Legislation	Linkage to Outcomes
		Number of water service points installed for informal settlement dwellings within a 200m radius by target date	• Improved water service points installed for informal settlement dwellers within a 200m radius e.g. standpipes, water tanks		
		Number of additional households provided with water connections by target date	Additional recipients (RDP) from the original connections of water supply system, with access to potable, piped water		
		% reduction in water backlog by target date % access to water by target date	• Consumers without access to safe drinking water		
	Number of households with access to basic sanitation service by target date	• Approved sanitation master plan by target date	• Develop/ review sanitation master plans Operation and maintenance plan developed and implemented		
		• Number of formal domestic customers receiving sewerage services by target	• Registered customers who have access to removal of waste water and refuse by means of sewers		
		• Number of sanitation service points	• Acceptable dry sanitation system points		

Local Government KPA	National/ Provincial Indicators	Municipal Indicators	Minimum Performance Standards	Legislation	Linkage to Outcomes
		(toilet) installed for informal settlements dwellings	installed for informal settlement dwellers		
		Number of additional households (RDP) provided with sewerage connections	• Additional recipients (RDP) from the original connections with access to removal of waste water and refuse by means of sewers		
		• % reduction in sanitation backlog by target date	• Consumers who have no access to basic sanitation		
		• % improvement in Green drop status			

F. Minister of Water and Sanitation's budget speech (21-May-2015)

The Department of Water and Sanitation presents today a total budget of **R16 446 530 000 – 00** (16 billion, four-hundred and forty-six million, five-hundred and thirty-thousand Rand). The breakdown of this budget per programme/branch is as follows:

- **Programme 1: Administration: R1 526 167 000 - 00** (One billion five-hundred and twenty-six million one hundred and sixty-seven thousand Rand)
- **Programme 2: Water Planning and Information Management: R808 655 000 – 00** (Eight-hundred and eight million six-hundred and fifty-five million Rand). Examples are feasibility study for uMkhomazi project and the Lusikisiki surface and ground water study
- **Programme 3: Water Infrastructure Development: R12 435 787** (Twelve billion four-hundred and thirty-five million rand, seven-hundred and eighty-seven thousand Rand): Examples are Mzimvubu, Clanwilliam, Hazelmere, Tzaneen/Nwamitwa, , Vaal Gamagara, Gariep Augmentation, and the Olifants bulk distribution system
- **Programme 4: Water and Sanitation Services: R1 444 582** (One billion four-hundred and forty-four million, five-hundred and eighty-two million Rand) Examples are rain water harvesting and support to Resource-Poor farmers
- **Programme 5: Water Sector Regulations: R231 339 000 – 00** (Two-hundred and thirty-one million three-hundred and thirty-nine thousand Rand) Examples are establishment of catchment management agencies and support to water institutions such as water boards
- On the other hand, understanding that the municipalities are at the coal face of service delivery, we will continue to support the local government through the Water Services Infrastructure programmes of:
- Municipal Water Infrastructure Grant to the tune of **R2 595 661 000 -00** (Two billion five-hundred and ninety-five million six-hundred and sixty-one thousand rand)
- Accelerated Community Infrastructure Programme to the amount of **R253 757 000 - 00** (Two-hundred and fifty-three million seven-hundred and fifty-seven thousand rand)
- Regional Bulk Infrastructure Programme has been allocated **R6 014 764 000 - 00** (Six billion and fourteen million seven-hundred and sixty-four thousand rand): 27 priority District Municipalities as well as strategic projects (e.g Sebokeng, Pilanesburg, Bushbuckridge, Sysferfontein, Lion's Park)
- Water Services Operating Subsidy has an amount of **R611 227 000 – 00** (Six-hundred and eleven million two-hundred and twenty-seven thousand rand)
- Water Services Projects to the tune of **R209 377 000 – 00** (Two-hundred and nine million three-hundred and seventy-seven thousand rand). (PMG, 2015b)

G. WASH related decision-making support tools

G.1 Decision-making support tools

There are a myriad of sanitation technologies available for the sanitation treatment train, from collection and conveyance through to treatment for reuse and/or disposal, which when combined make up a sanitation system. As noted by Palaniappan et al. (2008), however, most sanitation practitioners working in underserved communities and end-users are not familiar with the range of water, sanitation and hygiene (WASH) solutions available. Decision-making support tools can assist, not replace, practitioners 'in selecting among various technologies and approaches as they implement [WASH] projects' (Palaniappan et al., 2008:4). These tools are helpful for comparing and contrasting advantages and disadvantages of different technologies and approaches, which can also contribute towards improved sustainability and equity during the planning stages of a sanitation project or programme if a wide range of factors such as social, financial, and environmental impacts are included in the tool. Palaniappan et al. (2008) identified five types of support resources: evaluation tools, process guides and documents, technical briefs, technical references and policy papers. A sample of various decision-making support tools that are available is presented in Table G.1a:

Table G.1a: Sample of decision-making support tools

Summary	**SANEX™ (Loetscher & Keller, 2002)**	**DWAF Guide (Holden & Swanepoel, 2004)**	**Tilley et al. Compendium(Tilley et al., 2008 ; 2014)**	**CLARA (Restoy et al., 2014)**	**WASH Technology Assessment Framework (Olschewski, 2013)**	**Sanitation Technology Assessment Framework (DST & WRC, 2016)**
Description	Computer based multi-criteria model used to compare alternative sanitation technologies based on indices for 'implement-ability' and 'sustain-ability'	Guideline for municipal-ities and service providers as an introduction to a range of water supply and sanitation solutions, and appropriate-ness for different situations	A compilation reference that describes various sanitation systems and technologies which are categorised into functional groups	Computer-based "pre-planning" stage tool to compare costs of various water and sanitation options based on net present value	A four-step participatory assessment framework for a single WASH technology or system and its application in a specific context	A sanitation assessment protocol aimed at providing tools for a scientific assessment of household sanitation technologies for the purpose of selecting an appropriate technology for a specific context.

Table G.1b: Sample of decision-making support tools

Summary	**SANEX™ (Loetscher & Keller, 2002)**	**DWAF Guide (Holden & Swanepoel, 2004)**	**Tilley et al. Compendium(Tilley et al., 2008 ; 2014)**	**CLARA (Restoy et al., 2014)**	**WASH Technology Assessment Framework (Olschewski, 2013)**	**Sanitation Technology Assessment Framework (DST & WRC, 2016)**
Type	Evaluation tool in form of computer software programme	Process guide & technical brief	Technical reference	Evaluation tool in form of computer software programme	Evaluation tool	Process guide, evaluation tool, technical brief
Sustainability considerations	Sustain-ability criteria are built into the model algorithm based on the willingness of community to be involved/pay, ability to meet community needs, and O&M management ability	A Sustain-ability indexing toolkit for assessing rural water & sanitation schemes is linked	Not explicitly discussed but designed as reference to assist with choosing a technically and economically appropriate system	Not explicitly considered beyond financial cost implications. Assumed in the framework that all systems which meet legal requirements already consider social, health and environment-al aspects	Built into the assessment framework using six dimensions: social, economic, environmental, institutional & legal, skills & knowhow & the technical dimension	Within the functionality and suitability assessment stages, some criteria address dimensions of sustainability, *e.g.* life cycle cost consideration, technical suitability, environmental impact, social acceptability
Equity considerations	Not explicitly mentioned, but addressed as part of feasibility criteria	Not included	Not included	Not included	Not explicitly included, but incorporates perspectives of different stakeholders	Not explicitly included, but mentioned as part of acceptability consideration
Case studies	Bolivia, Costa Rica, Ghana, Indonesia, Kenya, Mozambique, Tanzania	Focused on South Africa	Used internation-ally	Country-specific versions developed for Burkina Faso, Ethiopia, Kenya, Morocco, South Africa	Burkina Faso, Ghana, Uganda	Focused on technologies used in South Africa

Most of the decision-making support tools shown in Table G.1a compare different types of sanitation systems, with the exception of the WASH Technology Assessment Framework, which focuses on the assessment of a single technology or system. While sustainability criteria were included in three of the five tools reviewed, social equity considerations were not explicitly considered in any of the tools, which points to a gap in the formulation of decision-support tools. An encouraging development, however, in recently developed tools such as the Wash Technology Assessment Framework is the acknowledgment of the need to incorporate the perspectives of different stakeholders as shown in Table G.2 (Olschewski, 2013).

Table G.2: 18 TAF indicators (Olschewski, 2013)

Perspective / Sustainability Dimension	User / buyer	Producer / provider	Regulator investor facilitator
Social	(1) Demand for the technology	(2) Need for promotion and market research	(3) Need for behavioural change and social marketing
Economic	(4) Affordability	(5) Profitability	(6) Supportive Financial Mechanisms
Environmental	(7) Potential for benefits or negative impacts for user	(8) Potential for local production of product or spares	(9) Potential for negative impacts or benefits for natural resources on a larger scale
Legal, institutional, organisational	(10) Legal structures for management of technology and accountability	(11) Legal regulation and requirements for registration of producers	(12) Alignment with national strategies and validation procedures
Skill and knowledge	(13) Skill set of user or operator to manage technology including O&M	(14) Level of technical and business skills needed	(15) Sector capacity for validation, introduction of technologies and follow up
Technological	(16) Reliability of technology and user satisfaction	(17) Viable supply chains for product, spares and services	(18) Support mechanisms for upscaling technology

G.2 Expansion of Olschewski Technology Assessment Framework with Equity Dimensions

In Olschewski's original Technology Assessment Framework, some dimensions of equity were not addressed which are important to consider in relation to the sustainability of the technology under evaluation. The Diepsloot pilot recycled wastewater CAB project was used

as an example for how the technology and the management model using caretakers and contractors could be assessed according to sustainability and equity criteria to determine whether or not the pilot should be expanded to other informal settlements.

The spatial scale was confined to the catchment area around the CAB facility. The Technology Assessment Framework developed by Olschewski (2013) was selected as an appropriate tool for assessment. The primary stakeholder involved was the water service provider, Johannesburg Water (Figure 4.1), which providers water and sanitation services on behalf of CJ (the WSA), although CJ as the regulator could have been more involved. The temporal scale for assessment should ideally go beyond the length of the project, i.e. greater than one year, and potentially follow at minimum lower range of the medium-term planning time frame of five years (Figure 4.2), although at present the system has only been operating for just over a year. After determining the scale at which to perform the assessment, context-appropriate assessment criteria were selected and data was collected from Johannesburg Water (WSP), the contractor who designed and is managing the facility for the pilot period and from a field visit to meet with janitorial staff (users) conducted by the author. N.B. Ideally, there would have been more time to conduct the assessment collaboratively with identified stakeholders.

For the Diepsloot pilot project, the perspectives of users, service providers and regulators are considered with an example of sustainability and equity criteria shown in Table G.3 related to the assessment of the technology and management arrangement:

Table G.3: Sustainability criteria for Diepsloot pilot project (modified from Olschewski, 2013)

Sustainability and equity criteria	Regulator	Service provider/ Contractors	Users
Sustainability			
Environmental	(S1) Potential impact on natural resources and energy consumption	(S2) Potential for valuable resource recovery or energy production	(S3) Potential for benefits or protection from negative impacts
Economic	(S4) Availability of sufficient funding	(S5) Profitability	(S6) Willingness to pay*
Technical	(S7) Support mechanisms for upscaling technology	(S8) Viable supply chains for product, spares and services	(S9) Reliability of technology and robustness for communal use
Socio-cultural	(S10) Need to promote behavioural change and social marketing	(S11) Need for promotion and marketing of service and product	(S12) User satisfaction and acceptance
Health and hygiene	(S13) Monitoring of health and hygiene programme	(S14) Inclusion of health and hygiene promotion and facilities for handwashing	(S15) Awareness of health and hygiene and adherence to practice
Institutional	(S16) Alignment with national strategies and regulations	(S17) Meeting legal and contractual requirements	(S18) Proactive involvement with O&M and M&E

Table G.4: Equity criteria for Diepsloot pilot project

Equity			
Perspectives	(E1) Meets required minimum health and environmental safety standards for all user groups	(E2) Meets demands of regulators and users	(E3) Meets notions of dignity
Resource allocation	(E4) Funds are distributed according to greatest need	(E5) Workers are paid adequately	(E6) Jobs are created for local people
Access	(E7) Meeting minimum ratios of facilities to users and walking distance does not exceed 150m	(E8) Facilities are open 24/7	(E9) Safe and convenient for all users including vulnerable groups

*Currently, residents in informal settlements do not pay for water or sanitation services, but if service levels are increased or policies changed, willingness to pay surveys are useful to gauge demand when planning a service.

18 sustainability indicators and 9 equity indicators were selected as an example of assessment criteria tailored to the pilot project, which is testing out a janitorial service for a wastewater recycling CAB facility in an informal settlement in Diepsloot, Johannesburg. A 'traffic light' system as proposed in the Technology Assessment Framework (TAF) (Appendix C) was applied with values ranging from a positive or supportive impact (green), potential impact and needs follow-up (yellow), negative or hindering impact (red), and unclear impact or more information needed (black) as shown in Table G.5.

Table G.5: Traffic light symbols and values for assessment (after Olschewski, 2013)

+	Positive or supportive impact
0	Potential impact that needs follow-up
-	Negative or hindering impact
?	Unclear impact or more information needed

The sustainability and equity assessment is based on a combination of qualitative and quantitative criteria, which was sent to research participants in the regulator category for verification given their primary responsibility for monitoring services. In terms of the sustainability criteria 7 indicators were assessed as positive or supportive indicators (green), 4 could have a potentially negative impact without follow-up in the future (yellow), 3 have a

negative or hindering impact on sustainability (red), and 4 require more information (black). The category which the pilot project scores best in with regards to sustainability is environmental sustainability for regulators and users. The category it scores the lowest in is with respect to health and hygiene, which may be because health and hygiene promotion was not a primary aim of the pilot testing. Three sustainability criteria for concern (red) are (S7) given the lack of clear support mechanisms for upscaling the technology from a regulatory perspective, (S13) a lack of clear monitoring for health and hygiene promotion and (S18) users (excluding paid janitorial staff) are not actively involved with O&M or M&E of the service, which sets a precedent for users not to take responsibility for services.

For the equity criteria, there was one criterion that scored green, (E6), for jobs that were created through the project locally, through two janitorial positions and two security guard positions. There were four criteria that were assessed as yellow, one red, and three black. The four yellow criteria did not appear to be hindering operations as of 2015, but could become issues once the management contract expires (August 2016). The red assessment for E8 was due to the observation that facilities are not open 24 hours a day, 7 days a week although that was part of the initial pilot plan. Three criteria (E2), (E4) and (E7) could not be assessed with available data.

Table G.6a: Sustainability and equity assessment results for Diepsloot Pilot Project

Sustainability and equity criteria	Regulator	Service Provider/ Contractor	Users
Sustainability			
Environmental	(S1) Potential impact on natural resources and energy consumption	(S2) Potential for valuable resource recovery or energy production	(S3) Potential for benefits or protection from negative impacts
Economic	(S4) Availability of sufficient funding	(S5) Profitability	(S6) Willingness to pay
Technical	(S7) Support mechanisms for upscaling technology	(S8) Viable supply chains for product, spares and services	(S9) Reliability of technology and robustness for communal use
Socio-cultural	(S10) Need to promote behavioural change and social marketing	(S11) Need for promotion and marketing of service and product	(S12) User satisfaction and acceptance
Health and hygiene	(S13) Monitoring of health and hygiene programme	(S14) Inclusion of health and hygiene promotion and facilities for hand-washing	(S15) Awareness of health and hygiene and adherence to practice
Institutional	(S16) Alignment with national strategies and regulations	(S17) Meeting legal and contractual requirements	(S18) Proactive involvement with O&M and M&E

Table G.6b: Sustainability and equity assessment results for Diepsloot Pilot Project

Equity			
Perceptions	(E1) Meets required minimum health and environmental safety standards for all user groups	(E2) Meets demands of regulators and users	(E3) Meets notions of dignity
Resource allocation	(E4) Funds are distributed according to greatest need	(E5) Workers are paid adequately	(E6) Jobs are created for local people
Access	(E7) Meeting minimum ratios of facilities to users and walking distance does not exceed 150m	(E8) Facilities are open 24/7	(E9) Safe and convenient for all users including vulnerable groups

Overall the Diepsloot pilot recycled wastewater CAB facility with janitors performed better in terms of meeting sustainability criteria than equity criteria with 7 of 18 criteria scoring green for sustainability and only 1 of 9 criteria scoring green for equity. For sustainability, the two categories that scored the strongest were environmental and institutional with health and hygiene requiring more information and better monitoring. The equity of the system is unclear with the major benefit to users being potential jobs, but the numbers of jobs created locally were limited to janitorial or security services at the time of writing, which are relatively low-wage positions.

Given that this is the first year of operation for the pilot facility, and the management contract runs until August 2016, a follow-up assessment should be performed in another year. The most critical areas that need attention are (S7), (S13), (S18) and (E8). In the short-term, revising facility operation hours could be facilitated by hiring security staff full-time, however, there is a cost-implication that would need to be re-negotiated in the service provider contract. Monitoring of health and hygiene promotion could be coordinated with the municipal environmental health department, who did not appear to be part of the initial project committee. Getting users to be more involved with O&M and M&E and building support mechanisms for scaling up the technology within Johannesburg Water will require capacity building in terms of staff resources and skills, which are more realistic as medium-long term objectives. The pilot project does demonstrate potential to be expanded successfully to other settlements, but would require adjustments for scaling up and greater attention particularly to some of the equity criteria mentioned.

H. A framework for assessing the status of O&M

(after Cotton, 2000:18-20)

Step 1: Performance evaluation

Commentary

Performance evaluation has to:

- answer specific questions so that those in a senior position can take action relating to O&M.
- take place against a number of clearly defined criteria or targets which have been set for the particular reporting period.
- define performance indicators with quantitative or qualitative values, which cover the field of O&M activity. Associated with each performance indicator is a performance target; the status, or 'performance', of O&M is then assessed by comparing each performance indicator with its respective target.

This enables performance comparisons to be made, such as:

- between different time periods for a programme or organization;
- between different programmes or organizations.

Performance targets must be set within the local context.

Key points/ Questions

- Are action plans to improve O&M based on an evaluation of the actual performance?
- Is the evaluation based on the use of indicators and targets?

Step 2: Performance reporting

Commentary

The development of a sound performance reporting system, along with the choice of appropriate performance indicators, are important elements in O&M management.

Key points/ Questions

Investigate the existing performance reporting systems, what they are and whether they are sufficiently well developed to permit a thorough evaluation of O&M activities to be carried out

Step 3: Selecting performance indicators

Commentary

Performance indicators can be defined as *variables whose purpose is to measure change in a process or function.* Characteristics of a good performance indicator are:

- A valid link between the indicator and the question being addressed;
- The information required to define the indicator is readily available.

Information relevant to O&M can usefully be grouped as follows:

- User opinions and satisfaction

- Community management issues
- Levels of service
- Financial
- Materials
- Personnel
- Equipment
- Work order control.

Key points/ Questions

When setting up performance indicators, make sure that they display the appropriate characteristic; use the above groupings as a starting-point to focus attention on the key areas.

Step 4: Performance indicators for water supply and sanitation

Commentary

Indicators selected will vary from place to place according to the local context and management system.

Key points/ Questions

- It is essential to think about what a particular indicator is telling you; can the information be used as the basis for actions.
- Avoid collecting large amounts of data (either through objective means or using participatory techniques), which cannot subsequently be put to the intended purpose.

Step 5: Defining and selecting information

Commentary

The nature and form of the information systems is important for determining performance indicators and developing performance reports. We must know:

- what information needs to be collected in relation to each indicator; and
- where that information can be found.

This requires a careful review of the different performance indicators in order to see whether or not information will be readily available, and if necessary to plan for the collection of the information required.

Key points/ Questions

- For centrally managed schemes, information about O&M should be available through a management information system; in many cases this will be poorly developed or non-existent.

- For community-based schemes, the key knowledge lies with the community of users and may not be recorded in a formal sense.

Step 6: Collecting the information

Commentary

- Performance indicators which can be assessed in an objective manner by collection of performance data; this could be done internally using the staff of the institution or by using external consultants.
- Data on community- and household-managed schemes and consumer perceptions of O&M; this is qualitative as well as quantitative and requires participatory assessments of performance.

In particular, information related to service levels must involve consumer satisfaction surveys as well as more objectively obtainable data on physical performance.

Key points/ Questions

Distinguish clearly between indicators which require different data collection methodologies. Make sure that the overall assessment of performance includes user satisfaction surveys covering the full range of consumers (high to low income groups)

N.B. Additional tools which link to the assessment framework can be found in the same document (Cotton, 2000).

I. Nodes in Nvivo and list of interviewees

Table I.1: Nodes used for coding in Nvivo

Name	Sources	References
backlog	15	26
poor planning	13	17
housing	23	47
urbanisation	13	16
bulk services	11	17
challenges	61	217
service delivery	35	101
janitorial services	18	23
programme	23	51
civil society	23	60
job creation	7	9
O&M	29	65
partnership	19	30
health & hygiene	15	24
access	32	73
human rights	3	6
toilet	43	165
dignity	8	16
costs	39	95
sustainability	30	130
sanitation as business	10	33
upgrade methods	27	65
greywater	19	27
Laws and policies	18	46
monitoring	21	61
equity	31	64
politics and sanitation	27	49
apartheid	3	3
poverty	4	4
interdepartmental coordination	14	24
community dynamics	36	72
solid waste	7	9
contractors involvement	21	40
institutional structure	23	62
backyarders	15	29
pilot project	19	43
cost recovery vs free basic services	14	20
formal vs informal	16	26

Name	Sources	References
drainage	7	8
ownership	16	27
master planning	8	16
treatment and recycling	13	39
behavioural change	9	12
urban vs rural	8	12
National Sanitation Task Team	2	3
technology choice	20	52
pollution	1	2
decentralization and local government	1	2
project cycle	3	3
sanitation ladder	2	2
participation	5	8
temporary and permanent	4	5

Table I.2: List of interviewees

Name	Position	Sector	Met
1. Aditya Kumar	Architect for SDI	NGO	22-May-13
2. Andreas Fourie	Director of Professional and Project Management Services for Western Cape	Provincial Government	
3. Andy Bolnick	Manager of iKhayalami (a Slum Dwellers International affiliate)	NGO	21-May-13
4. Antonino Manus	Director of Water Directorate for City of Johannesburg	Local Government	24-Mar-14
5. Axolile Notywala	Social Justice Coalition	NGO	2-Dec-13
6. Cobus Kotze	Proramme manager, Biocycle, Venture Leader, Agriprotein	Business	26-Jun-13
7. Cyprian Mazubani	Director of sanitation formerly DWA now DHS	National Government	30-May-14
8. Daniel Reinecke	Technical Services and Departmental Projects, Department of Human Settlements	Provincial Government	16-May-13
9. David Schaub-Jones	SeeSaw co-founder	Business	2-Sep-13
10. Densil Faure	Senior Professional Officer, Department of Human Settlements, CCT	Local Government	28-Apr-13
11. Doug Jooste	Engineering Unit, eThekwini	Local Government	28-Jul-14
12. Dr.Vera Scott	Lecturer, Faculty of Community and Health, UWC	Academic	2-May-2013

Name	Position	Sector	Met
13. Enoc Mudau	Johannesburg Water	Local government - MOE	13-Apr-15
14. Faith Ramatsoele	Johannesburg Water, Project Manager, New Services Development	Local government - MOE	26-Jan-15
15. Faizel Andrews	EHP, Mitchell's Plain, CCT	Local Governmen t	3-Sep-14
16. Joel Bregman	Social Justice Coalition	NGO	2-Dec-13
17. John Harrison	Senior Engineer, eThekwini Water and Sanitation	Local Governmen t	29-Jul-14
18. Joseph Tsatsire	Head of WSISU, CCT	Local Governmen t	5-Dec-14
19. Kenneth Sinclair-Smith	Information Management, Department of Water and Sanitation, CCT	Local Governmen t	25-Jul-13
20. Leon Poleman	Development Services, Human Settlements, CCT	Local Governmen t	19-Jun-13
21. Lucky Sibaya	Education Manager	Local Governmen t	20-May-15
22. Lungi Zuma	eThekwini Water and Sanitation, Customer Services	Local government	20-May-15
23. Luxolo Madubedube	Backyarders, Urbanisation, Human Settlements Department, CCT	Local Governmen t	8-May-13
24. Luzuko Gangatele	Monitoring and Evaluation Officer, Informal Settlements Unit, Water and Sanitation, CCT	Local Governmen t	16-May-13
25. Marc Lewis	Project manager for BioCycle	Business	17-Mar-15
26. Mark Byerley	Human Settlements Department	Local Governmen t	28-Jul-14
27. Motebang Matsela	Architect for SDI in Johannesburg	NGO	10-Jul-13
28. Mthokozisi Ncube	Johannesburg Water, Research Officer	Local government - public private (?)	13-Apr-15
29. Mzwandile Sokupa	Manager for Informal Settlements in Human Settlements Department, CCT	Local Governmen t	7-Aug-13
30. Niyemat Williams	Head EHP, Mitchell's Plain, CCT	Local Governmen t	3-Sep-14
31. Noah Schermbrucker	Program officer for SDI	NGO	21-May-13

Name	Position	Sector	Met
32. Nomvula Mofokeng	Acting Unit Head: Water services regulation and policy development, Johannesburg	Local government	18-Dec-14
33. Olwethu Jack	SDI/CORC	NGO	4-Oct-13
34. Philemon Mashoko	HOD Water and Sanitation, Ekurhuleni Municipality	Local Governmen t	26-Sep-14
35. Phillip Nelson	Johannesburg Water	Local government	17-Feb-14
36. Richard Holden	Former Mvula Trust technical director	NGO	30-Jun-14
37. Shamile Manie	Senior Professional Officer, Information Management, Water and Sanitation, CCT	Local Governmen t	13-Jun-13
38. Shehaam Sims	Chief Director for Urbanisation, CCT	Local Governmen t	20-Nov-13
39. Soyisile Magwayi	EHP, Mitchell's Plain, CCT	Local Governmen t	3-Sep-14
40. Susan Groenewald	Planner for Informal Settlements Human Settlements Dept, CCT	Local Governmen t	5-Nov-13
41. Teddy Gounden	Customer Service, eThekwini Water and Sanitation	Local Governmen t	29-Jul-14
42. Tertius de Jager	Acting Head for WSISU, CCT	Local Governmen t	3-Sep-13
43. Thantaswa Mtsabe	Information Management, Department of Water and Sanitation, CCT	Local Governmen t	25-Jul-13
44. Thozama Mngcongo	Social Justice Coalition	NGO	2-Dec-13
45. Tinyiko Masondo	Johannesburg Water, Operations	Local government - public private (?)	13-Apr-15
46. Walter Fieuw	CORC, City Fund Manager	NGO	5-Dec-14

J. Example of field note and interview transcription

Field research 18-June-2014

23 June 2014
03:56 PM

Klipheuwel visit with Jonny Harris (formerly at Maluti Water now independent) met with Eric (community leader although he said that he is leaving for the Eastern Cape permanently in a month(?))

- Went to check out the five pour flush toilets installed as part of a WRC pilot
- They were installed in an area that did not have Afrisan toilets (need to get a map -- ask Jonny or Cobus?) likely because the residents moved in after the Afrisan pilot was completed (seem to be closer to the stream running adjacent to the settlement)
- Jonny explained that Eric had requested for households who did not have toilets already to benefit from the pilot
- Hired local person to build the top structures; although he noted as a result the construction quality may not have been very good particularly the quality of zinc sheeting used

Figure I.1: Pour flush toilet in Klipheuwel (Pan 18/6/2014)

- There was also discussion with Agriprotein about assisting with maintenance of the toilets so that they could eventually collect some of the faecal sludge from the septic tank which is linked to a leach pit (?) in an adjacent field

Figure I.2: Septic tank inspection point in Klipheuwel (Pan 18/6/2014)

- Two of the toilets which were the ones blocking more frequently (3-4 times over the year) were adjacent to what Jonny said was a church (speculation that perhaps church goers are using the toilet so there are more people using it who may also use bulky anal cleansing material)
- Eric said that he had paid one of the vacuum truck drivers who come to empty the chemical toilets "under the table" to unblock the toilets
    - Jonny directed him not to pay for an external service to unblock the toilets as the problem is likely easily fixed if it is a blockage in the sewer pipe not the actual septic tank and told Eric to call him instead
    - Jonny also made a note to re-establish contact with Agriprotein to make a maintenance arrangement. Need to get a rod for unblocking the sewer pipe.
    - Jonny asked if people were happy with the pour flush toilets and Eric indicated that they were, although the woman using it didn't speak much English so we couldn't verify with her
    - They appeared to mainly be using toilet paper to flush with, although one gentleman was using newspaper
    - Jonny asked if people were cleaning the toilets themselves as opposed to by the EPWP workers as for the Afrisan toilets. The woman indicated that she was cleaning it herself. Then Jonny speculated whether or not it was equitable that some people had their toilets cleaned for them while others did not. (I found this to be a risky line of questioning)
- Noticed that some of the toilets were missing solar panels. Where did they go and what happened to them?

Figure I.3: Afrisan toilet with missing solar panel in Klipheuwel (Pan 18/6/2014)

- Eric said that he is leaving in a month and has appointed a "secretary" to assist with handling leadership issues. He added that although the move is permanent that he would return to Klipheuwel if people needed him.

K. Interview 16-May-2013 with Luzuko Gangatele

Date: 16 May 2013
Name: Luzuko Gangatele
Responsibility: Monitoring and Evaluation Officer for Water and Sanitation Department, Informal Settlement Unit, CCT
Location: Slaney Centre, Bellville

Transcription of interview :
Sophia: So Luzuko, can you please explain to me what your position is and what you do.
Luzuko: Okay umm… I'm a monitoring and evaluation officer for water and sanitation informal settlements unit. So my job entails… monitoring services that we render to informal settlements. Uh… our unit installs water and sanitation units in informal settlements, and what I actually do is to go out there and interview members of the community, community leaders, talk to them about the services that we render. Find out what our shortcomings are, what do we need to improve on, are the people happy with the service, what can be done, proposals whatever. And then propose to the project management team who actually do the implementation yeah of the services, yeah in a nutshell.
Sophia: Okay, umm.. How many M&E officers are there currently?
Luzuko: There's only four.
Sophia: Okay, and how is the work divided? Is it by district or region
Luzuko: Okay, the city is divided into 8 water districts so the M&Es are divided, yeah they are divided the water districts into 4. And I'm doing Hillstar and Southern Water districts, and then my other colleagues, due to Khayelitsha having a lot of informal settlements and there's only 1 M&E doing Khayelitsha (Sophia: that's very big). Yeah because it's big. The other one Nolufefe is doing uhh… Helderberg, and uh..uhh.. Now I don't know my water districts (Sophia laughing) but fine. She's doing 2 and Nashieta is doing 3 actually because of the other M&E only doing 1 area. Nashietah is doing Tygerberg, umm.. Ebenezer, and the Northern water district. And like I said I'm doing Hillstar and Southern. Yeah that's 2, 4 (me 1 and 1)? Okay I'm doing 2, Nolufefe is doing 2, Nashietah is doing 3 and Llast I doing 1. Yeah.
Sophia: Because Khayelitsha's very big. I see. So what you're doing I guess like, do you find that, okay first of all let me ask what do you think sustainable or sustainability for sanitation would entail?
Luzuko: Sustainability…
Sophia: What does that mean to you?
Luzuko: For me sustaina-ble san-sanitation is something that you can put out there in an informal settlement where people use it over a long time that doesn't really give too much problems. Doesn't need too much maintenance. Uh… people accept it. Uh. Yeah.
Sophia: Okay, and is there anyway that you think that could be measured or included in what you do?
Luzuko: Eh… for me, the way we are doing things at the moment like because I'm only doing monitoring right. There's the part of of introducing services to the community is right because we discover settlements almost every year there's a new settlement.
Sophia: Do they usually approach the city, or the city's driving around and notice something or…?
Luzuko: No they are… normally we would uh get information about informal settlements from environmental health people because as you know a settlement may exist for a few months before people discover no that people are living here. Maybe there's one little shack

and later there's 3 shacks, and it expands and only then they realize, okay there are people here, then they will need basic services like water and sanitation, and then we are always the first people to be approached by environmental health people to say okay these people will need basic services. So like if you're asking me like what can maybe added to my job description, is that what you were…?
Sophia: Or sort of like how would you bring in with sustainability something that could work for a long time without maintenance, how is that considered when you provide sanitation?
Luzuko: Okay, due to the nature of informal settlements we provide or end up with maybe in some cases what isn't sustainable but what is going to work.
Sophia: In like the immediate?
Luzuko: Yeah or for that particular, yeah for many reasons (laughs under breath) because we have portable chemical toilets for instance, which are available immediately, you know (pause) within 48 hours even under 48 hours. We can call the contractor because the chemical toilets, we have a chemical toilets tender. We don't own the chemical toilets, we rent them. We just give them a call and send them an e-mail then they deliver the chemical toilet. They service it on-site. It's a… it is a, for eh, it is not a sustainable solution to sanitation really because (pause) you need to service it frequently, it 's like uh....
Sophia: like twice a week or three times depending on how many people are using it.
Luzuko: Yeah, but we like to service it 3 times a week as a minimum, yeah, number of services because you find out like two times a week sometimes it is, it is a messed up because remember chemical toilets. You know informal settlements people don't care. They go there, use it anyhow. Fine, now you find if we go there 2 times a week there would be 3 days in between when the toilet has not been cleaned. Because when they service it they suck it out using a honeysucker machine then jet clean it inside. At least we know that if we do a minimum service of three times a week so at least it is cleaned between the two days. That is for me not a sustainable service, really, you know, but due to some other factors like bulk services, if they are not there where the settlement is, so we cannot install flush toilets where it sits. Cape Town, high water table, we cannot install like your (Me VIPs) like your dry sanitation types because there is a dry sanitation type that we like to use here, the Enviroloo (Sophia: but we have seen that. I've seen that) okay yeah, we can use the Enviroloo, but you cannot use say like your other dry sanitation types that release stuff to the ground, you know. We must, if we use pit toilets, they must be concrete, concrete lined, yeah those kinds.
Sophia: So they would fill quickly (Luzuko: Yeah)
Luzuko: Yeah, so yeah.
Sophia: Okay, and um so the other piece of it, the thing I'm also ooking at is equity, equity in sanitation service.
Luzuko: Sorry?
Sophia: Equity… Luzuko (Equity okay) yeah so I'm just going to pick your brain a little bit.
Luzuko: Umm.. okay fine, so for me you'd have to explain what you mean by equity, your "equitable" how? Like in terms of, the people in the same settlement, or with other people?
Sophia: It could be either, like if you looked at other people in different areas getting different services or within the same settlement, does everyone have equitable access? So it could be either.
Luzuko: So you see Sophia, there we have a problem there really. Huh (sigh), yeah so you find that in the same settlements you'll find that some people have flush toilets, and then the others have chemical toilets. The others have chemical toilets. Others don't have toilets at all you see, so they dig their own (Sophia: pits, yeah) so (pause). What we are offering really is not equitable, really, if you look at it that way because we are also dependent on so many factors, like your geo, okay like your geo for instance. How is the, how is the land uh…? Is

the terrain good enough to to, to install, to install services? Some of these areas are low-lying, you know, some of the informal settlements are in wetlands, some umm.. uhh.. are very dense. So you'll find out that if maybe it's a settlements, let's say it's a settlement like Masiphumelele where it is sitting in a wetland. The people whose shacks are along the road, those guys are enjoying flush toilets, but the people at the back, because you can't bring services like to to those because they live very close to the wetland, we can't install flush toilets, then maybe chemical toilets or container toilets or sometimes porta-pottis. So people like to think that uh… that uh… they are not given, like a equitable service as it were, but really, we are giving a service that, uh, we can at that point in time, depending on the external factors. So yeah, it is not equitable, really, mean like some settlements only have what we call VIPs, vent improved pit toilets. They all, they want flush toilets, bad, they don't understand why they don't have so uh.. Our one is nothing, is needed, whereby people can be made to understand why they can get a certain type of sanitation.

Sophia: And umm.. does it make a difference like in terms of how many people are sharing it. Like perhaps if you have a flush toilet but you share it with 4 families, but like even if you have a dry sanitation, but at least it's my own, do you think that people would be happier with that even if it's not what they consider the best, but at least it would be their own household's would people be happy with that?

Luzuko: Yeah, people don't like to share. I will take an example of a black bucket, the black bucket, the one that is being eradicated. There are people who still want to use the black bucket because it is not shared and because it is well serviced, they are happy to use it. Now when we come to these settlements, for example in KTC. They ...

Sophia: Is that in Khayelitsha?

Luzuko: KTC, no it's in Nyanga. No, they say, no they will accept the form of sanitation we bring as long as they will not share it, which is sort of a problem for us, you know, because the black buckets that they are using, they are using their own top structures there is no regulation for how it's built, as long as it's covered, you see. If we are going to put in a concrete structure, you know the one we use for informal settlements, it's going to be kind of difficult to put, the same number of structures as are available (phone rang) as the available black bucket toilets, so yeah. People, just to answer your question, people like accept the sanitation option they get, even if it's not as good as long as they don't share it, yeah. Yeah because like sharing it, it looks like it is a big problem, but the flush toilet seems to be the most acceptable way of sanitation even if people share it. It is only acceptable, but for the other types, they share it because there is nothing else they can do, but yeah, they share it.

Sophia: And umm let's say, are there special considerations that are made, if, if people have special needs like if somebody's disabled or people are elderly. I heard that in some settlements that you know women and children will get the porta-potti so they don't have to go out at night or something. Is that something that's considered when the services are being planned?

Luzuko: Yeah, we we do that if when we receive such requests. Say for instance, if we have umm… chemical toilets in an area and then there's a special request for a, a special need. Then we take at least for that particular person a toilet close by, but when it comes to disabled people, we we request (phone rang and interrupted…)

Sophia: You were just finishing and saying, what were you saying, yeah that you do try to make special considerations if there's a request for it.

Luzuko: Yeah if there's a request for it, but we don't have (Sophia: there's not a structure…), yeah but I think now because we have the chemical toilet contractors we requested that they give us, eh eh, um… a structure just show us a structure if they could of a, of a chemical toilet that can be used by disabled people so that if there's that particular request then we can, but otherwise at the moment even the way we build our toilets... Okay fine, for flush toilets if

it's not an ablution block that we build for an informal settlement, if we put like rows of concrete toilets, we, they're a standard size, a wheel chair cannot go in, you see. Yeah, so those are the new things that we, I'm not going to say that we are implementing, we are thinking about, you know, due to I think requests that are, you know coming up. Maybe these are the things that were not there, hence maybe they were not catered for, I don't know, but now we do get those requests. I think the project management team has got that in mind when they, you know, have those in mind as we do the new settlements.
Sophia: Okay, umm.. What else was I going to say? Umm, yeah so I think you had mentioned it when we just started, but I was going to ask what some of the major challenges are that you're facing in terms of providing sanitation services for people.
Luzuko: Yeah, bulk services. The existence of bulk service, it's a challenge. In some settlements, improving the existing services, like in terms of better, you know, what do they normally call it, what, I'm forgetting the name now, but "decent" sanitation. So now, when, yeah, okay, it's either bulk services, they are not available or in some settlements where there are bulk services nearby, but these settlements are dense, you see. So these are the challenges now, people don't want to relocate or move just for services to be installed and then maybe come back. Yeah those are the challenges, yeah like geography of the area is also a problem. Like what else, okay um… there's something, but that came to my mind...okay fine, land ownership. Yeah, that is what nearly slipped my mind. In some cases, there are services available, like bulk services are available, but the land doesn't belong to the government or City of cape town, it's privately owned, the owners then they don't allow us to put in services. Point, the most recent case was it happened in, there's a new settlement called Siqalo.
Sophia: That's going to be difficult to spell.
Luzuko: (Chuckles) S i q a l o
Sophia: Where is this one?
Luzuko: It is in Phillippi.
Sophia: I'm assuming it's still kind of small, or is it pretty big already?
Luzuko: No, it's one, in fact, I think it's going to take the title of the biggest informal settlement because I think Enkanini is maybe one of the biggest informal settlements. Siqalo is maybe coming in second. Eh… Siqalo is on private land.
Sophia: Is that why, maybe it wasn't necessarily registered before because it's on private land?
Luzuko: No, we can't put services there. We could only put services just on the, on the road reserve.
Sophia: Oh okay.
Luzuko: And not all around because you know there are two road reserves, but we can only put services on one road reserve on the side because the road service along, along, because the settlement is situated along Vanguard drive (Sophia: Vanguard?) in Mitchell's Plain. Uh...The people on the other side of Vanguard Drive, they have formal houses.
Sophia: The people on the other side have formal houses?
Luzuko: Yeah, the people on the opposite side they have formal services. When we put chemical toilets along that road reserve. They didn't like it, and the councillor was also against it. So you know, we don't do things against community leaderships, uh, what. You know, so we had to remove them, to one side of the settlement, and this settlement is so huge, you know. So those are the challenges, like to sanitation really. Yeah.
Sophia: Okay, great. I think that's all of my set questions that I had. Then if I think of anything else, then I might e-mail you.

L. City of Cape Town development matrix categories

Table L.1a: Informal settlement development matrix categories from CCT Department of Human Settlements

Category	Description		Factors
A1	Occupation permitted		Good location and accessible
	∞	Approved Projects	Consistent with higher order policy and spatial planning/ or amendment supported
	∞	For current and imminent full upgrades	New or Existing Housing intervention
	∞	(Full services, top structure and tenure)	Pilot Projects
			Beneficiaries of New Housing Project
			N2 Gateway Projects
			TRA's and IDA's
A2	Occupation permitted		No funding approval in place
	∞	Future Project in Planning Phase	Identified for project investigation
	∞	Commence with Pre-Planning	No immediate or significant environmental threat
	∞	Preparations of Funding- and Applications Submissions	Technically viable
			May have Engineering constraints (e.g. low lying areas which cannot be drained without earthworks, gravity sewers which cannot be installed due to undulating topography, etc.)
B1	Occupation temporary on City owned land		Ownership of properties
	∞	Adverse physical conditions	Significant de-densification
	∞	De-densification required	Outside the Urban Edge
	∞	Prioritizing	Current zoning of property unsuitable
	∞	Attached Proposed Budget to De-densification	Availability of Bulk Services
B2	Occupation temporary on other than City owned land		Access to Social - & Economic Facilities
	∞	De-densification required	Access to Health Facilities
	∞	Prioritizing	Age of Settlement
	∞	Attached Proposed Budget to De-densification	

Table L.1b: Informal settlement development matrix categories from CCT Department of Human Settlements

Category	Description		Factors
C	Occupation prohibited		In a Biodiversity Corridor or Coastal Zone or National Parks
	∞	Total Relocation required	Heritage / Environmental significance
	∞	Prioritizing	In a buffer zone (e.g. Koeberg, Noise or Waste Dump)
	∞	Attached Proposed Budget to Relocation	Located below 100 yr. flood line
	∞	Searching for suitable land	located in flood prone area / Water bodies
			Geotechnical Constrains / Unstable soil formations and Slope > 12%
			located over/ under servitude (services or electrical)
			located in road and railway reserve
			Privately owned land and unable to obtain consent or purchase land;
			Immediate or significant risk of natural disasters, toxic waste, etc.

M. Organogram for eThekwini municipality

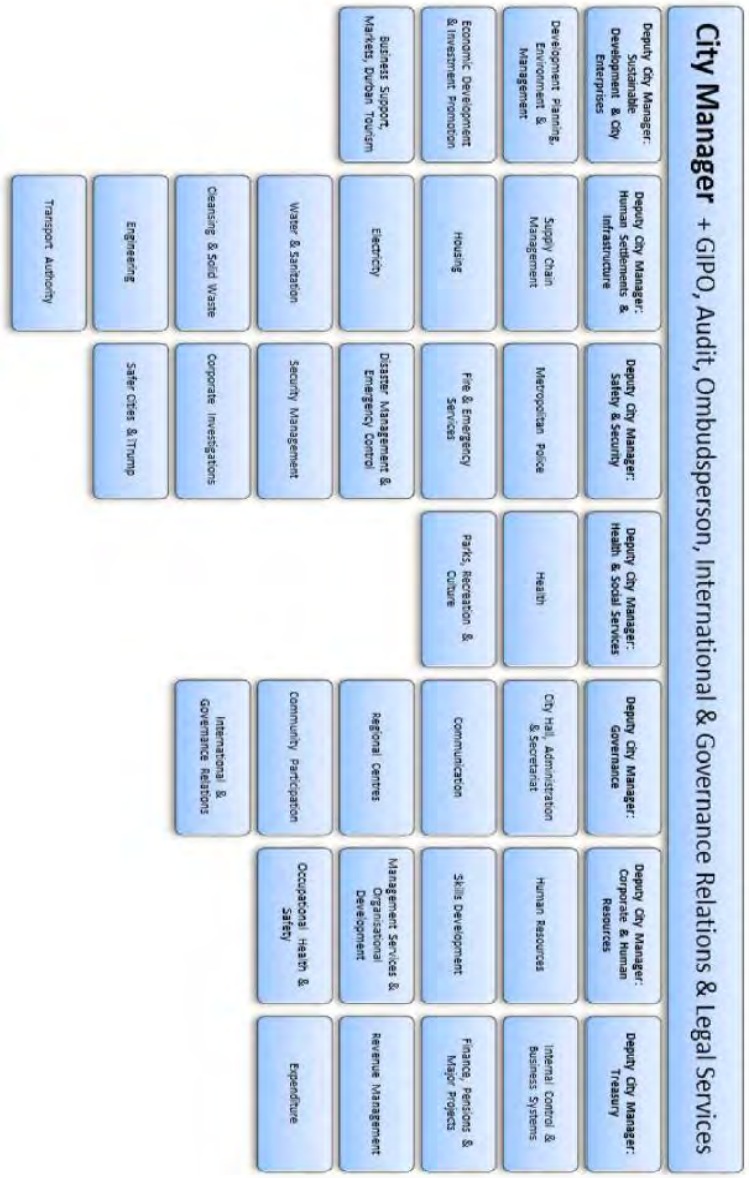


Figure M.1: Organogram of eThekwini municipality (Sutherland et al., 2013)

N. Water service authority and provider institutional arrangements

A ``water services authority'' means any municipality, including a district or rural council as defined in the Local Government Transition Act, 1993 (Act No. 209 of 1993), responsible for ensuring access to water services;

a ``water services intermediary'' means any person who is obliged to provide water services to another in terms of a contract where the obligation to provide water services is incidental to the main object of that contract;

a ``water services provider'' means any person who provides water services to consumers or to another water services institution, but does not include a water services intermediary. (RSA, 1997b)

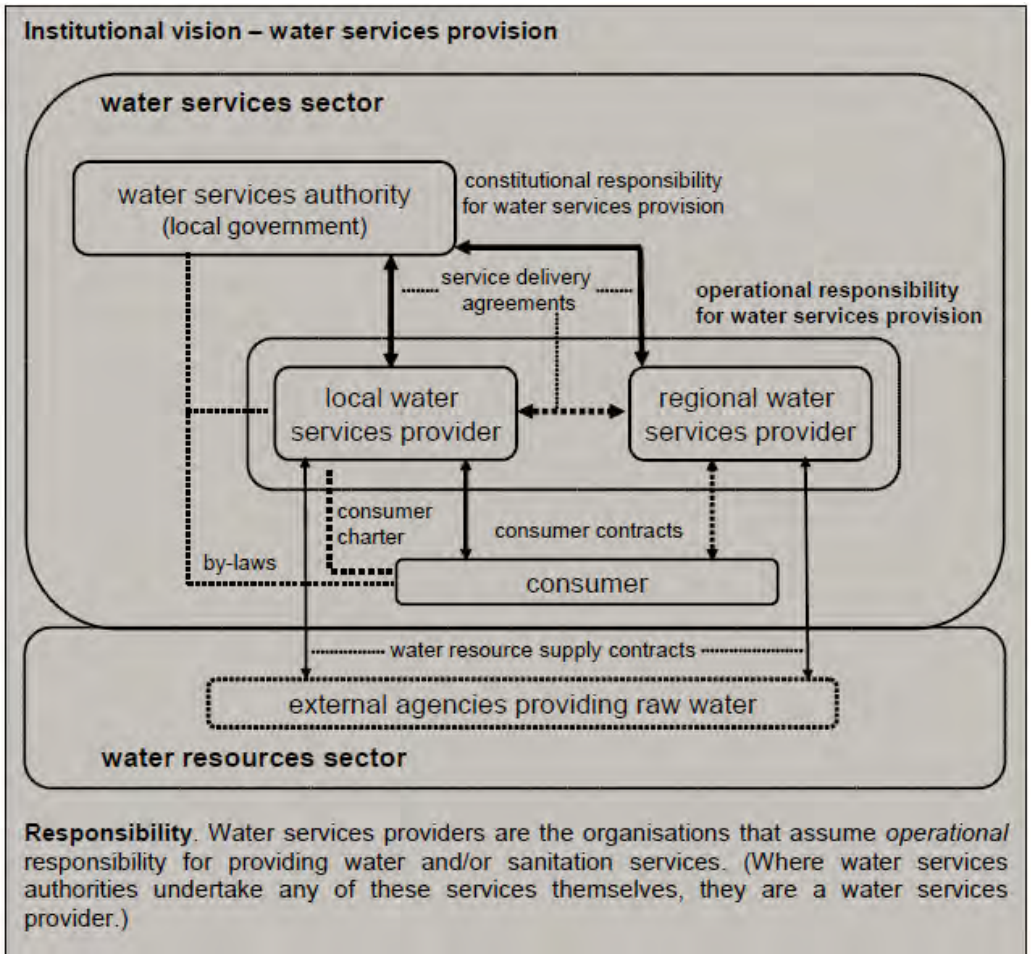


Figure N.1: Diagram of institutional arrangements for water services (DWAF, 2003)

O. City of Johannesburg management structure

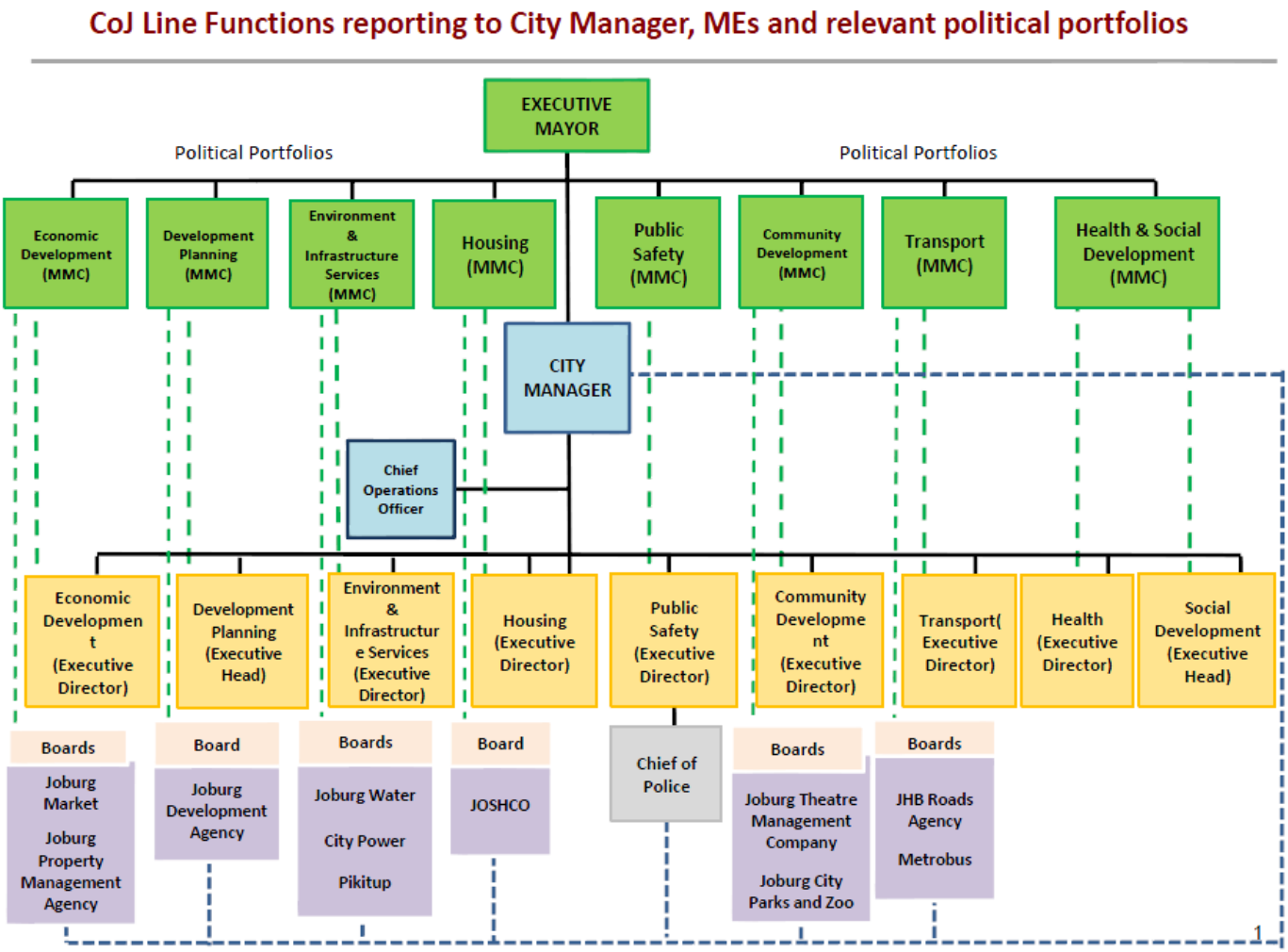


Figure O.1: CoJ management organogram (CJ, 2013b)

P. Monitoring checklist for Johannesburg Water conducted by City of Johannesburg

Table P.1: CJ monitoring checklist requested from JW

Regulatory Monitoring Area	Information needed during site inspections	Additional information needed from JW
1. Access to basic sanitation services		Current backlog
Ground conditions	High water table? Does it affect the whole area?	Rate of backlog reduction
Toilet Structure	Type of toilet?	Number of households with access to sanitation
	Is the pit sealed? (depending on water table in area)	Does JW have a health and hygiene awareness programme and sanitation practice (toilet use i.e things that are not supposed to be disposed in the toilet with measurable KPIs?
	Depth of pit?	Check SANS10365 standard for VIPs
	Any visible defects on the toilet structure? (condition of structure but also any vandalism)	
	Is the toilet on a stand or communal?	
	Is there sufficient access for trucks to desludge the pits?	
	Is the vent pipe covered with a sieve? (this prevents flies from entering toilet)	
	Is the vent pipe straight? (if not smell could occur at later stage)	
	Does the vent pipe clear the roof of the toilet?	
	When was the toilet constructed?	
	How often is the toilet deslugded	
	How often does it get full	
	Is toilet paper available	
	How many people using toilet	
	When was the toilet constructed?	
	the causes of VIP's to fill up before the time planned for.	
	The storm water in the community.	
	Use of and availability of dust bins and the disposal of objects like baby nappies.	
Health and Hygiene Awareness	When does JW conduct health and hygiene awareness? (Beginning of	

Regulatory Monitoring Area	Information needed during site inspections	Additional information needed from JW
	project, during?)	
	What methods are being used to do H&H promotion (posters, workshops, etc)	
	Does the education allow for communities to side on a technology option?	
	Are there any hand washing facilities present at toilets?	
	Are there any educational posters showing how the toilet operates	
	Is the lid closed?	
	Any flies detectable?	
	Is the latrines clean inside?	
	Is any monitoring being conducted by JW on the H&H aspects?	
VIP desludging points	How many desludging points still operates?	
	Is it fenced off? (Fence, closed off?)	
	How far from the community is it situated?	
	Any incidents reported at desludging points?	
	Is the toilet clean?	
2. Access to water services		
Infrastructure supplied	What water supply infrastructure is in place (stand pipes, communal taps, house connection, etc)	Current backlog
Condition of infrastructure	Are taps all in working order?	Rate of backlog reduction
	Any taps water leaking?	Number of households with access to sanitation
	Where is grey water draining too? (take photos please)	Does JW have a health and hygiene awareness programme with measurable KPIs?
		What is the ratio of number of taps to how many households?
	Types of taps e.g. plastic, copper etc	Check SANS Grey Water guideline
	Do standpipes have taps	
	Is there any visible run off water	
	Is there a sieve around the standpipe to drain run off water	
	Any visible improvements compared to other standpipes done in previous years	

Regulatory Monitoring Area	Information needed during site inspections	Additional information needed from JW
User education	Has any user education been done?	Any statistics from clinics on water borne related diseases reported?
	If yes, how regular?	
	What did it cover? (saving water, vandalism of taps, etc)	
	Are there many water puddles around the tap?	
	Is the stagnant water creating flies etc.?	
	What type of containers are used to collect water (observation, if its open there is a risk of contamination)	
3. Drinking water quality		Copy of SANS 241
Water quality programme	Copy of JW's monitoring programme needed. Check for:	Water safety plan is updated
	Testing requirements and standards clearly defined for each source and supply area	
	Sampling is taking place as required	
	Test are done at through a credible laboratory	
	Results are recorded and stored	
	Results are reported on BDS	
	Track implementation of Water Safety plan	
Water quality indicators	Check samples taken for the following allowing quality parameters: (a failure for one parameter represents a failure of the sample)	This will allow you to verify whether calculations for compliance are correct.
	1. % sample failure (E-coli)	
	2. % sample failure (Turbidity)	
	3. Check if JW has done any interventions with regard to the non-compliance of the above	
4. Impact on the Environment		
% of WWTW that are operating in terms of a current license	Check number of WWTWs operating in terms of a valid and current license divided by the total number of WWTW in the area.	Get licenses for the WWTWs from JW. Get license permit guideline from DWA
	Check when license expire and whether applications for new licenses have been done by JW.	

Regulatory Monitoring Area	Information needed during site inspections	Additional information needed from JW
Effluent quality monitoring system in place	Minimum standards that effluent quality programme must comply with:	Get effluent discharge monitoring programme from JW
	1. Effluent discharge standards are clearly specified for each discharge point	
	2. Samples are taken as per the relevant standard	
	3. Samples are tested in a credible laboratory	
	4. Sample results are recorded and stored	
	5. Results are reported on GDS	
	6. Monitor number of spills from the works that may have environmental impact to water resource	Check target on the permit guideline from DWA
	Track implementation of Waste Water Risk Abatement plan	Get W2RAP from JW.
% of samples passing the minimum standard(% compliance with effluent quality permit)	This is a calculation for the percentage of samples taken in monitoring effluent quality that meet or exceed the minimum requirements:	
	(flow-weighted by discharge point)	
	[Sum(samples passing/samples taken) x flow] / Total flow. (By parameter & averaged); for key parameters only.	
5. Strategic Asset management		
Asset management plan in place	Check IAM plan of JW. Does it comply to National legislation?	Get copy of JW IAM plan
	Monitor progress in terms of implementation of IAM plan.	
	How can the information in the asset register be verified?	
	Budgets spend on o&m (is it sufficient compared to international best practices?)	
	Number of staff employed to do o&m?	
6. Water use efficiency		Get Water Demand Management plan from JW.

Regulatory Monitoring Area	Information needed during site inspections	Additional information needed from JW
Meter coverage	**Meter reading performance**	
	Number of households metered (conventional and prepaid)	Estimate readings to be obtained and analysed
	Number of meters downloaded by JW	
	Number of meters visited by JW	
	Number of meters read by JW and sent to CoJ for billing	
	Number of readings received from contractor on monthly basis	
	Readings which failed validation due to possible incorrect readings from contractor	
	Number of meter readings billed by CoJ per month	
	Number of variances and Monitor the progression monthly	
	Conduct inspections by going out with contractors doing meter readings.	
	Number of vending systems in place.	
	Number of times per month consumers experienced problems with vendors	
	How many domestic meters are replaced/repaired per month?	
	How many illegal connections found per month?	How is this addressed?
UFW	Monitor progress of projects aimed at addressing UFW.	
Water demand management plan	Progress against WDM projects	
	Analysis of progress in demand reduction against target	
7. Customer service standards		
Continuity of water supply	Check stats on response times against approved SLA	Get updated SLA
	Monitor number of bursts per 100km.	
Sewer overflows and spillages	Check stats on response times against approved SLA –	Trend – Is the service improving or deteriorating?
	Monitor number of flows and	

Regulatory Monitoring Area	Information needed during site inspections	Additional information needed from JW
	spillages per 100km.	
8. Institutional performance		
Number of employees per 1000 connections	Check number of employees employed by JW in the execution of water services. (this includes permanent and temporary staff)	Get Annual report of JW for submission to DWA.

Q. Organogram for Johannesburg Water

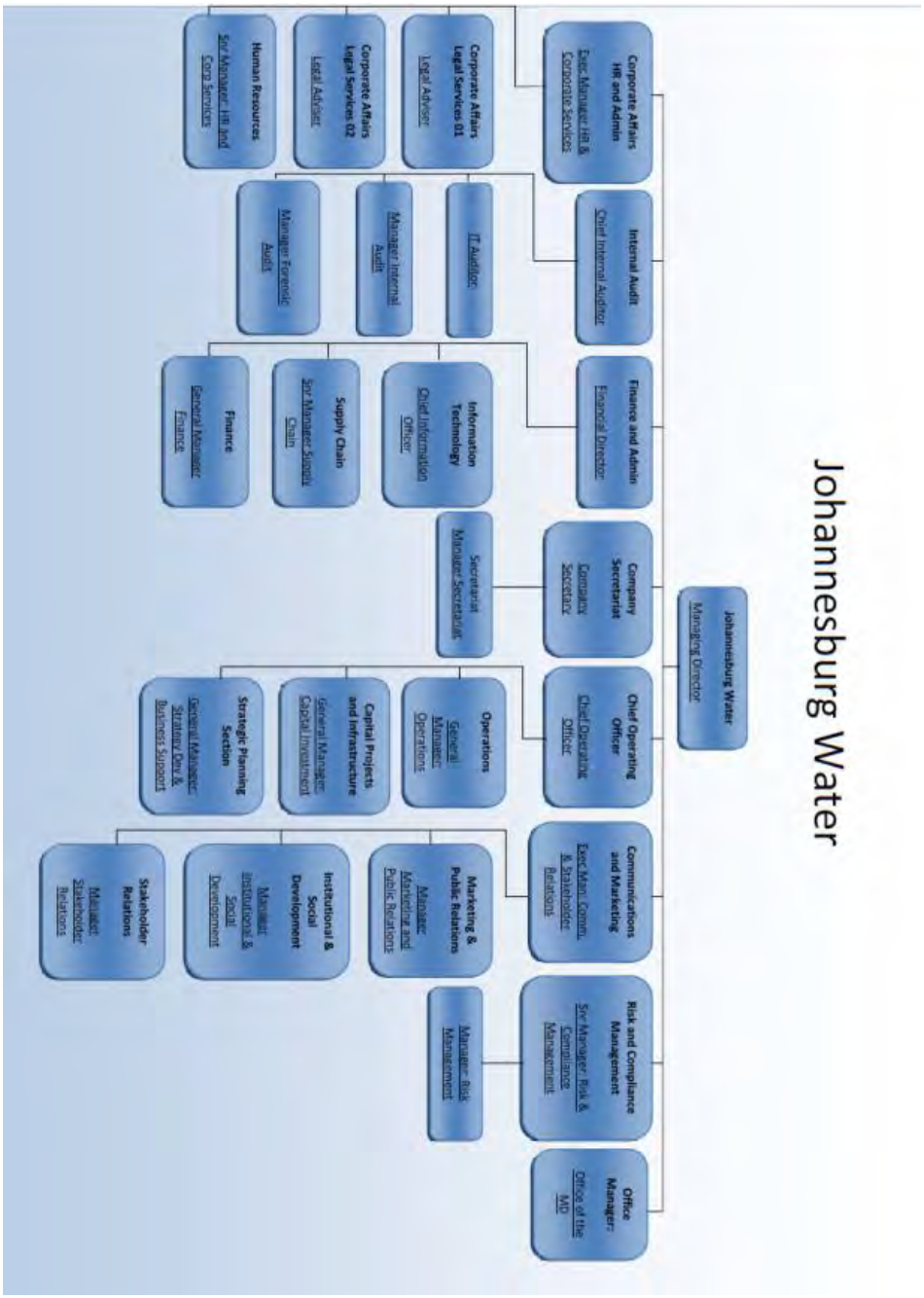


Figure Q.1: Johannesburg Water management structure organogram (JW, 2015d)

R. Diepsloot Ablution Facility

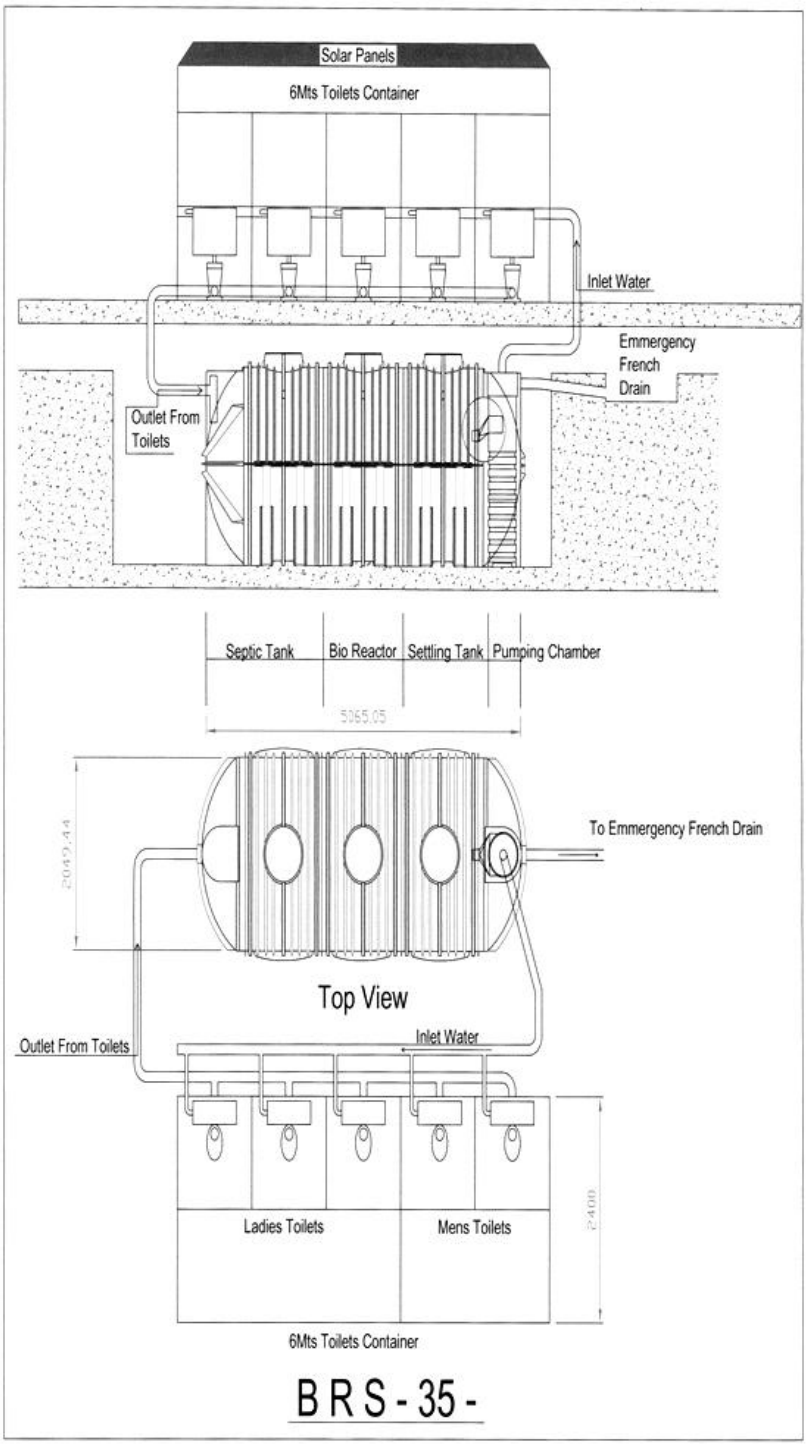
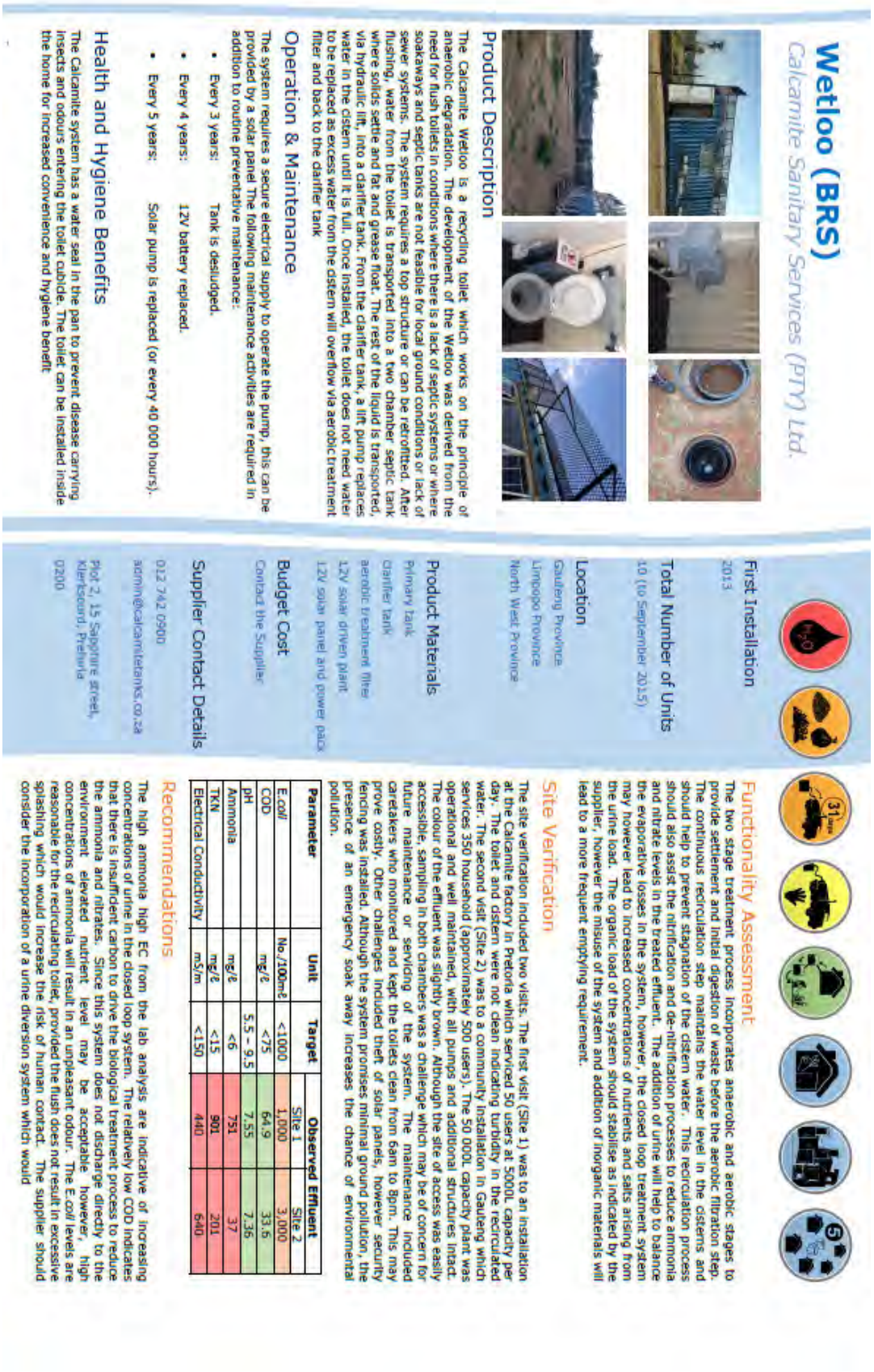


Figure R.1: Drawing of Diepsloot pilot ablution facility
(Calcamite Sanitary Services Ltd. & Reabetswe, n.d.)



Wetloo (BRS)

Calcamite Sanitary Services (PTY) Ltd.

Product Description

The Calcamite Wetloo is a recycling toilet which works on the principle of anaerobic degradation. The development of the Wetloo was derived from the need for flush toilets in conditions where there is a lack of septic systems or where soakaways and septic tanks are not feasible for local ground conditions or lack of sewer systems. The system requires a top structure or can be retrofitted. After flushing, water from the toilet is transported into a two chamber septic tank where solids settle and fat and grease float. The rest of the liquid is transported, via hydraulic lift, into a clarifier tank. From the clarifier tank, a lift pump replaces water in the cistern until it is full. Once installed, the toilet does not need water to be replaced as excess water from the cistern will overflow via aerobic treatment filter and back to the clarifier tank

Operation & Maintenance

The system requires a secure electrical supply to operate the pump, this can be provided by a solar panel The following maintenance activities are required in addition to routine preventative maintenance:

- Every 3 years: Tank is desludged.
- Every 4 years: 12V battery replaced.
- Every 5 years: Solar pump is replaced (or every 40 000 hours).

Health and Hygiene Benefits

The Calcamite system has a water seal in the pan to prevent disease carrying insects and odours entering the toilet cubicle. The toilet can be installed inside the home for increased convenience and hygiene benefit

First Installation

2013

Total Number of Units

10 (to September 2015)

Location

Gauteng Province
Limpopo Province
North West Province

Product Materials

Primary tank
Clarifier tank
aerobic treatment filter
12V solar driven plant
12V solar panel and power pack

Budget Cost

Contact the Supplier

Supplier Contact Details

012 742 0900
admin@calcamitetanks.co.za

Plot 2, 15 Sapphire street,
Klerksoord, Pretoria
0200

Functionality Assessment

The two stage treatment process incorporates anaerobic and aerobic stages to provide settlement and initial digestion of waste before the aerobic filtration step. The continuous recirculation step maintains the water level in the cisterns and should help to prevent stagnation of the cistern water. This recirculation process should also assist the nitrification and de-nitrification processes to reduce ammonia and nitrate levels in the treated effluent. The addition of urine will help to balance the evaporative losses in the system, however, the closed loop treatment system may however lead to increased concentrations of nutrients and salts arising from the urine load. The organic load of the system should stabilise as indicated by the supplier, however the misuse of the system and addition of inorganic materials will lead to a more frequent emptying requirement.

Site Verification

The site verification included two visits. The first visit (Site 1) was to an installation at the Calcamite factory in Pretoria which serviced 50 users at 5000L capacity per day. The toilet and cistern were not clean indicating turbidity in the recirculated water. The second visit (Site 2) was to a community installation in Gauteng which services 350 household (approximately 500 users). The 50 000L capacity plant was operational and well maintained, with all pumps and additional structures intact. The colour of the effluent was slightly brown. Although the site of access was easily accessible, sampling in both chambers was a challenge which may be of concern for future maintenance or servicing of the system. The maintenance included caretakers who monitored and kept the toilets clean from 6am to 8pm. This may prove costly. Other challenges included theft of solar panels, however security fencing was installed. Although the system promises minimal ground pollution, the presence of an emergency soak away increases the chance of environmental pollution.

Parameter	Unit	Target	Observed Effluent	
			Site 1	Site 2
E.coli	No./100ml	<1000	1,000	3,000
COD	mg/ℓ	<75	64.9	33.6
pH		5.5 – 9.5	7.55	7.36
Ammonia	mg/ℓ	<6	751	37
TKN	mg/ℓ	<15	901	201
Electrical Conductivity	mS/m	<150	440	640

Recommendations

The high ammonia high EC from the lab analysis are indicative of increasing concentrations of urine in the closed loop system. The relatively low COD indicates that there is insufficient carbon to drive the biological treatment process to reduce the ammonia and nitrates. Since this system does not discharge directly to the environment elevated nutrient level may be acceptable however, high concentrations of ammonia will result in an unpleasant odour. The *E.coli* levels are reasonable for the recirculating toilet, provided the flush does not result in excessive splashing which would increase the risk of human contact. The supplier should consider the incorporation of a urine diversion system which would

Figure R.2: Wetloo DEWATS product description (WRC & DST, 2016)

S. Sanitation technologies and service standards for informal settlements in Cape Town

Figure Q.1a: Brochure listing various sanitation technologies and service standards provided by CCT (CCT, 2011c)

ENVIRO LOO FROM ENVIRO OPTIONS

It is a rotation-molded, communal waterless dehydration (evaporation) toilet, manufactured in two sizes, serving either 10 or 20 users per day. The unit does not require urine diversion at source, but capitalises on air circulation (wind) and heat from the sun to promote the dehydration of solids and the evaporation of liquids.

The system provides the right environment in terms of sufficient heat, prolonged retention periods in relation to number of users, and adequate airflow and oxygen to dehydrate and decompose the waste efficiently.

AFRISAN DEHYDRATION TOILET

It is an injection molded, single-use dehydration (evaporation) toilet that has been designed to be installed inside a dwelling. The unit does not require urine diversion at source, but capitalises on air circulation (wind) and heat from the sun to promote the dehydration of solids and the evaporation of liquids. Water is heated via a roof-mounted solar panel and circulated into the system to transfer heat and promote evaporation.

The system provides the right environment in terms of sufficient heat to prolong retention periods and dehydrate and decompose the waste efficiently.

500 Series Basic – Solar powered

THE MOBISAN TOILET

The 12 m Mobisan toilet is a dry sanitation option consists of a row of 13 toilet closets (4 kids, 5 women, 4 men) and 12 separate urinals. This may be installed according to the informal settlement's needs and population. It is an independent and self-contained system. Urine and faeces are stored separately in the Mobisan, then disposed out to the nearest treatment plant.

The faeces falls into a ventilated chamber. A gearbox control mechanism on the outside of the cabin allows the solid waste to be stirred, which speeds up the drying of the excrement.

It is then channeled into a second compartment where the drying process is finalised.

This mobile unit can be easily moved to informal settlements, easily and various other features can be added depending on the requirements.

In this application a small office for maintenance staff was added.

This sanitation technology is being introduced to service ± 500 people when managed and maintained by dedicated janitorial services 24/7.
(Piloted at Pook se Bos informal settlement, Rylands)

OUR VISION

To become leaders in the provision of equitable and sustainable, people-oriented, affordable and dignified water and sanitation services to all.

WATER AND SANITATION

Informal Settlement Unit
Tel: 021 918 7424 or 021 918 7401
(week days from 08:00 am to 16:30 pm)
E-mail: water.informalsettlements@capetown.gov.za

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SANITATION TECHNOLOGIES AND SERVICE STANDARDS

Figure Q.1b: Brochure listing various sanitation technologies and service standards provided by CCT (CCT, 2011c)

T. Mtshini Wam reblocking layout

Figure T.1: Mtshini Wam reblocking layout (CORC, 2013)

U. Sustainability nodal coding frequency chart for all sub-categories for each municipality

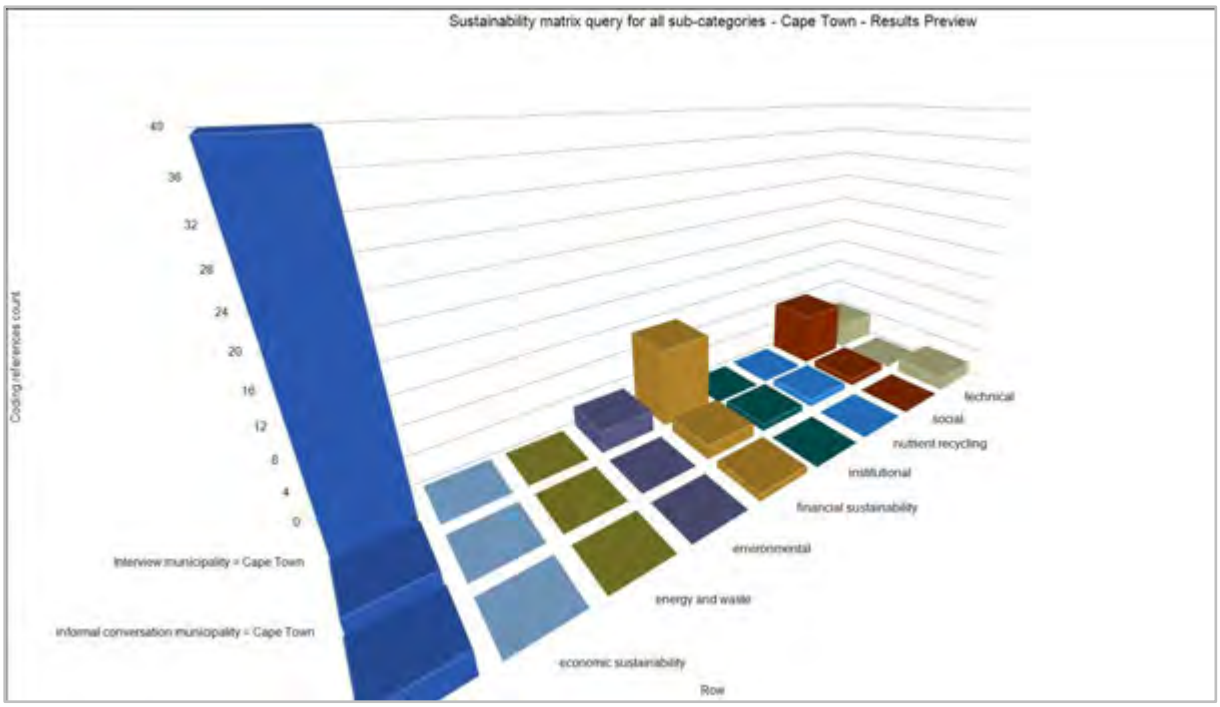

Figure U.1: Sustainability and sub-category nodal coding frequency for Cape Town sources

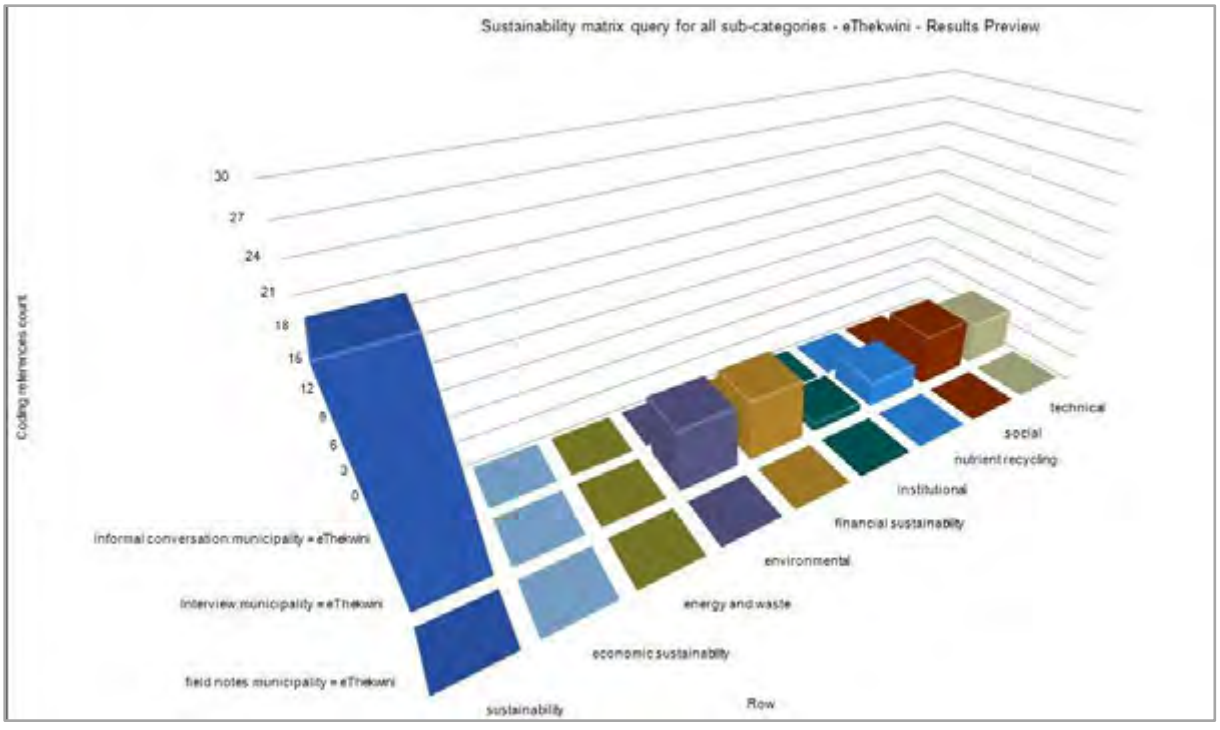

Figure U.2: Sustainability and sub-category nodal coding frequency for eThekwini sources

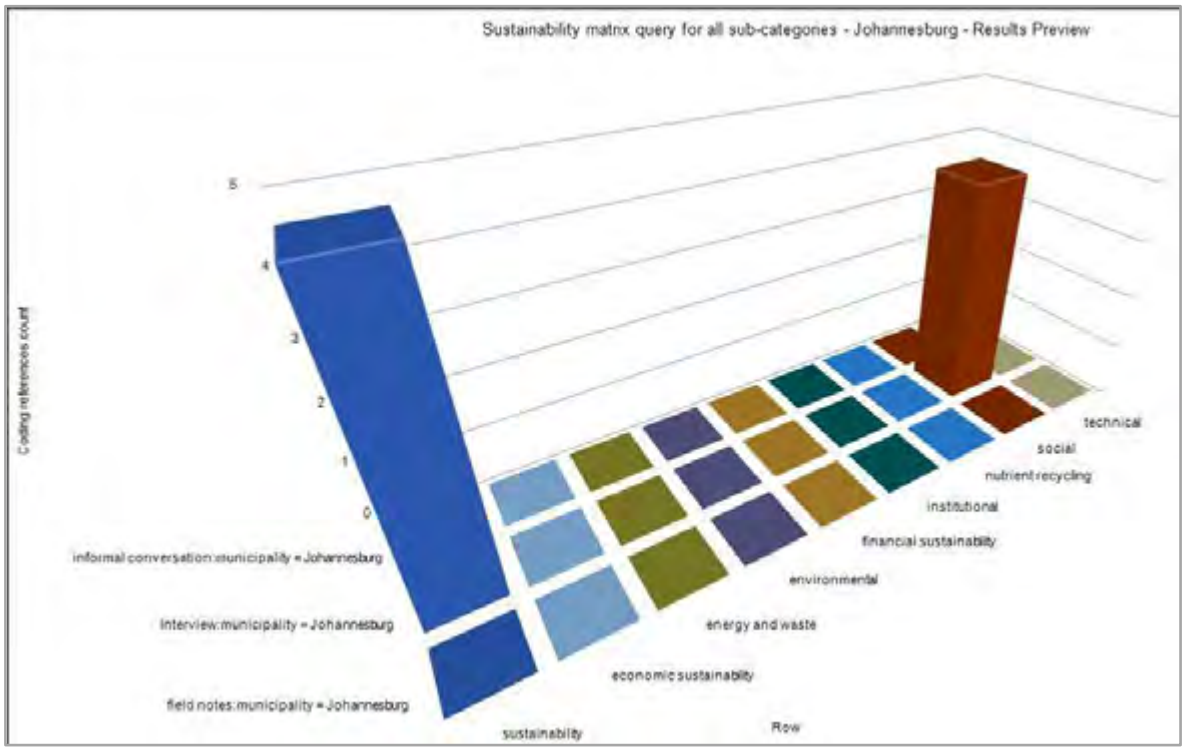

Figure U.3: Sustainability and sub-category nodal coding frequency for Johannesburg sources

V. M&E tools for water services in South Africa

Table V.1a: M&E Tools for water services in South Africa (DWAF, 2008; Carden, 2013; DWA, 2015b)

Tool	Responsible institutions	Description	Purpose	Relevance to basic sanitation sustainability & equity	Success
Regulatory Performance Measurement System (RPMS)	DWS – regulator WSAs – implementer	Reporting system between WSAs and DWS with various KPIs relating to water and sanitation services	• Monitoring local government performance • Allow WSAs to benchmark performance with peers • Improve data quality on water services	KPIs to measure backlog reduction rate, planned targets for reducing backlogs, & MIG funding spent on sanitation	Appears to have been discontinued
Blue Drop	DWS – regulator WSAs - implementer	Certification programme measuring drinking water quality and asset management	• Encouraging WSAs to comply with drinking water legislation • Provide citizens with information on drinking water status in their locale • Marketing tool for WSAs	No direct measurement of sanitation services, but blue drop status can be negatively affected by poor sanitation polluting water sources	
Green Drop	DWS – regulator WSAs- implementer	Certification programme monitoring wastewater quality and asset management	Encouraging WSAs to improve wastewater management practices	Monitoring that wastewater is treated to national standards; faecal sludge management from alternative systems is not directly addressed	

Table V1.b: M&E Tools for water services in South Africa (DWAF, 2008; DWA, 2015b)

Tool	Responsible institutions	Description	Purpose	Relevance to basic sanitation sustainability & equity	Success
Municipal Benchmarking Initiative (MBI)	SALGA -- lead WRC -- support Municipalities -- implement	A system to track municipal performance using water services data, and allow for comparison to other municipalities and national average	To improve municipal water service performance through systematic measuring of specific parameters and to increase interactions between municipalities	Recording data on access to different types of sanitation services and proportion of capital budget spent on eliminating backlogs	One report has been published and an online database/tool setup, but participation is voluntary and requires funding
Sustainability Index for Urban Water Management (SIUWM)	UCT – develop/ promote Municipalities -- implement	Composite index for assessing sustainability of urban water management in cities	Provide a holistic tool to assist decision-makers with goal setting and measuring progress of sustainability in water services	Indicators measuring access to sanitation, LoS, capacity to pay	10 case studies in South African cities; 1 in Mozambique, but participation is voluntary and requires funding