

UNIVERSITY OF CAPE TOWN

Water Supply and Sanitation Services in South Africa: A Cluster Analysis Approach

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Executive Summary

Previous government policy dictated that municipal services should **not** be distributed equally to all South Africans. Consequently, large inequalities in access to water supply and sanitation services were created along racial and geographic lines. After 1994, government policy sort to rectify this situation, largely through pro-poor service provision policies and programs.

Continuous and accurate monitoring and reporting of access statistics is crucial to ensuring that progress is made. Progress within the provinces, however, would not have been equal due to the difficulty with providing services to different regions. As such, large disparities still exist. In order to assess the current inequality, local municipalities were grouped according to *access to adequate services* and their *progress made* from 2001, using the statistical method of cluster analysis.

It was discovered that provinces, with access to improved services for over 75% of households, had municipalities with similar access to adequate services; this includes Western Cape, Gauteng and Free State. For the other provinces, great inequalities were found between municipalities. Some municipalities showed a decline in access to improved services; this is despite provincial access to improved services increasing for all provinces. Cases emerged where local municipalities in the same district municipality did not show similarly changes in access to improved services.

The progress between water supply and sanitation provision was dissimilar, with growth occurring in different timeframes. A large number of municipalities showed negative progress for sanitation for 2007-2011 despite the fact that the Bucket Eradication Programme – aimed at diminishing the number of bucket facilities in the country - was established in 2005.

The lag in sanitation progress between 2007 and 2011 could be attributed to the fact that sanitation provision from 2007 was focussed in rural areas, which are demonstrably difficult to deliver services to; that poorly built toilets needed restoration, diverting funds from providing new facilities; and that transferring responsibility of sanitation provision from DWA to DHS in 2009 led to non-efficient functioning of the *National Sanitation Programme*.

More provinces showed a correlation between progress made between 2001 and 2011, and prior access to *adequate* services for water supply than sanitation. This coupled with the fact that rural municipalities had a greater capital expenditure than other local municipalities for water supply and not for sanitation, indicates that the pro-poor initiatives have been more successful in water supply than in sanitation. This highlights that sanitation provision has been challenging and slow.

Major limitations of the study exist due progress being calculated as a percentage, and assuming that the facilities access are operational. Calculating progress as a percentage is effected by growth in the number of households in the municipality. The water services infrastructure in South Africa was found to be of an unsatisfactory standard. Re-examination of access to water services taking into account the condition of the services would yield markedly different results.

Looking forward, it would be worthwhile combining other data related to water supply and sanitation in the cluster analysis, such as Blue& Green Drop scores, MIG expenditure and operation and maintenance data. Future research could also analyse absolute backlog instead of percentage backlog. Blue and Green Drop reports have also only been done since 2009. Operation and maintenance, and state of infrastructure data are not widely available at municipal level.

University of Cape Town

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List of Abbreviations

cidb – Construction Industry Development Board

COGTA – Department of Cooperative Governance and Traditional Affairs

CSIR – Council for Scientific and Industrial Research

DHS – Department of Human Settlements

DM – District Municipality

DWA – Department of Water Affairs

DWF – Department of Water Affairs and Forestry

EA – Enumeration Area

HSRC – Human Sciences Research Council

JMP – Joint Monitoring Programme

LM – Local Municipality

LOS – Level of service

MAUP - Modifiable Areal Unit Problem

MDG – Millennium Development Goals

MIP - Municipal Infrastructure Program

PICC - Presidential Infrastructure Coordinating Commission

RDP – Reconstruction and Development Programme

SAICE – The South African Institution of Civil Engineering

SAIRR – South African Institute of Race Relations

SIP – Strategic Integrated Projects

Stats SA – Statistics South Africa

UNICEF – United Nations Children’s Fund

VIP Latrine – Ventilated Pit Latrine

VRC – Variance Ratio Criterion

WHO – World Health Organization

WSA – Water Service Authority

WSP – Water Service Provider

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Introduction

Background to water and sanitation services in South Africa

After coming into power in 1994, the newly elected democratic government inherited overwhelming municipal service backlogs that were found largely in rural, black, poor regions in South Africa (Manase et al., 2009). “Service delivery for the urban and rural poor was non-existent or desultory” (Levin, 2007: 2). The Department of Public Works, (1997) cited in Bond (1999), reported that “only 27% of African households have running tap water inside their residences, only 34% have access to flush toilets” (Bond, 1999: 44). Of the 15 million people without access to safe water supply in 1994, 12 million were located in rural areas (Lane, 2004: 10). Furthermore, “21 million people did not have adequate sanitation” (Torres, 2000: 157). The condition, according to the 1996 Census conducted by Statistics South Africa (StatsSA), was such that “one in three households rely on a pit latrine, while less than one in twenty use a bucket” (Torres, 2000: 165).

The service delivery challenge faced by the new government, according to Hemson, (1994) cited in Smith (2009), was “to reduce the apartheid backlog whilst concurrently raising the level of service delivered” (Smith, 2009: 20). The newly elected South African government, in 1994, undertook various measures to rectify these backlogs by ensuring “a more equitable distribution of public services” (Smith, 2004: 382). Water supply and sanitation were top priorities, with importance placed on quickly and efficiently providing services to the previously deprived, poor households (Nnadozie, 2011).

Rectifying measures included incorporating the right to adequate and sustainable water supply and sanitation services in Section 27 (1b) *Bill of Rights* in the *Constitution of the Republic of SA 1996* (No. 108 of 1996); producing various Acts, White Papers and policies focused on water supply and sanitation services; and implementing programs aimed at reducing the water supply and sanitation backlog. *The White Paper on Water Supply and Sanitation* (1994) further stipulates that performance monitoring is required to “ensure that standards are maintained” and “that adequate basic service coverage is achieved and maintained” (DWAF, 1994: 27).

Water sector governing structures were transformed to consolidate regulation of the sector, where previously, the homeland governments and local municipalities were each solely responsible for water supply and sanitation services. After 1994, Department of Water Affairs and Forestry (DWAF) was tasked with regulating the water sector (DWAF, 2004).

Notable progress has been achieved. The percentage of households without access to piped water declined from 16% in 2001 to 9% in 2011 and the percentage of households without access to toilets (including bucket latrine) declined from 18% in 2001 to 7% in 2011 (StatsSA, 2012).

Significance of the Water Supply and Sanitation Problem

The importance of ensuring delivery of acceptable water supply and sanitation systems has long been investigated. The obvious impact is on the reduction of largely preventable water-related diseases, such as diarrhoea. Globally, diarrhoeal disease is the fifth leading cause of death in the world between 2000 and 2011 (WHO, 2013a). The effect of diarrhoeal disease on children is more

severe; diarrhoeal disease is the second leading cause of death in children under the age of five (WHO, 2013b). In South Africa specifically, the mortality rate (65-70 per 1000 births) in children under the age of 5 is largely due to diarrhoeal disease, which is prevalent in informal settlements and rural areas (DWA, 2013).

Additional benefits of adequate water supply and sanitation include alleviating conditions associated with poverty (WEDC, 2003, as cited in Manase et al., 2009, and Heleba, 2009), generating economic benefits (Lane, 2004), being cost-beneficial (Hutton & Haller, 2004) and, in the case of improved sanitation, providing greater dignity (Lane, 2004).

It is important to note that while access to both water supply and sanitation services were included as a human right in the *South African Constitution* (Act 108 of 1996), progress in sanitation services has markedly lagged behind water supply; a reality seen in other developing countries. Additionally, “spending on sanitation was also only about one-tenth of what was spent on water delivery” (Khosa, 2000: 52). Lane (2004) argues that “this was partly because the communities themselves had always strongly prioritized water supply and partly because there was not a good system for promoting sanitation at the community level” (Lane, 2004: 12).

Initial backlogs were uneven, in that the backlogs were “more severe in the poorer black rural areas than they were in the mainly white and more affluent urban areas” (DWAF, 2004: 4). These previously deprived areas are further disadvantaged by the fact that building social services is more complex and costly and thus slower than simply maintaining it (Torres, 2000: 17). Given that “the poor are unevenly distributed by province” (Torres, 2000: 10), and rural areas are notably impoverished, delivery of these services would expectantly be disparate. As such, there was a notable pro-poor focus for government services (Nnadozie, 2011).

The *Reconstruction and Development Programme* (RDP) emphasized the delivery of basic services (DWAF, 2004). Since 1994, basic water supply and sanitation facilities have been delivered to 21.1 million and 17.3 million people respectively (DWA, 2013: 67). Currently, 1.3 million households (6%) lack access to piped water supply facilities, while 4.5 million households (31%) lack access to basic sanitation facilities (DWA, 2013). Furthermore, rural municipalities were found to have the highest number of municipal services backlogs (National Treasury, 2012). The backlogs indicate the on-going disparity in access to services.

While the backlog in the urban poor settlements is largely attributed to population growth from “increased migration and sharp growth of informal settlements” (WSP, 2007: 58), it should be noted that determining the cause of backlog is not simple. The increase in backlog could be due to an increase in households or a decline in service (Nnadozie, 2011).

With 71 protests in 2012 being attributed to dissatisfaction in the water sector (DWA, 2013), ensuring progress in service delivery is fundamental to socio-economic stability in South Africa. Access to water supply and sanitation services are consistently being assessed in order to evaluate progress. Focussing on disparate progress of the service delivery can shed light on areas that may be consistently experiencing slow progress and therefore need to be prioritised.

Hypothesis

The impoverished, rural local municipalities that possessed the worst access statistics after 1994 should have had more progress than the affluent municipalities that initially presented with favourable access statistics.

Aims and Objectives

- Analyse access statistics at municipal level with maps illustrating the statistics spatially.
- Perform correlation analysis to assess whether or not there is a relationship between *access to adequate services in 2001* and *progress from 2001-2011*.

Scope and Limitations

- Population Censuses prior to 1994 did not accurately represent all population groups in South Africa; access data after 1994 was used.
- Municipal demarcations were altered repeatedly over the past 18 years. The municipal statistics had to be with the same geographic demarcations.
- Access to services was measured at local municipal level.

Statement of Assumptions

- Progress in water supply and sanitation services were measured as the change in percentage of households that have access to adequate water supply and sanitation services.
- It is assumed that the water and sanitation systems were operational.
- The statistics were presented at 2011 municipal demarcation in order to assure comparability.

Literature Review

Global interest in water and sanitation

Inadequate water supply and sanitation service delivery is a concern in many countries, with over 780 million people without access to safe drinking water and 2.5 billion people without access to adequate sanitation (UNICEF & WHO, 2012). The reality of inadequate services unduly falls on the impoverished in developing countries, specifically in rural Africa where the worst access statistics are found (Hope, 2006: 168). Women and children are also understood to bear the burden of inadequate water supply and sanitation (Lane, 2004: 3; Tissington, 2011: 68 and Torres, 2000: 157). Negative effects include limiting the potential for reducing poverty, thus stifling human development and economic growth (Deininger & Mpuga, 2005: 171; Esfahani, 2005: 498 and Torres, 2000: 7).

Given that inadequate service delivery limits the potential for growth, the benefits for improving the services are numerous. Geographical, economic and ecological benefits are predicted (Bond, 1999: 52). The most notable benefit is in public health and related cost savings (Lane, 2004: 2). Public health benefits, arguably, should be the leading influence on policy-making, given the overwhelming burden that comes from the occurrence of water related diseases (Bond, 1999: 52).

It is crucial to note that sanitation, in conjunction with safe potable water, assists in minimising the burden of water related diseases. "Water provision, without adequate wastewater disposal provision such as that provided by waterborne sanitation, may be a health hazard in itself" (Bond, 1999: 54). Additionally, water supply and sanitation provision are integrally linked in that "for households living with waterborne toilets, access to sanitation requires a continuous supply of water for flushing. Without access to sufficient water that is affordable, households can have extremely compromised access to sanitation" (Tissington, 2011: 68).

The impact of water related diseases on developing countries is substantial. Globally, diarrhoeal disease is the fifth leading cause of death in the world between 2000 and 2011 (WHO, 2013a). The effect of diarrhoeal disease on children is more severe; diarrhoeal disease is the second leading cause of death in children under the age of five (WHO, 2013b). In South Africa specifically, the mortality rate (65-70 per 1000 births) in children under the age of 5 is largely due to diarrhoeal disease, which is prevalent in informal settlements and rural areas (DWA, 2013).

"The urgent need for basic water and sanitation services for the poor assumes even greater significance when the linked with other aspects of poverty such as poor education. Water and sanitation related sicknesses put severe burdens on health service." (DHS, 2012: 13)

Due to the importance of water supply and sanitation improvement, the *UN Millennium Development Goals* (MDGs) established in 2000, aimed at mitigating factors linked to poverty and mortality in developing countries. This included Target 7C that stipulates having to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation" (Heleba, 2009: 12). Furthermore, access to safe water has been recognised as a human right in various declarations and conventions. The UN Committee on Economic, Cultural and Social Rights, for example, states that "the human right to water entitles everyone to sufficient, affordable, physically accessible, safe and acceptable water for personal and domestic uses" (Lane, 2004: 5).

Minimum service provision standards have been set to ensure a universal standard. Regarding water supply, "WHO and UNICEF have set the minimum of 20 litres of safe drinking water per person per day, and water source must be located within a reasonable distance from the household" (Heleba, 2009: 11).

The 2012 *WHO/UNICEF Joint Monitoring Programme (JMP)* for water supply and sanitation report found that, between 1990 and 2010, over 2 billion people received access to adequate water supply facilities and 1.8 billion people received access to adequate sanitation facilities (UNICEF & WHO, 2012). The drinking water target was met in 2010, while the sanitation target will not be met (UNICEF & WHO, 2012). Urban-rural disparities still exist and not all countries are on track to meet the targets; a large number of these countries are in Sub-Saharan Africa (UNICEF & WHO, 2012).

The on-going disparity highlights that presenting overall statistics alone can obscure the inequalities that exist locally. "The overall statistics masked extreme contrast between different sectors of society. In most of the white-ruled local areas, standards were equal to those in industrial countries. In black rural areas there were often no services at all; in black urban areas service was mixed" (Lane, 2004: 6).

Understanding the water supply and sanitation disparities in South Africa

The consequence of Apartheid on the current problems experienced in South Africa is undisputed and widely evident. The Apartheid policies were aimed at creating a disparate country. There was inadequate provision of municipal services to severely under-resourced and overloaded municipal structures in rural, impoverished communities. This "presented the ANC with what might arguably be the greatest transformative challenge ever faced by a democratic government" (Heller, 2001: 143). The disparate access to services was stark. In October 1996, 18% of households in Northern Province had taps inside the dwelling, compared with 76% in Western Cape. And 29% of households in Eastern Cape do not have any toilet facilities, compared with 3% in Gauteng (StatsSA, 1996).

The service backlogs are still largely found in rural areas and within urban poor settlements, as illustrated in the following:

"Despite improvements in government services to the poor, there are concerns. Data released by Statistics South Africa in 2007 indicated that it has proven difficult to reach many of the poorest municipal districts as well as informal settlements and farm workers. As a result, poor households continue to lag in access to government services." (Heleba, 2009: 25)

Progress has been challenging, particularly with sanitation.

"It is extremely difficult to incrementally upgrade infrastructure, particularly sanitation systems, from pit latrines to waterborne sewage, resulting in permanently segregated low-income ghettos (from which households that raise their real earnings to above R800 per month will have to emigrate in order to gain access to improved infrastructure and services)." (Bond, 1999: 45)

DWA (2012c) estimates that the sanitation backlog is now at 1.4 million households (11%) (DWA, 2012c). There have, however, been many challenges and setbacks with the implemented projects and programs.

Elhiraika (2007) states the various roles established for the three spheres of government (Figure 3).

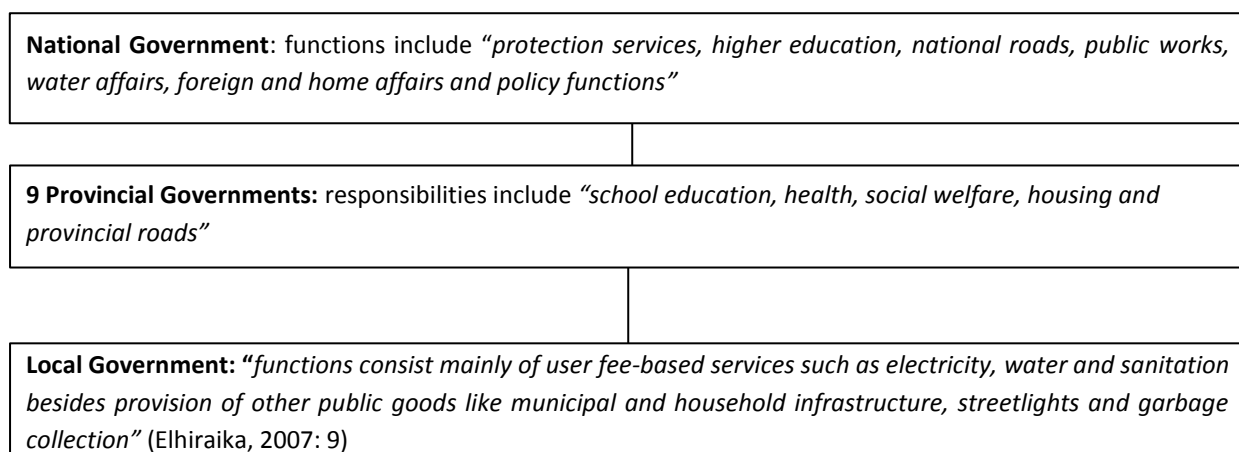


Figure 3: Current government structure

The municipalities were tasked to, according to the *Constitutional Assembly*, (1996) cited in Bond (1999),

“give priority to the basic needs of the community, and to promote the social and economic development of the community, and to participate in national and provincial development programmes (Constitutional Assembly, 1996, Section 153) ...The goal, as spelled out in the Bill of Rights (Constitutional Assembly, 1996, Ch. 2), is to progressively ensure that citizens can exercise their rights of access to water, health care, a clean environment, housing and, more generally, dignity” (Bond, 1999: 44).

According to BESG (2008), the local government is appropriate for providing certain services given that, *“local government is the closest sphere of government to the people, and is therefore assumed to be the tier that can most readily identify, prioritise, and implement programmes and projects to address development needs”* (BESG, 2008: 1).

Local Government is structured into 3 categories.

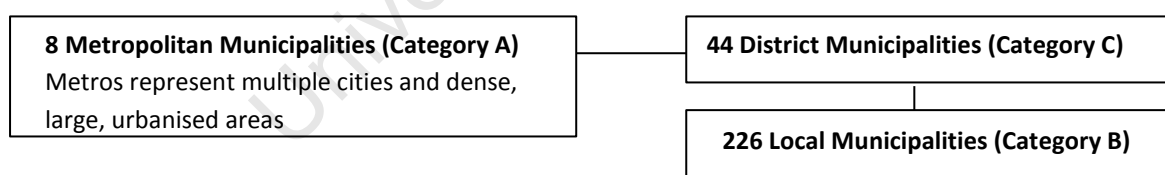


Figure 4: Local Government categorisation

Category B and C municipalities are further categorised as follows (Municipal Demarcation Board, 2012):

Table 1: Classification of municipalities

Category	Characteristics
Secondary cities (B1)	Local municipalities (LMs) with the largest budgets
Large towns (B2)	Local municipalities with large urban core
Small towns (B3)	Local municipalities with small towns and rural areas. Substantial proportion of the population is located in towns. Commercial farms characterise the rural areas.
Mostly rural (B4)	Local municipalities that are largely rural – typically located in former homelands – with at most one or two small towns.
Districts (C1)	District municipalities (DMs) that are not water service providers
Districts (C2)	District municipalities that are water service providers

B3 and B3 municipalities are rural municipalities; the population demographics below show that a substantial portion of the population lives in rural areas.

The population in 2011 was estimated at 51.77 million people, of which, “18.12 million people (or 35% of the population) live in small rural villages and scattered settlements” (DWA, 2013: 16)

Rural areas were defined in the *Rural Development Framework* (1997) as having the following two features:

- “sparsely populated areas in which people farm or depend on natural resources, including villages and small towns that are dispersed through these areas
- areas that include large settlements in the former homelands, which depend on migratory labour and remittances as well as government social grants for their survival, and typically have traditional land tenure systems” (National Treasury, 2012: 192).

Geographically, rural municipalities are concentrated in KwaZulu-Natal, Eastern Cape, Northern Cape and Limpopo. The metros such as eThekweni and Tshwane encompass rural areas (National Treasury, 2012: 192).

Furthermore, “[t]here are significant differences in settlement types between B3 and B4 municipalities. Statistics South Africa reported in Census 2001 that 52 per cent of households in B3 municipalities live in small urban settlements, 29 per cent on farms and 10 per cent in settlements located on tribal land. In B4 municipalities, 83 per cent of households live in tribal settlements, while only 7 per cent live on farms and in small towns respectively” (National Treasury, 2012: 192).

Governance in the water sector

Water sector governing structures were transformed to consolidate regulation of the sector. Previously, the homeland governments and local municipalities were each solely responsible of water supply and sanitation services (DWAF, 2004).

The roles and responsibilities of the water sector were divided up between different organizations, at various spheres of government. The following table sets out roles and responsibilities for water supply and sanitation sectors (DWA, 2013).

Table 2: Roles and responsibilities of various institutions for water supply and sanitation services

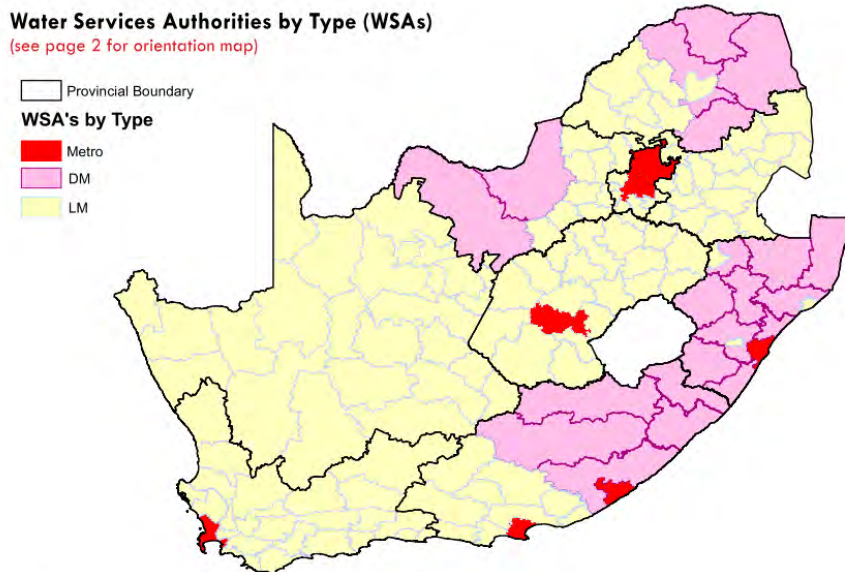
Sphere of Government	Institutions				
National	Department of Water Affairs Oversees and regulates the water sector including <i>water supply and sanitation</i> provision and manage water resources. It monitors performance, regulates water quality standards and develops policy and water sector guidelines.	Department of Human Settlements Took over regulation of <i>sanitation</i> provision from DWA in 2009. Responsible for water supply backlog eradication from informal settlements.	Catchment Management Agency		
Provincial			Manages water resources within a catchment area		
District and Local			Water Utilities and Water Boards Manage bulk water distribution	Water Service Authority Responsible for planning, implementing and operating infrastructure.	Water Service Provider Provides water supply services

The *Water Services Act* (1997) tasked the Department of Water Affairs (DWA) with regulating the water sector; Water Boards with providing bulk services; and municipalities as WSPs. DWA is governed by *National Water Act* (1998) and *Water Services Act* (1997). The department went from being responsible for service provision from 1994, to a supporting role to the WSAs in 2003, and finally national water services regulator in 2010 (DWA, 2013).

“As the national regulator, DWA has legal recourse against non-compliance by WSAs, as well as the ability to hand over water services functions to different departments or spheres of government if there is a major problem. DWA will also be able to intervene in service delivery if there is a gross failure on the part of a WSA and where lives and/or the environment are at risk.” (Tissington, 2011: 52)

Currently, DWA is responsible for bulk infrastructure, policy and regulation of the water sector. Municipalities, sometimes in conjunction with Water Boards, are responsible for water quality and provision of local water systems (SAICE, 2011). *“Locally, in general, water boards – the institutional tier between national and local government – are better equipped in terms of capacity and finance than municipalities. Infrastructure managed by water boards is thus usually in better condition”* (SAICE, 2011: 14).

There are currently 152 WSAs in South Africa; the DMs that are WSAs are largely located in former homeland regions (Figure 4).



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Figure 5: Water Service Authorities Map (DWA, 2013: 18)

Under the *Water Services Act* (No. 108 of 1997), the Water Affairs Minister and the relevant province is responsible for monitoring the performance of the water services institutions. The Minister then has to provide a national information system on water services to water services institutions, consumers and the public (DWA, 2005: 37).

Other institutions, such as *South African Institute of Race Relations* (SAIRR) and *Human Sciences Research Council* (HSRC), report on access to water and sanitation facilities. There are, however, no standards for collecting and verifying data, and reporting statistics. The absence of common measures can be problematic. “The problem has already manifested itself on a number of occasions, resulting in members of the public, government and politicians questioning the accuracy and consistency of government reporting with regard to service delivery statistics” (COGTA, 2009a: 10).

While sanitation provision is lagging behind water supply provision, Lane (2004) argues that the cholera outbreak in 2000 brought to light the slow progress made in sanitation provision (Lane, 2004: 12). There is still an “absence of regulation around sanitation at all levels of government” (Tissington, 2011). Sanitation provision is further complicated by the fact that sanitation functions has moved from the Department of Water Affairs (DWA) – previously DWA – to the Department of Human Settlements (DHS) in 2009 resulting in “institutional confusion over roles and responsibilities” (Tissington, 2011: 69).

“According to the DHS the transfer process took over 10 months to complete and: delays in the movement posed serious challenges to the functioning of National Sanitation Programme as neither the Department of Water Affairs nor Department of Human Settlements was willing to accept responsibility for the National Sanitation Programme during the preparatory stage of the move.” (Tissington, 2011: 61)

Right to safe drinking water and sanitation services in South Africa

The laws and policies advocated by the Apartheid government had to be restructured to better depict the democratic and non-racial disposition of the new government. The policies related to

public service aimed to redress the racial inequities by tackling complex issues associated with service delivery (Schwella, 2001: 372).

Government legislation which pertain to water and sanitation provision include, but is not limited to, the following

- The *Bill of Rights* in the *Constitution* (1996) includes the right to access to safe water (Constitution of the Republic of SA 1996, Act 108 of 1996, Article 27(1b)). While the Constitution does not explicitly state the right to safe sanitation, it is implied through the presence of rights to human dignity, Section 10, and a safe environment, Section 24 (Tissington, 2011: 68).
- *Water Services Act* (1997) and *Water Services Amendment Act* (2004), stipulates the basic sanitation standards, section 1(ii), and the basic water supply standards, section 1(iii) (Water Services Act, 108 of 1997). Additionally, responsibility for water services provision lies with local governments (WSP, 2007: 38).
- *National Sanitation Policy* (1996)
- *White Paper on National Water Policy* (1997)
- *Municipal Systems Act* (2000) which “set out the local government obligations to provide basic municipal services, with a particular focus the basic needs of the community and the promotion of social and economic development of the community” (Tissington, 2011: 68). Local government was stipulated as Water Service Authorities (WSAs) which oversee water services provision. The WSAs can outsource the service delivery to other capable entities, which then become the Water Services Providers (WSPs) (WSP, 2007: 38).
- The *White Paper on Water and Sanitation* (1994) was one of the first policy documents on the water and sanitation sector that highlighted the importance of rapid water and sanitation provision (DWA, 2004: 5). The *White Paper on Water and Sanitation* (1994) was revised in 2000 in response to sanitation lagging behind water supply (Tissington, 2011: 69).
- South Africa’s *Strategic Framework for Water Services* (2003) stipulates goals for water and sanitation provision, including “universal provision of access to a functioning basic water supply facility by 2008 and universal access to a functioning, basic sanitation facility by 2010” (WSP, 2007: 38).

The *Strategic Framework for Water Services* (2003) also provides definitions for basic water supply and basic sanitation.

- Basic water supply “means the provision of a basic water supply facility, the sustainable operation of the facility (available for at least 350 days per year and not interrupted for more than 48 consecutive hours per incident) and the communication of good water-use, hygiene and related practices. (A basic water supply facility is defined as the infrastructure necessary to provide 25 litres of potable water per person per day within 200 metres of a household and with a minimum flow of 10 litres per minute.)”

- Basic sanitation *“means the provision of a basic sanitation facility which is easily accessible to a household, the sustainable operation of the facility, including the safe removal of human waste and wastewater from the premises where this is appropriate and necessary, and the communication of good sanitation, hygiene and related practices. (A basic sanitation facility is defined as the infrastructure necessary to provide a sanitation service which is safe, reliable, private, protected from weather, ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of disease carrying flies and pests, and enables safe and appropriate treatment and /or removal of human water and wastewater in an environmentally sound manner.)”* (DWAF 2005: 29)

Furthermore, WSAs were instructed to provide Water Services Development Plans (WSDPs) which includes the current status quo and service delivery targets (DWAF 2005: 34).

Programmes, policies and funding

The *Reconstruction and Development Programme* (RDP), a socio-economic policy framework, stipulates the social development policy, aimed at amending the social and economic challenges in the country by extending basic services (van Niekerk, 1998: 1). Essentially, the main objective is to “eradicate the legacy of apartheid” (Torres, 2000: 7). The key emphasis of the RDP, with respect to water supply and sanitation, is ensuring that basic services are accessible universally in South Africa (Nnadozie, 2011).

The Municipal Infrastructure Program (MIP), created in line with the targets of RDP, aimed to:

“rehabilitate, upgrade and provide new municipal infrastructure to meet the basic needs of communities as efficiently and effectively as possible. A further objective was to enhance the developmental capability of municipalities and promote their financial viability and democratisation. Job creation and the transfer of skills were seen as a secondary benefit” (Torres, 2000: 157).

Funding is a crucial aspect of service delivery; if a service is not adequately budgeted for, government cannot provide the service (Torres, 2000: 21). Water and sanitation provision is solely funded by national government, a practice which is typical of middle-income countries and not developing ones (Lane, 2004: 17). Water and sanitation received the greatest proportion of the MIP funding, given the importance of water services at national government level (Torres, 2000: 158).

“All local government infrastructure grant funding is now consolidated into the ‘Municipal Infrastructure Grant’ which is aimed at assisting the poor to gain access to infrastructure. MIG funds can only be used for infrastructure for basic levels of service.” (DWAF, 2005)

The budget presented by government has obviously shifted since the Apartheid years, with the focus being on providing to the previously marginalised. The budget essentially “redistributes income from richer to poorer households” given that “the top quintile pays for lion’s share of income tax and because social spending as a proportion of income is higher for the poor than the rich” (Nattrass & Seekings 2001: 477). This redistribution of social spending is crucial given that increased public expenditure does not necessarily equate to “progressive distribution” (Nattrass & Seekings 2001: 477).

Social services accounted for almost 47% of total consolidated national and provincial expenditure in the 1997-1998 budget (May 1998: 4). Furthermore, social services spending increased faster than

other budget items (Torres, 2000: 14). The expenditure has varying effects within the municipalities depending on the initial level of service, given that building facilities cost more than maintaining them (Torres, 2000: 27).

The *Free Basic Services Policy*, adopted in 2001, sought to provide free basic municipal services to all South Africans, with the priority being the poor (Smith, 2009: 23). The policy was understood to assist in poverty alleviation and improve hygiene conditions in indigent communities (Smith, 2009: 23). According to Mjoli et al., (2009) cited in Tissington (2011), FBSan has not been implemented in many municipalities because “there is no common approach to the interpretation of free basic sanitation service policy by different municipalities” (Tissington, 2011: 65). While RDP standards state basic sanitation service requires access to a VIP toilet (Torres, 2000: 165), other communities see urine diversion (UD) toilet as basic level of service (Nnadozie, 2011).

In light of the difficulties surrounding sanitation provision, programmes specific to sanitation, such as the *National Sanitation Programme*, were initiated. An evaluation of the *National Sanitation Programme* was done to identify obstacles to sanitation provision. “The Minister’s undertaking was rooted in concern for the human dignity of communities affected by inefficiencies in sanitation provision as confirmed by various media exposé displaying the unacceptable realities in Makhaza, Moqhaka and Moutse communities for example” (DHS, 2012).

As a further means of remedying the lag in sanitation services, the bucket eradication programme was established in 2005. The aim of the programme was to replace existing, inadequate bucket facilities with more appropriate and acceptable services. At the proposed completion date, December 2007, “an estimated 252 254 households still needed to be reached” (National Treasury, 2012: 132).

The prioritisation of sanitation provision in rural areas was solidified with the establishment of the *Rural Household Infrastructure Programme* (RHIP) in 2010. The mandate of the RHIP is “every rural household to have basic sanitation and water” and the Programme is set to use R1.2 billion (DHS, n.d.).

“The RHIP is designed to help municipalities to reduce backlogs in sanitation and water supply. It is implemented in seven provinces except in Gauteng and Western Cape where there are no rural backlogs in sanitation. The other important facet of the programme is to alleviate poverty by implementing programmes through labour intensive methods” (DHS, n.d.: 5).

It is clear from the aforementioned policies and programmes that, after 1994, the focus of water supply and sanitation provision was pro-poor. This focus was to redress the preceding uneven access to adequate services. Bhorat et al. (2004); Bhorat and Canbur (2005); Bhorat et al. (2008a;b), cited in Nnadozie (2011), conducted studies into service delivery that corroborate the notion of a pro-poor focus. “Households at the bottom of the expenditure deciles (poorest of the poor) were found to have benefited more from government services” (Nnadozie, 2011: 340).

Despite these programmes and interventions, the service delivery goals set out by government have largely not been met.

“President Mbeki gave an undertaking in 2006 that the bucket system of sanitation would be eradicated in formally established areas by the end of this year. In addition, 2.07 million households

must be provided with potable water by December 2008. A total of 3.7 million households need to be provided with sanitation by 2010. A total of 3.4 million households need to be electrified by 2012. A total of 2.3 million households need to be provided with adequate shelter by 2014. In all these areas, on the current trajectory the targets will not be met.” (Levin, 2007: 3)

The water supply and sanitation provision targets have thus been revised:

- “All people in South Africa have access to a functioning basic water supply facility by 2014.
- All people in South Africa have access to a functioning basic sanitation facility by 2014.”
(DWA, 2013: 24)

The DWA has determined that revised targets will not be met (DWA, 2013: 22).

“The operational debt of some municipalities is so severe that, even if no further infrastructure were acquired, it could well still be impossible for them, without innovative external assistance, to catch up with existing maintenance backlogs and restore sustainable operations” (DHS, 2012: 71).

Government has stipulated service delivery plans for the future in the *South African National Infrastructure Plan* (PICC, 2012). Future Strategic Integrated Projects (SIPs) will “address the spatial imbalances of the past by addressing the needs of the poorer provinces and enabling socio-economic development”; the emphasis will be on regions lagging in service delivery provision (PICC, 2012: 15).

For water and sanitation infrastructure specifically,

“10-year plan to address the estimated backlog of adequate water to supply 1.4m households and 2.1m households to basic sanitation. The project will involve provision of sustainable supply of water to meet social needs and support economic growth. Projects will provide for new infrastructure, rehabilitation and upgrading of existing infrastructure, as well as improve management of water infrastructure” (PICC, 2012: 25).

Current issues impeding water supply and sanitation provision

Despite the pro-poor focus of water supply and sanitation provision, substantial backlogs still exist among poor households (Nnadozie, 2011).

Many factors influence the progress of service delivery in South Africa. Torres (2000) argues the following points illustrate the complexity of service delivery in South Africa:

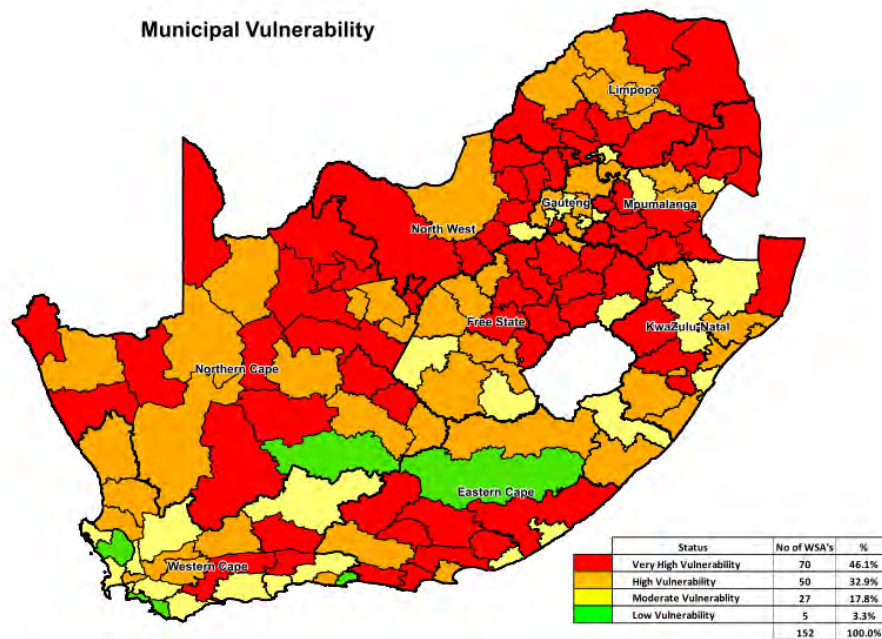
- Having to build services rather than maintain
- High poverty rates
- High unemployment
- Reconstruction of public service system/structure
- Social services expenditure is 21% of GDP while Norway, for example, is able to spend 50% of GDP on social services (Torres, 2000: 17).

With poor or nonexistent infrastructures found in at risk municipalities, the decentralisation of the water and sanitation services has had various challenges. 80% of all WSAs can be classified as “very high vulnerability” due to insufficient technical and financial capacity (DWA, 2012c). *“This is of significant concern, and although programmes have been instituted to boost the capacity of WSAs,*

these have generally taken the form of short-term interventions that did little to transfer skills and build and retain capacity within the WSAs” (DWA, 2012c: 8).

“From evidence, it is clear that much of local government is indeed in distress, and that this state of affairs has become deeply rooted within our system of governance. In assessing the reality of poor municipal performance, cognisance needs to be taken of the unresolved problems identified in previous assessments (despite recognition from national government, and legislation that is often in line with international best practice), and the intergovernmental impact of this failure, both institutionally and for communities. **A recurring theme is the inadequate capacity of service providers to fulfil their responsibilities.** Delivering and operating new infrastructure are complex activities but competent skilled persons are in short supply, especially in rural areas. The recent trend towards civil society partnerships with municipalities is beginning to have some positive impact, but the sustainability of this approach is constantly threatened.” (SAICE, 2011: 11)

In 2013, vulnerability self-assessment of WSAs in terms of planning, capacity, management and performance found that only 3% of WSAs are currently operating acceptably; 46% are in crisis (DWA, 2013: 35). “One of the most debilitating problems in this regard is a **severe lack of capacity at local level** (unchanged or worse since 2006). Many of the smaller, poorer municipalities require assistance in capacity building to operate as Water Services Authorities and Water Services Providers” (SAICE, 2011: 15).



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Figure 6: Map of Municipal Vulnerability from self-assessment (DWA, 2013: 36)

The 46% of WSAs that are in crisis are not limited to former homeland regions (Figure 5). This indicates that municipalities other than those that were previously disadvantaged are struggling. This in turn creates further disparities within the provinces. For example, the Blue Drop Score in 2012 for Mpumalanga was 60.9% - an adequate score; there were however Mpumalanga local municipalities (LMs) with poor scores and therefore undrinkable tap water. Bushbuckridge had a Blue Drop Score of 30.8% and the Blue Drop Score of Chief Albert Luthuli was 18.4% (DWA, 2012b).

Non-functional WSAs are problematic because inefficient infrastructure management leads to non-delivery of services and non-functional water schemes (DWA, 2013).

“There are approximately 1689 water schemes in South Africa. 9% are currently totally dysfunctional at present and lie mainly within the 24 DMs which cover the pre 1994 old homeland areas. Some 48% of schemes are in urgent need of refurbishment. Water treatment and wastewater treatment works are generally in poor condition, with 66% of WWTWs requiring short to medium term intervention, 35% requiring capacity upgrades and 56% requiring additional skilled operating and maintenance staff” (DWA, 2013: 48).

There are a number of factors that have resulted in water scheme functionality issues (Figure 6).

Typical Functionality Problems		Typical Functionality Problems	
Category	Type of problem	Category	Type of problem
Governance/ Policy	No enforcement of regulations	Technical/ Operations	Operational problems
	Inadequate bylaws/regulations		Condition and age of infrastructure
	Unsustainable policy/level of services		Lack of maintenance
Institutional	No capacity to manage		Badly designed infrastructure
	Corruption		High level of leakages
Financial	Cost of supply greater than income		Electricity interruptions
	Equitable share less than O&M costs	Inadequate infrastructure	
	No revenue collection	Water resources	Insufficient water supply
	Tariffs not affordable		Abstraction problems
Community	Excessive demands		Poor management
	Non-payment		Droughts
	Plumbing leakages	Pollution of WR	
	Vandalism/theft and illegal connections		
	Inadequate community buy-in		
	Inadequate education		

Figure 7: Water Scheme functionality issues (DWA, 2013: 49)

Operation and maintenance issues, specifically, have resulted in issues with quality of service. Consequently, the Blue and Green Drop initiatives were started to assess the capabilities of municipalities to provide safe water and sanitation services, respectively. The program, initiated in 2008, has revealed significant issues in certain municipalities. The annual Blue Drop report for 2012 included the following notice for Bushbuckridge in Mpumalanga: “[t]he Department hereby issues a warning to all residents and visitors to the Bushbuckridge Local Municipal area not to consume the tap water without taking appropriate measures to improve the drinking water quality” (DWA, 2012b: 248).

The water services infrastructure in South Africa is deteriorating, and therefore adversely affecting the quality of the service.

“The water infrastructure – with a weighted average age of 39 years – is subject to ageing effects associated with internal and external stresses and other impacts. Insufficient maintenance and capital renewal have resulted in further deterioration. According to the DWA, there is substantial

maintenance non-compliance with regards to the National Water Resources Strategy (NWRS) of September 2009. There is also an urgent need to review the NWRS” (SAICE, 2011: 15).

The situation for sanitation systems is also worrying” (SAICE, 2011: 15).

“According to DWA’s 2011 Green Drop assessment report on the performance of waste water treatment and management in South Africa, of the 821 systems assessed in 2011 only 40 received Green Drop certification from DWA. Also extremely worrying is that 20 of the previous recipients of the Green Drop certificates in 2010 lost their certification status in 2011.” (Tissington, 2011: 64)

The findings of the Blue and Green Drop Reports illustrate a key issue in the current service delivery discourse, where improved infrastructure has not ensured a proficient level of service. As such, quantity does not equate to quality, even for the most basic of services and infrastructure provided to many impoverished communities throughout South Africa. Focus has been put on quantity in order to meet coverage targets and goals, while maintenance has taken a backseat (Tissington, 2011: 59). “Inadequate maintenance has meant that water is no longer flowing through newly installed pipes and taps in many rural areas” (Natrass & Seekings, 2001: 480).

“The [State of Local Government Overview] report shows that on the whole local government is struggling to fulfil this developmental mandate, and many municipalities are failing altogether... The severity of the number of ever-increasing backlogs across all basic services means that realistically speaking, meeting the 2014 goals of Government and the Millennium Development Goals may not be achievable with respect to service” (COGTA, 2009b: 7).

This coupled with the self-assessed vulnerability of a substantial number of municipalities, highlights the need to critically assess the provision of services at municipal level. Furthermore, setting general targets for all municipalities is not pragmatic. “National targets for service delivery that apply uniformly irrespective of the economic and institutional differences between municipalities simply set municipalities up to fail” (COGTA, 2009b).

In conclusion, despite substantial progress since 1994, backlogs still persist. The pro-poor focus, to redress the previous unequal service provision, has not yet rectified the backlogs. Furthermore, municipalities that were not of those that were previously disadvantaged are self-proclaimed vulnerable WSAs and are unable to provide services adequately; this results in further disparities in services. Critically assessing progress at municipal level, in order to determine where the disparities are, can assist in creating focused targets that consider the structural variances between municipalities. Focussed targets would better suit service delivery assessment; the targets do not create a situation where municipalities are “set-up to fail”.

Method of Research

Large disparities exist between local municipalities within the same province. This reality is evident from the Blue Drop report of 2012 where provinces with a satisfactory score, for example the Eastern Cape had a score of 82%, have municipalities with tragic scores; Koukamma Local Municipality scored the lowest Blue Drop Score in 2012, 5.6% (DWA, 2012a).

This study aimed to assess the progress made in water and sanitation provision at local municipal level. A cluster analysis was done on access to water supply and sanitation data from the 2001 and 2011 Censuses and the 2007 Community Survey, at local municipal level. The Pearson product moment correlation test was used to ascertain the strength of the relationship, between the prior level of access to adequate services and the progress made since then.

Selecting a data source

There are many entities that monitor household access to water supply and sanitation facilities, inter alia:

- The various governmental structures: municipalities, provinces and national government
- Department of Water Affairs (DWA previously DWAF) and Department of Human Settlements (DHS)
- South African Institute of Race Relations (SAIRR): South African Survey
- Human Sciences Research Council (HSRC)
- Statistics South Africa (StatsSA)

Most institutions monitor the access to water and sanitation at a provincial level given that it is an arduous process to collect data at municipal level. "The yearly delivery [of municipal] data are very erratic and this clearly illustrates the difficulty of undertaking a year by year monitoring and evaluation of delivery of basic services in numerical terms" (Nnadozie, 2011: 341). All local municipalities that have to submit annual reports; some have a history of poor reporting.

StatsSA was felt to be the most suitable data provider. They conduct numerous surveys and have rigorous accompanying metadata documentation, which adds to the understanding of the data. Other institutions, however, largely rely on data from local and national government; StatsSA gathers its own data. Through the Census and Community Survey specifically, StatsSA, collects household level data that is made available at local municipal level.

Census and Community Survey data were selected as appropriate surveys. StatsSA provides access to these surveys electronically through the PX-WEB platform³.

Census and Community Survey

Various factors have changed between the different Censuses and, as such, the data had to be aligned in order to be comparable.

Census data was gathered from StatsSA Online PX-Web platform. Censuses prior to 1996 were not suitable for inclusion given that the "Census 1996 was the first population census conducted after

³ <http://www.statssa.gov.za/timeseriesdata/timeseriesdata.asp>

the 1994 elections” (StatsSA, 2001). Various factors have changed between the different Censuses and, as such, the data had to be aligned in order to be comparable.

The survey questionnaire has changed over the years, making different level of service data available. The following level of service options were not included in the Census 1996 questionnaire:

- Water supply
- Distance to community tap (i.e. 200m)
 - Rain tank
 - Dam/pool/stagnant water
 - Other
- Sanitation
- Flush septic tank
 - Chemical toilet
 - VIP

To ensure comparable level of service data, Census 1996 was not included in analysis.

Geographical boundaries and names of municipalities, with which the surveys were conducted, have changed since 1994.

Geographical Boundaries in the various post-1994 surveys were:

- Census 1996 – Local boundaries consist of Local Councils and Traditional and Magisterial Districts
- Census 2001 – Local and District Municipalities at 2001 demarcations
- Community Survey 2007 - Local and District Municipalities at 2005 demarcations, with 237 local municipalities. The Community Survey statistics were collected at 2011 boundaries.
- Census 2011 – Local and District Municipalities at 2011 boundaries with 234 local municipalities.

The data was gathered at the 2011 boundaries in order to be comparable across the years. Following are changes to 2005 boundaries - 2001 data collected at 2005 boundaries.

The Community Survey was not an actual census. Data collection was done using a two-stage stratified random sampling of 17 098 out of 80 787 Enumerator Areas (EAs) (COGTA, 2009a). The sampling entails cautionary use of the Community Survey data.

“No reliance should be placed on numbers for variables broken down at municipal level (i.e. age, population group etc.)... in a number of instances the number realised in the sample, though not zero, was very small (maybe as low as a single individual) and in some cases had to be re-weighted by a very large factor (maximum nearly 800 for housing weight and over 1000 for person weight). As a further consequence, small sub-populations are likely to be heavily over- or under-represented at a household level in the data.” (StatsSA, 2007)

Data at municipal level was used because “the aggregated total number per municipality provides more reliable estimates” (StatsSA, 2007).

Name, boundary and category changes can be found in Appendix 1.

Identification of survey variables

The access to water supply and sanitation data, presented in terms of levels of service (LOS), were grouped depending on whether or not they met the UN MDG standard of “improved” or “adequate” facilities. The *WHO/ UNICEF Joint Monitoring Programme (JMP)* – the body monitoring the progress towards the MDG water supply and sanitation targets – defines standard for improved services as follows.

“JMP classifies as “improved” water supply: piped water into dwelling, plot or yard; public tap; tube-well or borehole; protected dug well or spring; and collected rainwater. To be classified as improved, at least 20 litres per capita per day from a protected source within one kilometre of the user’s dwelling is required. The classification of improved sanitation comprises flush or pour-flush toilet to piped sewer system, septic tank or pit latrine; a ventilated improved pit-latrine (VIP); pit latrine with slab; or composting toilet.” (Hutton & Bartam, 2008: 14)

Furthermore, the South African Government specified that the potable water source be located at least 200 meters from each dwelling in order to be considered as “improved” water supply (DWA, 2004: 6).

The following groups were formed: *above basic, basic, below basic* and *meagre* LOS (Table 3).

Table 3: Water Supply and Sanitation groups

LOS Categories	Water Supply	Sanitation
Above Basic	Piped on site, Piped in yard	Flush toilet connected to sewerage network or septic tank
Basic	Community tap less than 200m	Ventilated Pit Latrine
Below Basic	Community tap greater than 200m	Pit Latrine, Chemical Toilet ⁴
Meagre ⁴	Dam/Stagnant Water/Pool, River/Stream, Spring, Rain water tank ² , Borehole ² , Water Vendor ³ and Other	Bucket, None, Other

The variables were calculated as the percentage of households in the municipality that had access to *above basic, basic, below basic* and *meagre* water supply and sanitation LOS. The water supply and

¹ *Meagre* category essentially consists of water sources that are not provided through a service provider or sources where it cannot be guaranteed that the water quality is protected

² Despite the inclusion of rain water tanks and boreholes as “improved” facilities by the JMP, the water quality cannot be guaranteed, the facilities are not provided by a WSP, and as such have been placed in the *meagre* category

³ Water Vendors are delivered through a service provider but quality cannot be verified; it is therefore placed in the *meagre* category

⁴ Chemical Toilets is a *below basic* LOS given that they are not suitable for long-term usage

* <http://www-01.ibm.com/software/analytics/spss/>

sanitation provision data were analysed separately for each of the surveys. Analysis was performed with *IBM SPSS**.

Cluster Analysis

Cluster analysis is a method used to determine natural groupings in data sets. The clusters have a high level of homogeneity, where the variability within clusters is minimised and variability between clusters is maximised. Using cluster analysis therefore forms groups based on natural tendencies in the data instead of using predetermined groups.

Studies like Vázquez & Sumner (2012), Ruger & Kim (2006) and Saint-Arnaud & Bernard (2003), focussing on different characteristics - development indicators, mortality statistics and welfare regimes, respectively - have used cluster analysis to classify and group countries. Martinez et al. (2008) performed a cluster analysis of cities depending on shelter characteristics and Ruger & Kim (2006) used cluster analysis to group countries by mortality to "*identify groups, assess intergroup disparities and examine risk factors associated with such disparities*" (Ruger & Kim, 2006: 932).

Similarly, this study used cluster analysis to group local municipalities in terms of access to improved water supply and sanitation facilities. The creation of clusters is a means of identifying if groups exist, how many, and which municipalities are grouped together; assessing the differences between the groups; and how these groups have changed over the years. A change in the number of clusters over the years would indicate whether or not more municipalities become similar to one another – in terms of access to services. Assessing how the groups have changed would indicate whether municipalities, which were found to be similar in terms of access to services, remained similar.

Clustering Procedure

Hierarchical and k-means cluster analysis are clustering procedures available in SPSS. K-means clustering was selected because the procedure involves maximising variability between clusters and minimising variability within clusters. K-means clustering requires an initial input stating the number of clusters. Cases are categorized to the closest cluster based on their distance or proximity to the cluster centres. A number of iterations occur. Cluster centres are recalculated based on the allocated cases. Cases are then reclassified into new clusters, based on the updated centres. The iterations continue until the cluster centre remains relatively fixed between successive iterations (IBM, 2011). With hierarchical clustering, once a case is classified into a cluster it will remain there; even if more a suitable cluster is formed after its classification. K-means is however, sensitive to outliers, which may obscure the initial cluster means (IBM, 2011: 390).

The number of suitable clusters for local municipal water and sanitation access data was unknown. Consequently, hierarchical clustering was performed prior to k-means clustering in order to determine the suitable number of clusters.

Determining the number of clusters using hierarchical analysis

Using hierarchical cluster analysis in SPSS requires two inputs, a clustering method and a distance measure.

Cluster methods stipulate the manner in which clusters are combined. *Ward's method* – cluster membership is determined as the "total sum of squared deviations from the mean of a cluster"

(Burns & Burns, 2008: 558) - was selected. A study comparing the accuracy of four clustering methods, suitable for continuous variables, found that Ward's method exhibited the highest accuracy values (Blashfield, 1976).

The distance measure essentially determines the similarity or proximity between the cases. The distance measure selected was *Squared Euclidean distance* (Equation 1):

$$d_{Euclidean}(B, C) = (\sqrt{(x_B - x_C)^2 + (y_B - y_C)^2})^2 \quad (1)$$

Squared Euclidean distance squares the Pythagoras' right angled triangle formula for calculating distances, thereby increasing the significance of large distances and decreasing the significance of small distances. Squared Euclidean distance and Ward's method are preferred measures in hierarchical clustering (Vazquez & Sumner, 2012; Burns & Burns, 2008: 557; Clatworthy et al., 2005: 352).

"Specifically, the Ward's method begins by calculating, for each cluster, the means for all variables. Then... the squared Euclidean distance to the cluster means is calculated. These distances are summed for all of the cases. At each step, the two clusters that merge are those that result in the smallest increase in the overall sum of the squared within-cluster distances." (Vazquez & Sumner, 2012: 38)

The number of clusters was estimated visually using the 'elbow' method on a Scree Plot. The Scree Plot plots *coefficients* - which is the distance value used to form the cluster (IBM, 2011) - against the number of clusters formed at that stage. The coefficient or distance value essentially informs "how unlike the clusters being combined are" and "[l]arge coefficients tell you that you're combining dissimilar clusters" (IBM, 2011: 383). The 'elbow' method essentially represents the point at which creating another cluster is not significantly different to the existing clusters (Vazquez & Sumner, 2012: 18). This method is not very accurate and, as such, was used only to gain an approximate range for the number of clusters, k .

The approximated k values, from the hierarchical analysis, were used in the *Variance Ratio Criterion* (VRC) equation (Equation 2) that introduced by Calinski and Harabasz (1974) to determine the correct number of clusters (Mooi & Sarstedt, 2011 and Vazquez & Sumner, 2012).

$$VRC_k = \frac{\frac{SS_B}{K-1}}{\frac{SS_W}{N-K}} \quad (2)$$

K : number of clusters

N : number of objects

SS_B : overall between-cluster variation

SS_W : overall within-cluster variation

VRC_k : in essence, represents the F-statistic of a one-way ANOVA which can be done on SPSS

$$\omega_k = (VRC_{k+1} - VRC_k) - (VRC_k - VRC_{k-1}) \quad (3)$$

ω_k was calculated for different values of k . The value of k selected was the one that minimizes ω_k . This k was used in the k-means analysis.

K-means analysis

The K-means procedure, described above, computes distances with simple Euclidean distance measure in SPSS (IBM, 2011b: 184).

Pearson product moment correlation test

The variables used in the correlation test were *progress made* (percentage of households with access to adequate service from 2001 and 2011) and *previous level of access to adequate service* (percentage of households with adequate service in 2001).

The *Pearson correlation test* was used because it measures correlation of continuous variables (Wheater & Cook, 2000). This test requires data that is normally distributed in order for the results to be appropriate. For the purpose of this study, however, the correlation test is of the whole dataset – all municipalities in South Africa.

The correlation coefficient (r) – which indicates the strength of the relationship between the variables – is affected by probability (p) and size (n). If the probability is greater than 0.05, the probability of the relationship measured occurring by chance is greater than 5%; the correlation coefficient is not significant; and no linear relationship exists between the data. A small sample size increases the probability of the measured relationship occurring by chance. A critical values table must be consulted in order to determine if the results are significant (Appendix 2).

If a negative correlation is established for municipalities in a province, it indicates that the backlogged municipalities had greater progress than the favourable municipalities. If pro-poor service provision was effective, a negative correlation would exist between *progress made* and *access to adequate service in 2001*.

Findings and Analysis

The following section describes the analysis of the water supply and sanitation statistics. Descriptive statistics of water supply and sanitation are presented to demonstrate the overall change in access statistics. The results from the k-means cluster analysis for water supply and sanitation are then presented. This is followed by an analysis of the differences between the water supply and sanitation results.

Descriptive Statistics

The bar graphs below illustrates the overall progress made - with respect to the different Levels of Service (LOS): *above basic*, *basic*, *below basic* and *meagre* - in the access to water supply and sanitation facilities for 2001, 2007 and 2011. The solid red line marks 50% of South African households.

Water Supply: The overall trend was positive, with an increase in *above basic* and *basic* LOS and notable overall decrease of *below basic* and *meagre* LOS (Figure 8). The change, in *above basic* LOS particularly, over the years was notable. 67% of the households had access to this LOS in 2011, up from 57% in 2001 - an increase of 10%. This indicates that *above basic* LOS was the service most provided. Overall changes in the other LOS were of a lesser magnitude – a 2% increase for *basic* LOS, a decrease of 5% and 8% for *below basic* and *meagre* LOS, respectively. The *above basic* LOS then showed the greatest change, compared to the other LOS.

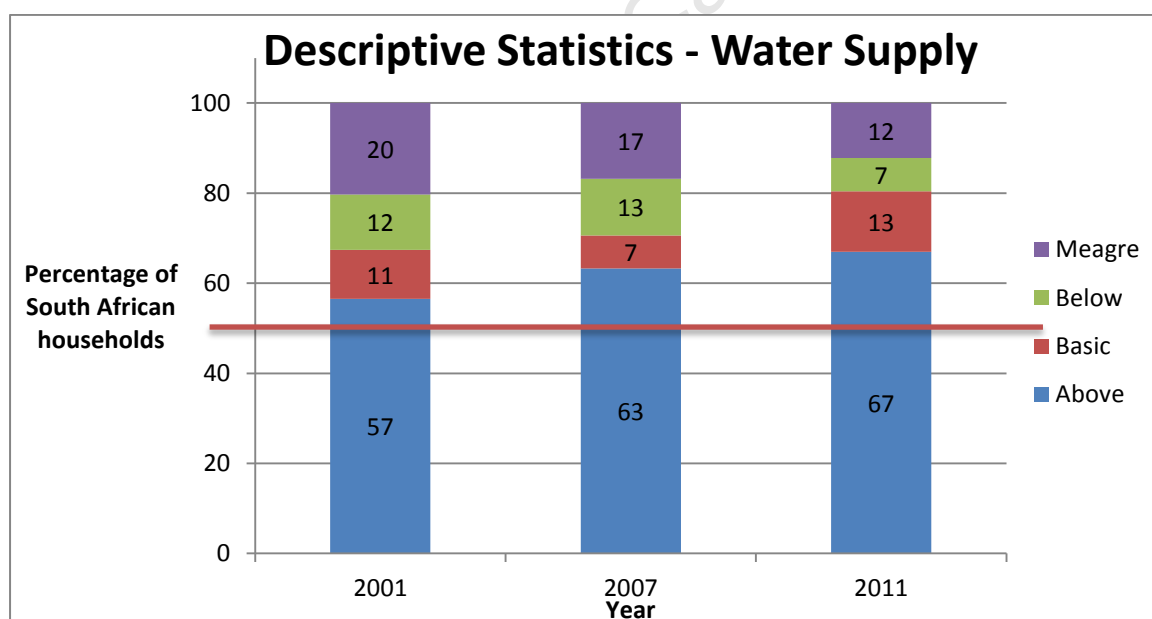


Figure 8: National water supply descriptive statistics

Sanitation: The overall trend was positive, with an increase in *above basic* and *basic* LOS and overall decrease of *below basic* and *meagre* LOS (Figure 9). This trend is similar to water supply services. The most notable change, however, was for *meagre* LOS, which decreased from 26% in 2001 to 13% in 2011 – a 13% reduction. This indicates that *meagre* LOS was the service most replaced. 11% of the 13% decrease occurred between 2001 and 2007, indicating more sanitation progress in this period than between 2007 and 2011. Lesser overall changes include 4% increase in *basic* LOS and a

decrease of 2% and 12% for *below basic* and *meagre* LOS, respectively. *Meagre* LOS then showed the greatest change, compared to the other LOS.

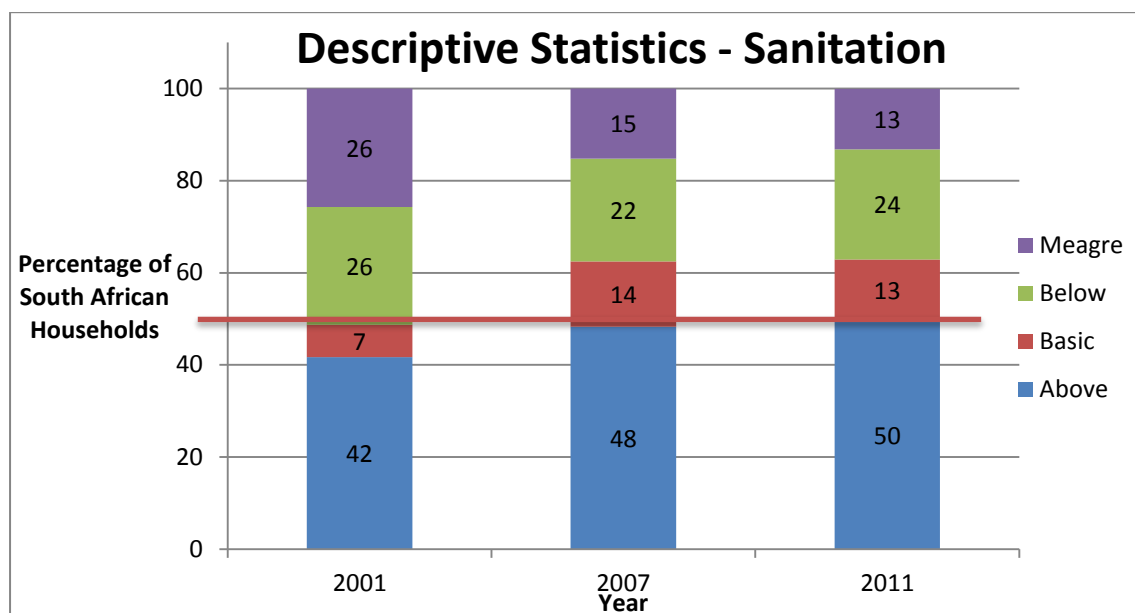


Figure 9: National sanitation descriptive statistics

Combined: It can be seen that there has been improvement in access to water supply and sanitation facilities overall. The majority of households, for both water supply and sanitation, used the *above basic* LOS at any given point. Access to *above basic* and *meagre* LOS showed a notable increase and decrease, respectively. Conversely, *basic* and *below basic* LOS showed varying increases and decreases between the years. As such, water supply and sanitation service delivery have clearly been different; water supply showing the greatest change in *above basic* LOS and sanitation showing the greatest change in *meagre* LOS. This translates to more taps supplying water and fewer buckets used for sanitation.

Adequate or *Improved* Service comprises of *above basic* and *basic* LOS; *Inadequate* or *Unimproved* Service comprises of *meagre* and *below basic* LOS.

The majority of *adequate* service was made up of *above basic* LOS for both water supply and sanitation services. This would indicate that, of the households using *adequate* services, the majority have access to taps within the household property and flush toilets; *basic* LOS is used by a minority. The bulk of *inadequate* service is made up of *meagre* LOS for water supply and *below basic* LOS for sanitation services.

Overall, more than 50% of the households have always had access to adequate water supply services, increasing from 68% in 2001 to 80% in 2011. This is not the case for sanitation services; *adequate* service was less than 50% in 2001 and increased to 63% by 2011.

Cluster Analysis: Water Supply

This section presents the results from the cluster analysis for water supply.

K-Means Clustering

The following tables show the results of the cluster analysis for Census 2001, Community Survey 2007 and Census 2011 for water supply.

Nine clusters were found for 2001; detailed description of this can be found in Appendix 3.

Three of the nine clusters (1-3) had *above basic* means greater than 50%, at 87.3%, 74.1% and 58.8% respectively (Table 4). This indicates a prominence of taps within the site in these municipalities, which included the Metros and all of the LMs from Western Cape, Gauteng and Free State; Buffalo City was the only metro belonging to cluster 3.

Three clusters (6, 8 and 9) had *meagre* LOS means greater than 50% at 56.4%, 62.1% and 81.2% respectively. The LMs in these clusters were solely from KwaZulu Natal and Eastern Cape, except for one Limpopo LM in cluster 8 – LIM 473: Makhuduthamaga. This indicates that there was a prevalence of *meagre* services in these LMs in KwaZulu Natal and Eastern Cape; both provinces where homelands were located.

For the other three clusters, no one LOS had a mean greater than 50%. Only cluster 7 had a *basic* LOS greater than the corresponding *above basic* LOS. LMs in this cluster were largely from Limpopo, KwaZulu Natal and Eastern Cape, indicating a substantial growth in *basic* LOS - taps within 200m - compared to *above basic* LOS – taps on site - for LMs in this cluster.

5 out of 9 clusters had greater than 50% of households with access to *adequate services* (*above basic* + *basic* LOS). The *adequate* LOS means for clusters 6 and 7 were equal, but the different LOS proportions created two different clusters; cluster 6 had a *basic* LOS mean of 6% while cluster 7 had a *basic* LOS mean of 20%. Nearly the entire cluster 6 consisted of LMs from KwaZulu Natal, such as KZN 431: Ingwe. Cluster 7 was more diverse; it included LMs from North West and Northern Cape, such as NW381: Ratlou and NC451: Joe Morolong.

Table 4: Final cluster centres for 2001 Water Supply (in percentages)

	1	2	3	4	5	6	7	8	9
Above Basic	87.3	74.1	58.8	34.5	42.2	28.1	13.7	12.1	4.6
Improved Services	93.0	84.6	73.6	56.2	52.3	34.0	33.9	22.2	9.5
Below Meagre	4.8	9.6	14.8	27.3	13.4	9.6	27.5	15.7	9.3
Unimproved Services	7.0	15.4	26.4	43.8	47.7	66.0	66.1	77.7	90.5

The number of LMs belonging to each cluster was different; almost 50% of the LMs belonging to cluster 1 and 2 (Table 5). Clusters 6 to 9, where less than 35% of households in the LMs had access to *adequate* services, consisted of only 20% of the LMs. This indicates the high level of access to improved water supply facilities for almost half of the municipalities.

Cluster 1 was clearly the most favourable regarding access to water supply facilities; it had the highest mean for the *above basic* LOS (87%) and low means for the rest. Cluster 1 included metros like Cape Town and Johannesburg, as well as a large number of LMs from the Western Cape and Northern Cape. Limpopo and North West each had 1 LMs in Cluster 1, LIM 366: Bela-Bela and NW 403: City of Matlosana. Cluster 9 was clearly the most backlogged; it had the highest mean for *meagre* LOS (81%) and the lowest mean for the *above basic* LOS. Cluster 9 included LMs from the Eastern Cape and KwaZulu Natal, with 70% of the LMs from the Eastern Cape, such as EC 443: Mbizana.

The spatial distribution between clusters was uneven. The Western Cape and Gauteng had 100% of their municipalities in clusters 1 and 2 with *improved* LOS greater than 75%; these provinces were greatly favourable in terms of access to water supply facilities. Mpumalanga, Free State and the Metros had 100% of their municipalities are in clusters (1-5) with improved LOS access to greater than 50% of households; these provinces were moderately favourable. The Northern Cape, North West and Limpopo had more than 85% of their municipalities are in clusters with improved LOS greater than 50%. Eastern Cape and KwaZulu Natal only had between 45% and 55% of their municipalities in clusters with improved LOS greater than 50%. Furthermore, Eastern Cape and KwaZulu Natal had between 25% and 35% of their municipalities in clusters with improved LOS less than 25%. As such, Eastern Cape and KwaZulu Natal were the most backlogged provinces in 2001.

Table 5: Provincial distribution of clusters for 2001

	1	2	3	4	5	6	7	8	9	Percentage of municipalities with improved services		
Improved services	93.0%	84.6%	73.6%	56.2%	52.3%	34.0%	33.9%	22.2%	9.5%	> 50%	< 25%	N
WC	22	2	-	-	-	-	-	-	-	100	-	24
GT	4	3	-	-	-	-	-	-	-	100	-	7
Metros	3	4	1	-	-	-	-	-	-	100	-	7
FS	5	11	3	-	-	-	-	-	-	100	-	19
MP	-	10	3	2	3	-	-	-	-	100	-	18
NC	16	9	-	1	-	-	1	-	-	96	-	27
NW	1	4	6	6	1	-	1	-	-	95	-	19
LIM	1	1	7	8	5	-	2	1	-	88	4	25
KZ	-	7	7	-	10	8	4	11	3	48	28	50
EC	5	5	5	3	1	1	4	6	7	51	35	37
N	57	56	32	20	20	9	12	18	10			234

Eight clusters were found for 2007; see Appendix 4 for detailed description.

Four of the eight clusters (1 to 4) had *above basic* means greater than 50%, at 92.6%, 79.7%, 61.8% and 57.5%, respectively (Table 6). This was greater than the 3 clusters in 2001, indicating an increased variability among municipalities with more than 50% household access to *above basic* LOS. These were the only clusters that had more than 50% household access to *adequate* LOS (*above basic + basic*). This was less than the 5 clusters in 2001, indicating a decrease in the variability of municipalities with more than 50% household access to *adequate* LOS. The Metros and all of the LMs from Western Cape, Gauteng and Free State were all located in Clusters 1 and 2, instead of being located over 3 clusters like in 2001. This indicates that the municipalities had

become similar enough to be clustered into fewer clusters. Buffalo City shifted to Cluster 2 in 2007 – with other metros - from Cluster 3 in 2001, where it was the only metro.

Two clusters (7 and 8) had *meagre* LOS means greater than 50%, at 54.3% and 77.4% respectively. This is less than the 3 clusters in 2001, indicating a decreased variability of LMs with more than 50% access to *meagre* LOS. Like in 2001, the LMs in these clusters were solely from KwaZulu Natal and Eastern Cape, except for one Limpopo LM in cluster 7 – LIM 472: Elias Motsoaledi. This was different to the LM in 2001, LIM: 473 – Makhuduthamaga, which shifted to Cluster 6 (*meagre* LOS = 27.9%); in 2001, Elias Motsoaledi belonged to Cluster 5 (*meagre* LOS = 34.3%). This indicates a marked increase in *meagre* LOS for Makhuduthamaga (therefore a decline in services) and decrease for Elias Motsoaledi (therefore an improvement in services). Both LMs belong to the same District, DC 47 – Greater Sekhukhune, which is a water service provider; evidently progress in the district had not been even.

For the other three clusters, like in 2001, no one LOS had a mean greater than 50%. Only Cluster 5 had a *basic* LOS greater than the corresponding *above basic* LOS (*basic* LOS = 34%); this was the case for Cluster 7 in 2001 (*basic* LOS = 20%). Cluster 7 in 2001 had 12 LMs while Cluster 5 in 2007 had 5 LMs. Unlike Cluster 7 in 2001, Cluster 5 for 2007 had no LMs from Limpopo; thus indicating that the progress of the relevant Limpopo LMs shifted the LOS proportions. The LMs from North West and Northern Cape, which belonged to Cluster 7 in 2001 (NW381: Ratlou and NC451: Joe Morolong), shifted to Cluster 5 in 2007. This indicates the similar manner in which both of these LMs had progressed, with an increase in *basic* LOS. KZN 431: Ingwe shifted from Cluster 6 in 2001 to Cluster 7 in 2007. Both clusters had *meagre* means greater than 50%, indicating that the LOS proportions remained similar.

Table 6: Final Cluster centres for 2007 Water Supply (in percentages)

	1	2	3	4	5	6	7	8
Above	90.3	74.2	45.4	52.6	11.9	21.5	18.7	6.8
Basic	2.3	5.5	16.4	4.9	34.0	17.3	10.3	4.2
Improved Services	92.6	79.7	61.8	57.5	45.9	38.8	29.0	10.9
Below	3.5	12.9	26.3	9.5	40.2	33.3	16.8	11.7
Meagre	3.9	7.4	11.9	33.0	13.8	27.9	54.2	77.4
Unimproved Services	7.4	20.3	38.2	42.5	54.1	61.2	71.0	89.1

The number of LMs belonging to each cluster was different. Almost 60% of the LMs belonging to cluster 1 and 2 (Table 7); this is up from 50% of LMs in 2001. Clusters 7 and 8, with less than 35% household access to *adequate* services, consisted of only 13% of the LMs; this is down from 20% in 2001.

Cluster 1 was clearly the most favourable regarding access to water supply facilities; it had the highest mean for the *above basic* LOS (90.3%) and low means for the rest. Cluster 1 included half of the metros and nearly all of the LMs in Western Cape and the Free State. Limpopo and North West each had more than 1 LM in Cluster 1, compared to 2001. Like in 2001, NW 403: City of Matlosana belonged to Cluster 1 in 2007, while LIM 366: Bela-Bela shifted to Cluster 2 in 2007; this indicates dissimilar progress. Cluster 8 was clearly the most backlogged; it had the highest mean for *meagre* LOS (77.4%) and the lowest mean for the *above basic* LOS. Cluster 8 had 10 LMs in 2001 and 7 in 2007, indicating that some LMs had progressed more than others, to not be grouped to Cluster 8 in 2007. Like for Cluster 9 in 2001, Cluster 8 in 2007 had LMs from Eastern Cape and KwaZulu Natal, such as EC 443: Mbizana.

The Western Cape, Free State, Gauteng and the Metros had 100% of their municipalities in Clusters 1 and 2, both with *improved* LOS greater than 75%, indicating *greatly favourable* provinces. The Free State and Metros were not classified as *greatly favourable* in 2001. Northern Cape and Mpumalanga had more than 94% of their municipalities in clusters with improved LOS greater than 50%. This is down from 100% of municipalities in 2001, indicating that some LMs in Northern Cape and Mpumalanga did not improve similarly, in order to be clustered together. The North West and Limpopo had between 75 and 80% of their municipalities in clusters with *improved* LOS greater than 50%. This is down from more than 85% in 2001, indicating that some LMs in North West and Limpopo did not improve similarly, in order to be clustered together. The Eastern Cape and KwaZulu Natal had between 54 and 60% of their municipalities are in clusters with improved LOS greater than 50% (up from 45-55% in 2001). The Eastern Cape and KwaZulu Natal also had 6% and 11% of municipalities belonging to Cluster 8 in 2007, with *improved* LOS less than 25% (down from 35% in 2001). Eastern Cape and KwaZulu Natal were still the most backlogged provinces but some LMs were able to progress enough to not be grouped in clusters representing severely backlogged LMs, such as Cluster 8 in 2007 with 11% access to *improved* LOS.

Table 7: Provincial distribution of clusters for 2007

	1	2	3	4	5	6	7	8	Percentage of municipalities with improved services		
Improved services	92.6	79.7	61.8	57.5	45.9	38.8	29.0	10.9	> 50%	< 25%	N
WC	23	1	-	-	-	-	-	-	100	-	24
FS	16	3	-	-	-	-	-	-	100	-	19
GT	4	3	-	-	-	-	-	-	100	-	7
Metros	4	4	-	-	-	-	-	-	100	-	8
NC	19	6	1	-	1	-	-	-	96	-	27
MP	5	10	1	1	0	1	-	-	94	-	18
NW	5	6	4	-	2	2	-	-	79	-	19
LIM	2	4	11	2	-	5	1	-	76	-	25
KZN	3	5	5	16	1	2	15	3	58	6	50
EC	12	3	5	0	2	3	8	4	54	11	37
N	93	45	27	19	6	13	24	7			234

Nine clusters were found for 2011, like for 2001; detailed description can be found in Appendix 5.

Three of the nine clusters (1 to 3) had *above basic* means greater than 50%, at 89.5%, 62.7% and 69.3% respectively (Table 8). This indicates a decrease in variability of these LMs from 2007. The Metros and all of the LMs from Western Cape were all located in Cluster 1 instead of over 2 clusters, like in 2007. Gauteng and Free State each had 1 LM in Cluster 2; the rest were in Cluster 1. This indicates that the LMs in these provinces all progressed such that they are tending towards one cluster; the LMs in lower clusters progressed enough to be grouped into Cluster 1. Buffalo City was the only metro in Cluster 2, like in 2001 where it was the only metro in Cluster 3. This indicates that the progress in Buffalo City was not similar to the other metros.

Two clusters (8 and 9) had *meagre* LOS means greater than 50%, at 53.1% and 77.0% respectively. Like for 2001 and 2007, the LMs in these clusters were solely from KwaZulu Natal and Eastern Cape; Cluster 9 comprised solely of 2 LMs from Eastern Cape. There were no LMs in Cluster 9 from Limpopo, like in 2001 and 2007. LIM 472: Elias Motsoaledi (Cluster 7 in 2007 – *meagre* LOS: 54.2%) and LIM: 473 – Makhuduthamaga (Cluster 6 in 2007 - *meagre* LOS: 27.9%) were shifted to Clusters 6 and 7 in 2011, respectively (*meagre* LOS between 30% and 35%). This indicates slight increase in *meagre* LOS for Makhuduthamaga (therefore a decline in services) and marked decrease in *meagre* LOS for Elias Motsoaledi (therefore an improvement in services). This is opposite to what happened between 2001 and 2007, indicating the irregular progress in Greater Sekhukhune District.

For the other four clusters, no one LOS had a mean greater than 50%. Clusters 5, 7 and 8 had a *basic* mean greater than the corresponding *above basic* mean; only 1 cluster met this criterion for both 2001 (Cluster 7 – *adequate* LOS: 34%) and 2007 (Cluster 5 - *adequate* LOS: 46%). Collectively Clusters 5, 7 and 8 in 2011 contained 50 LMs while Cluster 5 in 2007 only contained 6 LMs. This indicates a striking progress of *basic* LOS between 2007 and 2011. Clusters 5, 7 and 8 in 2011 largely consisted of LMs from KwaZulu Natal and Eastern Cape. The LMs from North West and Northern Cape, which belonged to Cluster 5 in 2007 (NW381: Ratlou and NC451: Joe Morolong), belonged to Cluster 5 in 2011. This indicates the similar manner in which these LMs had progressed, with an increase in *basic* LOS. KZN 431: Ingwe belonged to Cluster 6 in 2011 (shifted from Cluster 6 in 2001 to Cluster 7 in 2007). Cluster 6 in 2001 and Cluster 7 in 2007, both had *meagre* means greater than 50%. For Cluster 6 in 2011, the LOS with the greatest mean was *above basic*, at 44%; this indicates improvement in Ingwe, with less than 35% of households access *meagre* LOS.

6 out of 9 clusters had greater than 50% of households had access to *adequate services (above basic + basic)*. This was greater than both the 5 clusters in 2001 and the 4 clusters in 2007, indicating an increased variability of LMs with more than 50% of households that had access to *adequate* LOS.

Table 8: Final Cluster centres for 2011 Water Supply (in percentages)

	1	2	3	4	5	6	7	8	9
Above Basic	89.5	62.7	69.3	43.4	20.4	43.5	19.9	13.1	7.7
Improved Services	5.5	20.6	10.1	29.3	44.9	13.2	29.7	20.7	7.3
Below Meagre	95.0	83.3	79.5	72.7	65.3	56.7	49.6	33.8	15.0
Unimproved Services	2.6	8.9	6.1	15.8	25.3	8.8	18.9	13.1	8.0
	2.4	7.7	14.4	11.5	9.4	34.5	31.5	53.1	77.0
	5.0	16.7	20.5	27.3	34.7	66.0	50.4	66.2	85.0

The number of LMs belonging to each cluster was different (Table 9). Almost 60% of the LMs belonging to Clusters 1 and 2; this is up from 50% of LMs in 2001. Clusters 7 and 8, where less than 35% household access to *adequate* services, consisted of only 13% of the LMs; this is down from 20% in 2001.

Cluster 1 was clearly the most favourable regarding water supply delivery; it had the highest mean for the *above basic* LOS (89.5%) and low means for the rest. Cluster 1 included 100% of the LMs in the Free State and Western Cape. Both Gauteng and the Metros had 1 municipality that belonged to Cluster 2, the rest belonged to Cluster 1. Like in 2001 the LMs, LIM 366: Bela-Bela and NW 403: City of Matlosana, both belonged to Cluster 1 in 2011. Bela-Bela belonged to Cluster 2 in 2007 and City of Matlosana belonged to Cluster 1, indicating varying progress for City of Matlosana. Cluster 9 was clearly the most backlogged; it had the highest mean for *meagre* LOS (77.0%) and the lowest mean for the *above basic* LOS. Cluster 9 had 2 LMs from the Eastern Cape, which is less than the 7 LMs that belonged to Cluster 8 in 2007, indicating that some LMs had progressed more than others to not be grouped back into Cluster 9. Like in 2001, EC 443: Mbizana was found in Cluster 9; Mbizana always belonged to the most backlogged cluster.

The Western Cape and Free State had 100% of their municipalities in Cluster 1 (from Cluster 1 & 2 in 2007). Gauteng and the Metros have 100% of their municipalities in Clusters 1 and 2, with improved LOS greater than 80% (up from 75% of municipalities). The favourable provinces have thus improved. The Northern Cape, Mpumalanga and North West had 100% of their municipalities in clusters with improved LOS greater than 50% (up from 94% of municipalities). This indicates that the moderately favourable provinces improved back to 2001 standards, for Northern Cape and Mpumalanga. North West made notable improvement to join this group of provinces instead of being grouped with Limpopo. Limpopo and KwaZulu Natal had between 80 and 95% of their municipalities in clusters with improved LOS greater than 50% (up from between 75% and 80% of municipalities in 2007), indicating improvement; KwaZulu Natal made notable improvement to be grouped with Limpopo instead Eastern Cape. The Eastern Cape had 65% of its municipalities in clusters with improved LOS above 50% and 5% of its municipalities (2 LMs) belonged to Cluster 9. Eastern Cape was the most backlogged province.

Table 9: Provincial distribution of clusters for 2011

	1	2	3	4	5	6	7	8	9	Percentage of municipalities with improved services		
Improved services	95.0%	83.3%	79.5%	72.7%	65.3%	56.7%	49.6%	33.8%	15.0%	> 50%	< 25%	N
FS	19	-	-	-	-	-	-	-	-	100	-	19
WC	24	-	-	-	-	-	-	-	-	100	-	24
Metros	7	1	-	-	-	-	-	-	-	100	-	8
GT	6	1	-	-	-	-	-	-	-	100	-	7
NC	23	-	2	1	1	-	-	-	-	100	-	27
MP	10	-	7	1	-	-	-	-	-	100	-	18
NW	7	5	3	2	2	-	-	-	-	100	-	19
LIM	4	4	4	7	1	3	2	-	-	92	-	25
KZN	5	4	7	7	2	15	5	5	-	80	-	50
EC	13	2	1	5	2	1	6	5	2	65	5	37
N	118	17	24	23	8	19	13	10	2			234

Cluster Analysis: Sanitation

This section presents the results from the cluster analysis for sanitation.

K-Means Clustering

The following tables show the results of the cluster analysis for Census 2001, Community Survey 2007 and Census 2011 for sanitation.

Ten clusters were found for 2001; detailed description of this can be found in Appendix 6.

Three of the ten clusters (1-3) had *above basic* means greater than 50%, at 81.0%, 62.4% and 54.1% respectively (Table 10); this translates to a prominence of flush toilets in these LMs. These were also the only clusters that had more than 50% household access to *adequate services (above basic + basic)*. Western Cape, Gauteng and the Metros made up 63% of the LMs in Cluster 1, 21% of the LMs in Cluster 2 and 6% of the LMs in Cluster 3. The Northern Cape alone made up 33% of the LMs in Cluster 3. Cluster 2 had municipalities from all provinces, including Buffalo City, LIM 366: Bela-Bela and NW 403: City of Matlosana.

Three clusters (5, 8 and 9) had *below basic* means greater than 50%, at 53.6%, 55.5% and 74.0%, respectively. The only provinces that did not have LMs located in these clusters were Western Cape, Gauteng and Metros. Clusters 5 and 9, particularly, had the *below basic* means considerably higher than the corresponding *meagre* means. LMs in these clusters were largely from the North West, Eastern Cape and KwaZulu Natal. NC451: Joe Morolong belonged to Cluster 8, while KZN 431: Ingwe and NW381: Ratlou belonged to Cluster 9. The only LMs from Limpopo, which belonged to Cluster 9, were LIM 472: Elias Motsoaledi and LIM 473: Makhuduthamaga.

Two clusters (6 and 10) had *meagre* LOS means greater than 50%, at 54.3% and 63.5% respectively; Eastern Cape and KwaZulu Natal made up 47% of LMs in Cluster 6 and 79% of LMs in Cluster 10. For the other two clusters, no one LOS had a mean greater than 50%, which indicates that no one LOS was prominent in the relevant LMs. About 50% LMs in these clusters were from KwaZulu Natal, indicating a variety of LOS proportions for these municipalities.

Only two of the ten clusters (7 and 9) have *basic* LOS which are greater than the corresponding *above basic* LOS. LMs in this cluster were largely from KwaZulu Natal and Eastern Cape, indicating a substantial proportion of *basic* LOS compared to *above basic* for these LMs.

Table 10: Final cluster centres for Census 2001 Sanitation (in percentages)

	1	2	3	4	5	6	7	8	9	10
Above Basic	81.0	62.4	54.1	37.8	20.9	30.7	11.1	10.2	6.1	7.9
Improved Services	83.4	67.6	58.2	47.6	36.8	34.9	23.0	20.9	17.0	15.0
Below Meagre	4.7	19.9	8.7	34.9	53.6	10.8	36.6	55.5	74.0	21.5
Unimproved Services	11.9	12.5	33.1	17.5	9.6	54.3	40.3	23.7	9.0	63.5
	16.6	32.4	41.8	52.4	63.2	65.1	77.0	79.1	83.0	85.0

The number of municipalities belonging to each cluster was different; almost 50% of the LMs belonging to Clusters 1 to 3 (Table 11). Clusters 7 to 10, with less than 25% household access to *adequate* services, consisted of only 30% of the LMs.

Cluster 1 was clearly the most favourable regarding sanitation delivery; it had the greatest mean for the *above basic* LOS (81.0%) and low percentages for the rest. Municipalities from the Western Cape, Gauteng and the Metros accounted for 63% of LMs in Cluster 1. No LMs from Limpopo were found in Cluster 1. Cluster 10 was clearly the most backlogged; it had the highest mean for *meagre* LOS and one of the lowest percentages for the *above basic* LOS. More than 50% of LMs in Cluster 10 were from Eastern Cape, including EC 443: Mbizana.

The spatial distribution between clusters was uneven. The Western Cape, Gauteng and the Metros had 100% of their municipalities in Clusters 1 to 3 with improved LOS greater than 50%; these provinces were *greatly favourable*. The Northern Cape, Mpumalanga and Free State had between 50% of 90% of their municipalities in clusters with *improved* LOS greater than 50%; these provinces were *moderately favourable*. North West, Eastern Cape, KwaZulu Natal and Limpopo had between 10% and 30% of their municipalities in clusters with *improved* LOS greater than 50%. The Eastern Cape, KwaZulu Natal and Limpopo have more than 50% of their municipalities belonging to Clusters 7 to 10, which have less than 25% of households with improved LOS. Limpopo, KwaZulu Natal and Eastern Cape were the most backlogged provinces. For Eastern Cape, of the 20 LMs of the located in clusters with less than 25% household access to *adequate* LOS, 10 LMs belonged to the Cluster 10 (*meagre* at 63.5%). Cluster 10 consisted of 19 LMs, 10 of which are from the Eastern Cape.

Table 11: Provincial distribution of clusters for 2001

	1	2	3	4	5	6	7	8	9	10
Improved services	83.4%	67.6%	58.2%	47.6%	36.8%	34.9%	23.0%	20.9%	17.0%	15.0%
WC	22	1	1	-	-	-	-	-	-	-
GT	5	2	-	-	-	-	-	-	-	-
Metros	4	3	1	-	-	-	-	-	-	-
NC	10	2	11	1	-	1	-	1	-	-
MP	2	7	3	1	2	-	1	1	2	-
FS	1	2	7	-	1	5	-	-	-	3
NW	3	1	1	5	4	2	-	-	3	-
EC	1	3	6	1	-	6	5	4	1	10
KZ	1	5	1	10	4	1	11	8	4	5
LIM	-	3	2	3	2	-	3	9	2	1
N	49	29	33	21	13	15	20	23	12	19

Percentage of municipalities with improved services		
> 50%	< 25%	N
100	-	24
100	-	7
100	-	7
88	4	26
63	21	19
53	16	19
26	16	19
27	54	37
14	56	50
20	60	25
		234

Eight clusters were found for 2007; detailed description of this can be found in Appendix 7.

Two of the eight clusters (Clusters 1 and 2) had *above basic* means greater than 50%, at 83.7% and 58.3% respectively; 53% of LMs were in Clusters 1 and 2 (Table 12). Two clusters in 2007 were less than the 3 clusters in 2001 (47% of LMs), indicating a reduced variability of LMs with more than 50% household access to *above basic* LOS, even though there was an increased number of LMs that met this criterion. 100% of the LMs from Western Cape, Gauteng and the Metros belonged to Clusters 1 and 2. KwaZulu Natal alone made up 30% of LMs in Cluster 2. LIM 366: Bela-Bela, NW 403: City of Matlosana and Buffalo City belonged to Cluster 2 in 2001. Buffalo City was the only municipality of the 3 that remained in Cluster 2 in 2007, while Bela-Bela and City of Matlosana shifted to Cluster 1. This indicates that the Metro did not progress enough to be shifted to Cluster 1, with Bela-Bela and City of Matlosana.

One of the eight clusters (Cluster 8) had *below basic* means greater than 50%, at 67.4%; down from 3 clusters in 2001. For the other five clusters, no one LOS had a mean greater than 50%, which indicates that no one LOS was prominent in the relevant LMs. Mpumalanga contributed the least to these clusters, only contributed 1 LM each to Cluster 5 and 6 – MP 322: Mbombela and MP 324: Nkomazi; both LMs belong to the same District - DC 32: Ehlanzeni.

None of the clusters had *basic* LOS or *meagre* LOS means greater than 50%. In 2001, there were 2 clusters that had *meagre* LOS means greater than 50%, indicating a notable reduction in *meagre* LOS.

Cluster 3 had *basic* LOS mean (48.5%), which was considerably higher than the corresponding *above basic* LOS mean (13.9%); almost 1 in every 2 households in these LMs used *basic* LOS (VIP latrine). 8 of the 10 LMs in Cluster 3 were from KwaZulu Natal. None of the clusters in 2001 had *basic* mean greater than the *above basic* mean, indicating notable growth in *basic* LOS in the relevant LMs such as NC451: Joe Morolong. NC451: Joe Morolong made remarkable progress; it shifted from Cluster 8 in 2001 (*adequate* LOS mean at 21%) to Cluster 3 in 2007 (*adequate* LOS mean at 62%). For other LMs that belonged to Cluster 9 in 2001 - such as NW381: Ratlou, LIM 472: Elias Motsoaledi, LIM 473: Makhuduthamaga and KZN 431: Ingwe - the first three LMs shifted to Cluster 8 in 2007 (*adequate* LOS mean at 24%) and Ingwe shifted to Cluster 6 (*adequate* LOS mean at 42%); this indicates that progress in Joe Morolong was not the norm.

Table 12: Final Cluster centres for 2007 Sanitation (in percentages)

	1	2	3	4	5	6	7	8
Above	83.7	58.3	13.9	48.9	30.8	8.8	8.8	9.6
Basic	3.6	16.0	48.5	6.0	13.3	32.8	20.5	14.4
Improved Services	87.3	74.3	62.4	54.9	44.1	41.6	29.2	24.0
Below	4.3	16.0	15.9	5.7	46.1	44.2	24.2	67.4
Meagre	8.4	9.7	21.6	39.4	9.8	14.3	46.6	8.6
Unimproved Services	12.7	25.7	37.6	45.1	55.9	58.4	70.8	76.0

The number of municipalities belonging to each cluster was different; almost 50% of the LMs belonging to Clusters 1 to 3 (Table 13). Clusters 7 to 10, with less than 25% household access to *adequate* services, consisted of only 30% of the municipalities.

Cluster 1 was clearly the most favourable regarding sanitation delivery; it had the highest mean for the *above basic* LOS (83.7%) and low means for the rest. 100% of the LMs in the Western Cape, Gauteng and the Metros were in Cluster 1. Cluster 8 was clearly the most backlogged; it had the highest mean for the *below basic* LOS and one of the lowest means for the *above basic* LOS. It contained LMs from Cluster 9 in 2001, were LIM 472: Elias Motsoaledi and LIM 473: Makhuduthamaga. 4 out of 8 clusters had greater than 50% household access to *adequate services (above basic + basic)*.

The Western Cape, Gauteng and the Metros had 100% of their municipalities in clusters with improved LOS greater than 50%. The Northern Cape and Free State has above 80% of their municipalities in clusters with *improved* LOS greater than 50%. North West, Eastern Cape, KwaZulu Natal and Mpumalanga had between 40 and 70% of their municipalities in clusters with *improved service* greater than 50%. The North West and Mpumalanga also has more than 20% of their municipalities in Cluster 8. Limpopo had only 24% of its municipalities with *improved* LOS greater than 50%. The Eastern Cape and KwaZulu Natal had about 50% of their municipalities with between 25% and 50% household access to improved LOS.

Table 13: Provincial distribution of clusters for 2007

	1	2	3	4	5	6	7	8	Percentage of municipalities with improved services		
Improved services	87.3%	74.3%	62.4%	54.9%	44.1%	41.6%	29.2%	24.0%	> 50%	< 25%	N
WC	24	-	-	-	-	-	-	-	100	-	24
GT	6	1	-	-	-	-	-	-	100	-	7
Metros	4	4	-	-	-	-	-	-	100	-	8
NC	16	7	1	2	1	-	-	-	96	-	27
FS	8	1	-	7	1	-	2	-	84	-	19
EC	10	3	1	3	2	4	13	1	46	3	37
KZN	1	13	8	-	5	13	6	4	44	8	50
NW	5	4	-	1	3	2	-	4	53	21	19
MP	7	5	-	-	1	1	-	4	67	22	18
LIM	2	4	0	0	3	4	1	11	24	44	25
N	83	42	10	13	16	24	22	24			234

Seven clusters were found for 2011; detailed description of this can be found in Appendix 8.

Two of the seven clusters (1 and 3) had *above basic* LOS means greater than 50%, at 83.9% and 65.3%, respectively (Table 14). One of the seven clusters had *below basic* LOS means greater than 50%, at 60.5%. For the other four clusters, no one LOS had a mean greater than 50%, which indicates that no one LOS was prominent in the relevant LMs. Clusters 4, 6 and 7 had the *basic* LOS means that were higher than the corresponding *above basic* means. For municipalities in these clusters, VIP latrines were more prominent than toilets.

Cluster 1 was clearly the most favourable regarding sanitation delivery; it had the highest mean for the *above basic* LOS (83.9%) and low means for the rest. Cluster 7 was clearly the most backlogged; it had the highest mean for the *below basic* LOS and one of the lowest percentages for the *above basic* LOS. 3 out of 7 clusters had greater than 50% household access to *adequate services* (*above basic + basic*).

Table 14: Final Cluster centres for 2011 Sanitation

	1	2	3	4	5	6	7
Above Basic	83.9	38.5	65.3	10.2	34.9	10.8	9.6
Below Basic	2.8	35.4	7.2	37.9	13.1	20.3	19.5
Improved Services	86.7	73.9	72.5	48.2	48.0	31.0	29.1
Below Meagre	4.6	12.2	14.1	36.8	38.0	34.7	60.5
Unimproved Services	13.3	26.1	27.5	51.8	52.0	69.0	70.9

The Western Cape, Gauteng and the Metros have 100% of their municipalities in clusters with improved LOS greater than 50%; they were the most favourable provinces. The Northern Cape and Free State had more than 93% of their municipalities in clusters with *improved service* greater than 50%. Mpumalanga had 61% of its municipalities in clusters with *improved service* greater than 50%. North West and the Eastern Cape had between 40% and 50% of their municipalities in clusters with *improved service* greater than 50%. KwaZulu Natal and Limpopo had 24% of their municipalities in clusters with *improved service* greater than 50%. Mpumalanga, the North West and KwaZulu Natal also had between 15% and 26% of their municipalities belonging to cluster 7, while Limpopo has 56% of its municipalities belonging to cluster 7. Limpopo was the most backlogged province.

Table 15: Provincial distribution of clusters for 2011

	1	2	3	4	5	6	7	Percentage of municipalities with improved services		
Improved services	86.7%	73.9%	72.5%	48.2%	48.0%	31.0%	29.1%	> 50%	< 30%	N
WC	23	-	1	-	-	-	-	100	-	24
GT	6	-	1	-	-	-	-	100	-	7
Metros	5	-	3	-	-	-	-	100	-	8
FS	10	1	7	-	1	-	-	95	-	19
NC	13	3	9	1	1	-	-	93	-	27
MP	6	-	5	2	2	-	3	61	17	18
EC	10	1	5	3	4	11	3	43	8	37
NW	4	1	4	1	4	-	5	47	26	19
KZN	1	2	9	14	8	6	10	24	20	50
LIM	1	1	4	1	3	1	14	24	56	25
N	79	9	48	22	23	18	35			234

Combined: The cluster analysis revealed that cluster groupings were different for water supply and sanitation. The clusters were based on the percentage of households in the municipality with access to improved services. The fact that access to water supply services was superior to access to sanitation services is evident.

The greater number of sanitation clusters, in 2001, indicated a greater disparity in terms of access to sanitation services than water supply services. There were 9 clusters for water supply services for both 2001 and 2011. There were 10 clusters for sanitation services, which declined to 7 clusters in 2011. The fact that the number of clusters notably declined indicated that municipalities became more similar in terms of access to improved services.

The municipalities that had *access to improved services* for greater than 50% of households were more disparate for water supply services than sanitation services. For water supply, 5 of the 2001 clusters were for municipalities that had more than 50% household access to improved services, increased to 6 clusters in 2011. For sanitation, 7 of the 2001 clusters were for municipalities that had less than 50% household access to improved services, which decreased to 4 out of 7 clusters in 2011.

The clusters with the greater *access to improved services* percentages were more likely to have more municipalities than clusters with low *access to improved services* percentages. The number of municipalities belonging to clusters with *access to improved services greater* than 50% increased, indicating that access to improved services increased over time.

Furthermore, the more backlogged the province, the greater the number of clusters that the municipalities belonged to. This indicated the greater disparity in backlogged provinces compared to the well-off provinces.

Combined Cluster Description

The bubble graphs below illustrate the cluster movement and changes to the number of municipalities for both water supply and sanitation. The position along the x-axis demonstrates the percentage of the households with access to *adequate service*, the y-axis demonstrates year, and the width of the bubbles is determined by the number of municipalities that belong to the cluster – demonstrated by the data labels. The solid red line marks where 50% of households in the municipalities had access to *adequate services* – the *50 line*.

Water Supply: Number of clusters had change over the years (Figure 10). From 2001 to 2007, there is one less cluster – decreasing from 9 to 8 clusters. Despite the reduction, essentially, the same amount of clusters (5 clusters) and municipalities (about 50 LMs) fall below the *50 line*. This indicates that municipalities above the *50 line* became more similar, resulting in fewer clusters.

From 2007 to 2011, the number of clusters increased to 9 again, with one less cluster below the *50 line*. The last cluster, Cluster 9, was substantially small with only 2 LMs. The number of municipalities below the *50 line* reduced from 50 in 2007 to 25 in 2011, illustrating a notable improved shift in the cluster centres. The increase in the number of municipalities and the number of clusters above the *50 line* indicates that the progress that occurred was disparate, resulting in 2 more clusters forming in 2011 from 2007.

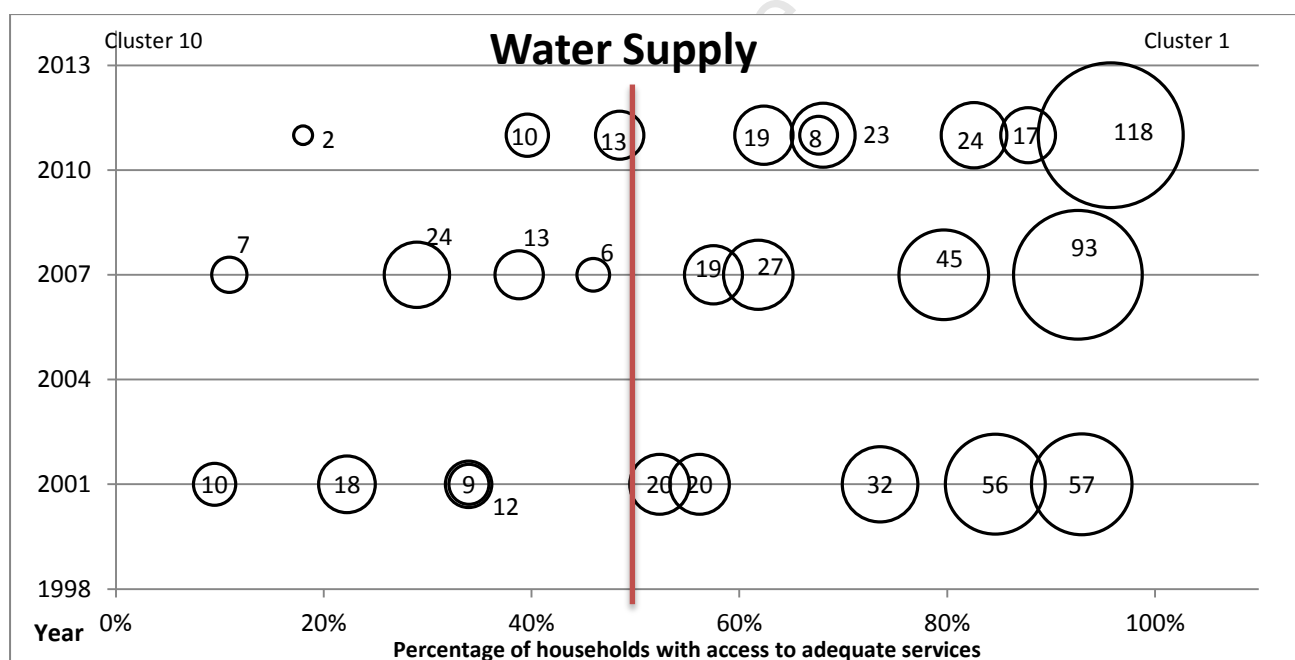


Figure 10: Illustrating changes in cluster centres for water supply clusters

The cluster range (difference between the first cluster, Cluster 1, and last cluster of a given year) has decreased over the years: 92% in 2001 to 82% in 2007 and increasing to 88% in 2011 (Figure 10). A reduction in the cluster range means that the municipalities in the clusters forming the rear (with low *adequate* LOS) progressed greater than Cluster 1. The inequality of overall access statistics therefore reduced.

Cluster 9 in 2011 (*adequate* LOS at 15%), included 2 LMs from the Eastern Cape, EC 153: Ngquza Hill and EC 443: Mbizana. The *adequate* LOS for Cluster 8 in 2011 (33.8%), was twice that of Cluster 9. This substantial gap between cluster centres indicates that Cluster 9 LMs were outliers. Bearing this in mind, excluding Cluster 9, the reduction in the cluster range was substantial. Between 2001 and 2011, the cluster range decreased by 36%, indicating that the overall inequality in access to adequate services had declined.

The number of municipalities in Cluster 1 (the rightmost cluster whose centre remains above 90% household access to *adequate* LOS) had notably increased, from 57 municipalities in 2001, 93 municipalities in 2007 and 118 municipalities in 2011. Cluster 1 in 2001 had an *above basic* LOS greater than 87%, which increased to 90%. This indicates a marginal increase in these municipalities where a substantial proportion of households accessed *above basic* LOS.

A few provinces had more than 50% of their municipalities in Cluster 1. Cluster 1 in 2001 consisted of 92% of Western Cape municipalities, between 55% and 60% of municipalities from Gauteng and Northern Cape, and 3 of the 8 Metros: Cape Town, Ekurhuleni and Johannesburg. Cluster 1 in 2007 consisted of 96% of Western Cape municipalities, 84% of Free State municipalities, 70% of Northern Cape municipalities, 57% of Gauteng municipalities, and 4 of 8 Metros: the aforementioned metros plus Nelson Mandela Metro. Cluster 1 in 2011 consisted of 100% of Western Cape and Free State municipalities, 85% of Gauteng and Northern Cape municipalities, and 7 of 8 Metro: all the metros except Buffalo City. These provinces increased their proportion of municipalities in Cluster 1. The municipalities in these provinces became more similar and are tending toward 100% of municipalities being clustered in Cluster 1.

The municipalities in Cluster 1 had shifted. Over 90% of the municipalities in Cluster 1 in 2001 were in Cluster 1 in 2007; 95% of these municipalities then were in Cluster 1 in 2011. The rest of the municipalities shifted to Cluster 2 in 2007 (for example, GT 484: Merafong City) and Cluster 3 in 2011 (for example, EC 106: Sundays River Valley). By and large, municipalities in Cluster 1 tended to remain in Cluster 1 – indicating similar progress across the board. Of the small number that shifted to other clusters, the shift was to clusters close to Cluster 1 and with similar LOS proportions: high *adequate* LOS (75%) and high *above basic* LOS (70%).

The number of LMs in the last cluster (the most backlogged) decreased, from 10 in 2001, 7 in 2007 to 2 in 2011. All of the last clusters had *meagre* LOS greater than 50%. The *meagre* LOS reduced: 81% for Cluster 9 in 2001 to 77% for Cluster 9 in 2011; all of which indicated progress made. 100% of the LMs from Cluster 9 in 2001 were in Clusters 7 and 8 in 2007; 100% of the LMs from Cluster 8 in 2007 were in Clusters 8 and 9 in 2011. The shifting of LMs from the last cluster was to clusters nearby; either to the last cluster or the one neighbouring it. This, like with Cluster 1, shows similar progress of LMs in the last cluster; the resultant clusters also had *meagre* LOS greater than 50%. Additionally, only Eastern Cape and KwaZulu Natal LMs were found in the last cluster; EC 153: Ngquza Hill and EC 443: Mbizana remained in the last cluster for 2001, 2007 and 2011.

For the central clusters, the shifting of the LMs was more disparate. For example, Cluster 4 in 2001 had an *adequate* LOS of 56%; the greatest LOS was *above basic* LOS (34%). 70% of the LMs were

from North West and Limpopo, including LIM 331: Greater Giyani, LIM332: Greater Letaba and LIM 333: Greater Tzaneen which are in the Mopani District (DC 33) – a water service provider. 75% of LMs in Cluster 4 in 2001 were in Cluster 3 in 2007 (*adequate* LOS at 62%, *above basic* at 45% and 56% of LMs were from North West and Limpopo). The rest were in Cluster 5 (*adequate* LOS at 46% and *above basic* LOS at 12%) and Cluster 6 (*adequate* LOS at 39% and *above basic* LOS at 22%). The LMs, LIM 331: Greater Giyani, LIM332: Greater Letaba and LIM 333: Greater Tzaneen, were all in Cluster 3 in 2007. These LMs shifted from 2001 to 2007 together. LIM335: Maruleng, a LM in Mopani District was also in Cluster 3 in 2007.

56% of LMs in Cluster 3 in 2007 were in Cluster 4 in 2011 (*adequate* LOS at 73%, *above basic* LOS at 43% and 35% of LMs were from North West and Limpopo). The rest of the LMs were in Cluster 2 (*adequate* LOS at 83% and *above basic* LOS at 63%), Cluster 3 (*adequate* LOS at 80% and *above basic* LOS at 69%) and Cluster 6 (*adequate* LOS at 57% and *above basic* LOS at 44%). LIM 333: Greater Tzaneen was not in Cluster 4 in 2011 like the other LMs from Mopani; it was in Cluster 6. This illustrates that not all of the LMs went to clusters with *adequate* LOS greater than the cluster they belonged to before, indicating a decline in services. This holds true even for LMs in the same district, such as Mopani.

100% of LMs from Cluster 6 got redistributed to Clusters 4 and 7 in 2007, and 75% of LMs from Cluster 7 got redistributed to Clusters 5 and 6 in 2007. Despite the fact that Clusters 6 and 7 for 2001 had virtually equal *adequate* LOS, there were notable differences between these clusters, regarding LMs and subsequent progress. Clusters 6 and 7 for 2001 had virtually equal *adequate* LOS means at 34%. The differences between the LOS distributions resulted in there being 2 clusters instead of 1. Cluster 6 had *above basic* LOS greater than the *basic* LOS, while the converse was true for Cluster 7. 100% of LMs in Cluster 6 were from KZN and Eastern Cape, the single LM from the EC was EC 157: King Sabata Dalindyebo. 67% of LMs in Cluster 7 were from KZN and Eastern Cape. This illustrates the importance of considering LOS outside of *adequate* and *inadequate* LOS.

Cluster 7 in 2001, Cluster 5 in 2007, and Cluster 5, 7 and 8 in 2011 show instances where the *basic* LOS was the greater proportion of *adequate* water supply service. Cluster 7 in 2001 had 12 LMs, Cluster 5 in 2007 had 6 LMs and Clusters 5, 7 & 8 in 2011 collectively had 31 LMs. These clusters indicate a persistent growth in *basic* LOS in the relevant LMs. These clusters had municipalities that were backlogged; Cluster 5 in 2011 had the largest *adequate* LOS (65%). A large proportion of LMs in these clusters were from KwaZulu Natal and Eastern Cape: 67% of LMs for Cluster 7 in 2001, 50% of LMs for Cluster 5 in 2007, 50% of LMs for Cluster 6 in 2011, 85% of LMs for Cluster 7 in 2011, and 100% of LMs for Cluster 8 in 2011. This indicates the proliferation and increase of *basic* LOS in Eastern Cape and KwaZulu Natal.

Only 30% of LMs however, in Cluster 7 in 2001 (*basic* LOS at 20%) were in Cluster 5 in 2007 (*basic* LOS at 34%), including NW 381: Ratlou. 42% of LMs in Cluster 7 in 2001 were in Cluster 6 in 2007, including EC 441: Matatiele. Cluster 6 in 2007 had *above basic* LOS greater than *basic* LOS, indicating a change in the LOS proportions. 100% of the LMs in Cluster 5 in 2007 were in Cluster 5 in 2011, a cluster that had *basic* LOS greater than *above basic* LOS. This further indicates that the shifting of

LMs belonging to central clusters was not predictable; this was true even for the few clusters which had *basic* LOS greater than *above basic* LOS.

The following maps show the spatial aspect of the water supply cluster analysis results for 2001, 2007 and 2011. The green colour scale highlights Group 1 clusters (*adequate* LOS between 75% and 100%); the brown-orange colour scale highlights Group 2 clusters (*adequate* LOS between 50% and 75%); the yellow colour scale highlights Group 3 clusters (*adequate* LOS between 25% and 50%); and the red colour scale highlights Group 4 clusters (*adequate* LOS between 0% and 25%).

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Access to *adequate* LOS increased from 2001 to 2011; it was however not consistent growth in all provinces.

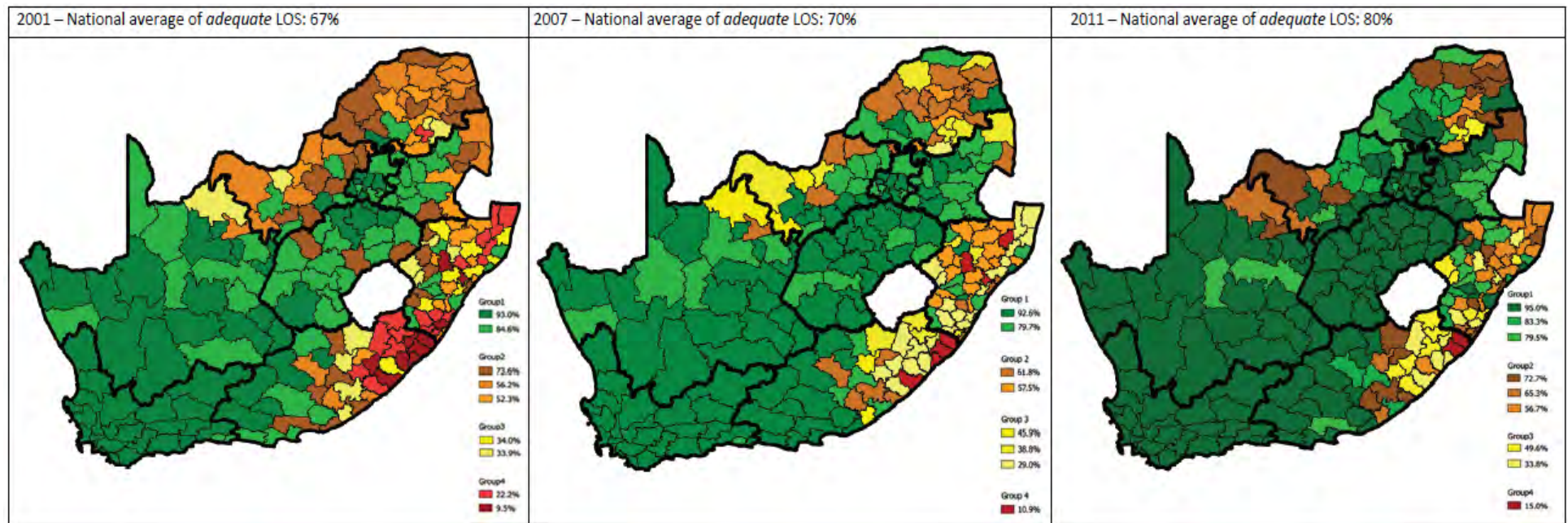


Figure 11: Water supply cluster analysis maps for 2001, 2007 and 2011

There was clearly a spatial component to access to water supply facilities in South Africa. In 2001, the favourable (in terms of access to adequate services) Group 1 municipalities were largely located in the western region of South Africa, the Free State and around Gauteng. The only LMs in the Northern Cape that were not in Group 1 in 2001 were NC 451: Joe Morolong (Group 3) and NC 452: Ga-Segonyana (Group 2); both LMs belong to the same DM, DC 45: John Taolo Gaetsewe.

Group 2 municipalities were largely concentrated in the Northern region in North West Limpopo and Mpumalanga; the only LM in Limpopo that was in Group 4 was LIM 473: Makhuduthamaga. Group 3 and 4 local municipalities were largely located in the eastern region of South Africa, in the Eastern Cape and

KwaZulu Natal. Group 1 municipalities were clearly in the majority for all years; this is verified by the high national average of water supply *adequate* LOS for all years.

From **2001 to 2007**, Group 1 municipalities spread to the eastern part of Mpumalanga, parts of Limpopo and the North West, and encompassing the entire Free State. Most of the Group 1 municipalities in 2001 were a darker shade of green in 2007. This indicates growth in *adequate* LOS in the Northern Cape, Free State and the western part of Eastern Cape. Joe Morolong and Ga-Segonyana were still not in Group 1 in 2007.

For Group 3 LMs, the LMs were either still in Group 3 or were in Group 2 in 2007; none of these LMs were in Group 4 in 2007. For Group 4 LMs, most of the LMs were in Group 3 in 2007, indicating growth in *adequate* LOS. Only 4 LMs in the Eastern Cape (EC 121: Mbhashe, EC 154: Port St Johns, EC 153: Ngquza Hill and EC 443: Mbizana) and 3 LMs in KwaZulu Natal (KZN 244: Msinga, KZN 294: Maphumulo and KZN 265: Nongoma) were in Group 4 in 2007. Only Port St Johns and Ngquza Hill belong to the same DM, DC 15: OR Tambo. EC 443: Mbizana, in fact, was a LM in OR Tambo District but was re-demarcated to DC 44: Alfred Nzo. As such, growth in Group 3 and Group 4 between 2001 and 2007 resulted in the LMs either remaining in the same group or improving.

The change in Group 2 from 2001 to 2007 was different to that of Group 1. A number of LMs in North West, Limpopo, and Eastern Cape that were in Group 2 in 2001 shifted to Group 3 in 2007, indicating a decline in access to *adequate* LOS. In the eastern part of Mpumalanga, however, most of the Group 2 municipalities in 2001 were in Group 1 in 2007, indicating growth in access to *adequate* LOS. The only LM in Mpumalanga that was in Group 2 for both 2001 and 2007 was MP 325: Bushbuckridge. This indicates that growth in Group 2 from 2001 to 2007 was less predictable than the other groups, with some decline in services occurring.

From **2007 to 2011**, Group 1 municipalities – similarly for 2001 to 2007 – spread to parts of North West and Mpumalanga, indicating growth. Group 2 municipalities in 2007 were either a darker shade of brown in 2011 or they shifted to Group 1. Growth for Group 2 LMs was evident, unlike for 2001 to 2007 which showed decline in services for some municipalities. Group 3 LMs in 2007 either remained in Group 3 in 2011 – largely in the Eastern Cape and the western part of KwaZulu Natal - or were in Group 2 in 2011 – largely in North West, Limpopo and the western part of KwaZulu Natal. Growth for Group 3 for 2007 to 2011 was similar to the growth for Group 3 municipalities between 2001 and 2007. The only Group 4 LMs in 2011 were Port St John and Ngquza Hill, indicating growth similar to that for 2001 to 2007 for both these LMs.

Sanitation: Similarly to water supply services, the number of clusters for sanitation services had changed. There was a constant decline in the number of clusters, decreasing from 10 clusters in 2001, 8 in 2007 to 7 in 2011. This illustrated a decrease in the disparity of the municipalities over the years.

Additionally, from 2001 to 2007, there was improvement with fewer municipalities and clusters below the 50 line: from 123 municipalities in 2001 to 86 municipalities in 2007. The reduction in the number of clusters below the 50 line indicates that these LMs became more similar in terms of access to improved sanitation services. From 2007 to 2011, however, there was an increase in municipalities below the 50 line, from 86 municipalities in 2007 to 98 municipalities in 2011. It should be noted however that Clusters 4 and 5 in 2011 (encompassing 45 LMs together) fell just below the 50 line, with *adequate* LOS at 48%.



Figure 12: Illustrating changes in cluster centres for sanitation clusters

The cluster range for sanitation services, similar to water supply, decreased over the years: 68.4% in 2001, 63.3% in 2007, and 57.6% in 2011. A reduction in the cluster range means that the municipalities in the clusters forming the rear (with low *adequate* LOS) progressed greater than Cluster 1; the inequality of overall access statistics thus reduced. The decrease in the cluster range was not drastic; the decline was just over 10% between 2001 and 2011.

The cluster member of Cluster 1 – whose centre remained between 80%-90% of the households with access to adequate service – grew from 2001 to 2007 (from 49 to 83 municipalities) before reducing slightly to 79 LMs in 2011. This indicates a decline in services between 2007 and 2011. Cluster 1 in 2001 had an *above basic* LOS of 81%. This increased to 84% by 2011, indicating a marginal increase

in these municipalities where a substantial proportion of households accessed *above basic* LOS. This is similar to what happened to Cluster 1 for water supply.

A few provinces had more than 50% of their LMs in Cluster 1. Cluster 1 in 2001 consisted of 92% of Western Cape municipalities, 71% of Gauteng municipalities, and 4 of the 8 metros: Cape Town, Ekurhuleni, Johannesburg and Nelson Mandela Metro. Cluster 1 in 2007 consisted of 100% of Western Cape municipalities, 86% of Gauteng municipalities (all except GT483: Westonaria), 59% of Northern Cape municipalities (up from 38% in 2001), and the 4 aforementioned metros. Cluster 1 in 2011 consisted of 1 less Western Cape municipality (WC011: Matzikama), 86% of Gauteng municipalities, 53% of Free State municipalities (up from 5% in 2001), and an additional metro: Tshwane. Northern Cape LMs in Cluster 1 shifted from 59% in 2007 to 48% in 2011. The change in the proportion of municipalities in these provinces was not consistent. The proportions of all provinces increased between 2001 and 2007, and not between 2007 and 2011. Between 2007 and 2011, municipalities from the Western Cape and Northern Cape shifted out of Cluster 1.

For sanitation, the *below basic* LOS declined but remained notably large. In 2001, Cluster 9 had the largest proportion at 74%. In 2011, Cluster 7 had the largest proportion at 61% and 3 other clusters had proportions greater than 30%. For water supply in 2011, the greatest *below basic* LOS is 25%.

Clusters 4 and 5 in 2011 had essentially equivalent *adequate* LOS (73%). Both clusters had a majority of the LMs from KwaZulu Natal (64% for Cluster 4 and 35% for Cluster 5); the LOS distribution, however, was different. The greatest LOS was essentially split for both clusters; Cluster 4 had *basic* LOS at 38% and *below basic* LOS at 37%, and Cluster 5 had *above basic* LOS at 35% and *below basic* LOS at 38%.

For sanitation, *above basic* LOS dominated the *adequate* service in 2001, this was similar to water supply. *Meagre* LOS, however, only dominated the *inadequate* service for half of the 10 clusters in 2001. This proportion remained true for 2007 to 2011.

There was a notable decline in *meagre* LOS in sanitation, with the largest percentage in 2001 belonging to Cluster 10, at 63%, and the largest percentage in 2011 belonging to Cluster 6, at 34%. *Meagre* LOS of Cluster 6 in 2011 (consisting of 18 LMs) was lesser than *meagre* LOS percentages of the last 3 clusters for water supply in 2011 (together consisting of 25 LMs); the *meagre* LOS were each greater than 40%.

Similarly to water supply, the *basic* LOS notably increased, 0 clusters in 2001, Clusters 3 and 6 in 2007, and Clusters 4, 6 and 7 in 2011 had *basic* LOS greater than *above basic* LOS. For Clusters 3 & 6 in 2007 and Cluster 4 in 2011, majority of LMs were from KwaZulu Natal. Clusters 6 and 7 in 2011 had the majority of LMs from Eastern Cape and Limpopo respectively – including the entire DM, DC47. This indicates a considerable increase in *basic* LOS provided in these LMs. The growth in *basic* LOS in water supply also occurred in KwaZulu Natal and Eastern Cape. Sanitation also showed growth in Limpopo.

The municipalities in Cluster 1 had shifted. 100% of the municipalities in Cluster 1 in 2001 were in Cluster 1 in 2007; 86% of these municipalities then were in Cluster 1 in 2011. The rest of the municipalities shifted to Cluster 3 in 2011; none of these 12 municipalities were metros and 5 were from Northern Cape (such as NC092: Dikgatlong). This indicates that by and large, similarly to water supply, municipalities in Cluster 1 tended to remain in Cluster 1 – indicating similar progress. Of the small number that shifted to Cluster 3 in 2011, the shift was to a cluster close to Cluster 1 and with similar LOS proportions - with high *adequate* LOS (72%) and with a high *above basic* LOS (65%).

The number of LMs in the last cluster (most backlogged) increased, from 19 in 2001, 24 in 2007 and 35 in 2011. The *adequate* LOS for the last cluster had also increased from 15% in 2001, 24% in 2007 and 29% in 2011. The LOS distribution for the last cluster had changed; this was unlike with water supply. *Meagre* LOS was greater than 50% (64%) for Cluster 10 in 2001 but not for Cluster 8 in 2007 or Cluster 7 in 2011; the latter pair had *below basic* LOS greater than 50% (67% and 60%, respectively). The LMs in the last cluster had also shifted. 68% of LMs, from Cluster 10 in 2001, shifted to Cluster 7 in 2007 instead of Cluster 8. 9 of these 15 LMs were from the Eastern Cape, such as EC 132: Tsolwana. 58% of LMs from Clusters 8 and 9 in 2001 were in Cluster 8 in 2007; these clusters all had similar LOS distributions, with *below basic* LOS greater than 50%. Additionally, the greatest shift for Cluster 10 in 2001 were for KZN 271: Umhlabuyalingana and KZN 283: Ntambanana, which shifted to Cluster 3 in 2007 (*adequate* LOS at 62%). 92% of LMs, from Cluster 8 in 2007 were in Cluster 7 in 2011. The greatest shift for Cluster 8 in 2007 were for EC441: Matatiele and MP301: Albert Luthuli, which shifted to Cluster 4 in 2011 (*adequate* LOS at 48%).

The shifting indicated that improvement of sanitation services was different to water supply progress. The last cluster for water supply showed both an 8% increase in *adequate* LOS from 2001 to 2011 and a decrease in the number of LMs. The improvement in sanitation services for the last cluster was greater than of water supply (increasing by 15%); there was a corresponding increase in the number of LMs. The last cluster for water supply had, consistently, *meagre* LOS greater than 50%, while the last sanitation cluster for 2007 and 2011 had *below basic* LOS greater than 50%. As such, the LOS proportions for the last cluster were not the same for water supply and sanitation.

The LMs for sanitation tended to remain in clusters with a similar LOS distribution. Since the LOS distribution for the last cluster does not remain the same between 2001 and 2007, a number of LMs shifted from Cluster 10 in 2001 to Cluster 7 in 2007 instead of Cluster 8. None of the LMs in Cluster 8 in 2001 were in Cluster 8 in 2007. Sanitation, therefore, showed substantial improvement with *meagre* LOS. The 2 clusters 2001, with *meagre* LOS greater than 50%, were reduced to 0 clusters in 2007.

The shifting of municipalities in the central clusters was more disparate, similar to water supply. Cluster 4 in 2001 had *adequate* LOS of 48%; the greatest LOS proportion was essentially split between *above basic* and *below basic* LOS at 38% and 35% respectively. 48% of LMs were from KwaZulu Natal, including KZN212: Umdoni and KZN216: Hibiscus Coast – both belonging to the same DM. 62% of LMs in Cluster 4 in 2001 were in Cluster 2 in 2007 (*adequate* LOS at 74%, *above basic* LOS at 58%, and 31% of LMs were from KwaZulu Natal). The rest of the LMs shifted to Cluster 5

(adequate LOS at 44%, below basic LOS at 46%) and Cluster 6 in 2007 (adequate LOS at 42%, below basic LOS at 44%); the 1 LM that shifted to Cluster 6 in 2007 was EC141: Elundini. KZN212 shifted to Cluster 2 in 2007 and KZN216 shifted to Cluster 5 in 2007, indicating that LMs in the same DM do not necessarily progress similarly. Note that 3 of the 15 LMs in Cluster 6 in 2001 had notable progress and shifted to Cluster 1 in 2007: EC104: Makana, EC144: Gariep, and NW 393: Mamusa.

64% of LMs in Cluster 2 in 2007 shifted to Cluster 3 in 2011 (adequate LOS at 72%, above basic LOS at 65%, and 20% of LMs were from KwaZulu Natal). The rest of the LMs shifted to Clusters 1, 2, 5 and 6; KZN212: Umdoni and KZN216: Hibiscus Coast were both in Cluster 5 in 2011.

The following maps show the spatial aspect of the cluster analysis for sanitation for 2001, 2007, and 2011. The green colour scale highlights Group 1 (adequate LOS between 75% and 100%); the brown-orange colour scale highlights Group 2 (adequate LOS between 50% and 75%); the yellow colour scale highlights Group 3 (adequate LOS between 25% and 50%); and the red colour scale highlights Group 4 (adequate LOS between 0% and 25%).

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Access to *adequate* LOS increased from 2001 to 2011; it was however not consistent in all provinces.

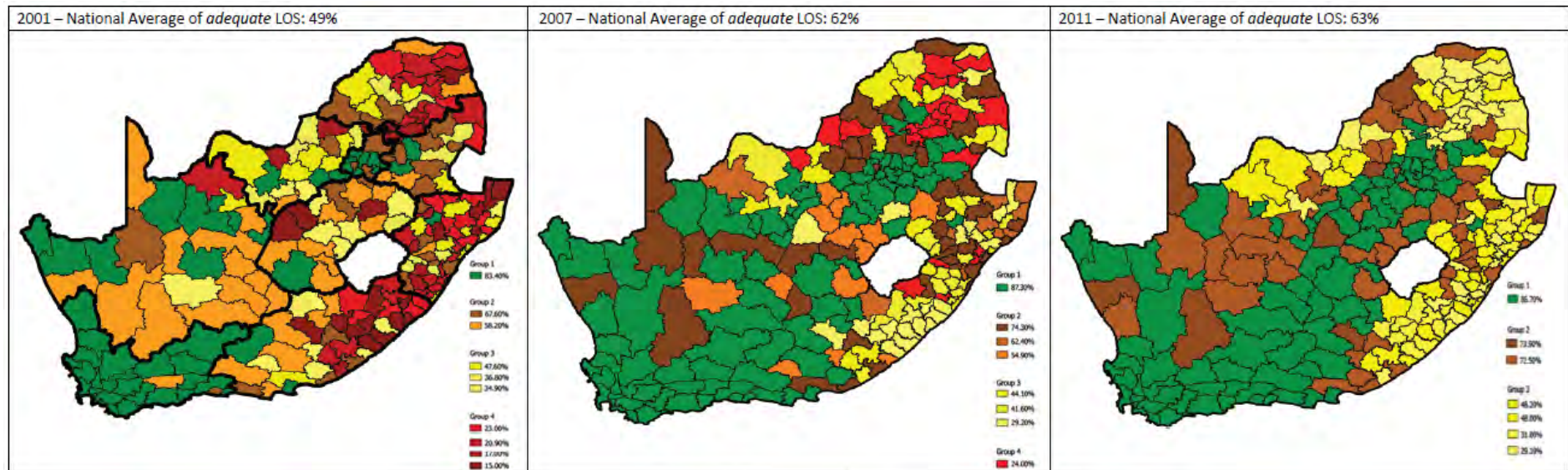


Figure 13: Sanitation cluster analysis maps for 2001, 2007 and 2011

There was clearly a spatial component to access to sanitation facilities in South Africa. There remained only 1 cluster in Group 1: Cluster 1, indicating that municipalities that were shifted to Group 1 were similar enough to be grouped to the preceding Group 1 municipalities.

In **2001**, the favourable Group 1 municipalities were largely located in the western region of South Africa, with a few located by Gauteng and the northern region of Northern Cape. No LMs in Limpopo were in Group 1. The North West had 3 LMs, the Eastern Cape and Mpumalanga each had 2 municipalities, and the Free State and KwaZulu Natal each had 1 municipality. Group 2 was mostly located in Limpopo, with at least 2 LMs from each province. Group 3 LMs were from all provinces except in Western Cape, with a concentration in North West. Group 4 LMs were from all provinces except Western Cape and Gauteng; and with a concentration in Eastern Cape, KwaZulu Natal and Limpopo. NC 451: Joe Morolong was the only LM in Northern Cape that was in Group 4.

The extensive sanitation backlog was evident, with the greatest number of LMs in Group 4 in 2001. In 2001, the number of LMs in Group 1 and Group 3 were equal (49 LMs); this was less than the number of LMs in Group 2 (62 LMs) and in Group 4 (74 LMs). By 2011, however, the absence of red shows that no LMs belonged to Group 4, indicating substantial progress in LMs in the sanitation most backlogged clusters.

From **2001 to 2007**, Group 1 municipalities spread from the Western Cape to the Northern Cape and around Gauteng to the Free State. Generally, in these provinces, the Group 2 municipalities in 2001 became Group 1 municipalities in 2007. The number of municipalities in Group 1 was the majority in 2007 (83 LMs); there was growth in this group. The Group 2 municipalities that remained in 2007 were scattered around all provinces except the Western Cape. There was an increase in the number of Group 3 LMs in Eastern Cape, which were Group 4 LMs in 2001. Sets of Group 3 LMs persisted in North West, Limpopo and KwaZulu Natal. The number of LMs in Group 4 diminished considerably; the remaining LMs were largely located in the North – in and around Limpopo. The only Group 4 LMs were in the Eastern Cape, KwaZulu Natal, North West and Mpumalanga. The only LMs that shifted from Group 3 LMs in 2001 to Group 4 LMs in 2007 were from the North West, KwaZulu Natal, Mpumalanga, and Limpopo.

From **2007 to 2011**, the number of municipalities in Group 1 spread, encompassing the entire Free State. Some of the 2007 Group 1 municipalities became Group 2 municipalities in 2011, indicating a decline in access to *adequate* LOS in these municipalities. Group 2 municipalities were located in all provinces except Western Cape. Group 3 LMs were in the majority in 2011 (98 LMs), with the greatest number of clusters (4 clusters); this was due to no Group 4 LMs in 2011. The Group 4 LMs were largely found on the outer border – in North West, Limpopo, western Mpumalanga, KwaZulu Natal and eastern portion of the Eastern Cape.

Combined: For both water supply and sanitation services, there was notable improvement with the number of LMs below the 50 line reducing, membership in Cluster 1 increasing, and the lowest clusters improving with their centres shifting to the right. While the number of clusters above the 50 line does not constantly increase, what is evident from the graphs above is that of the number of clusters above the 50 line, there was an increase in the number of LMs.

The range (distance between the centres of the first and last cluster) was greater for water supply than sanitation services, 87.8% and 57.6% in 2011 respectively. As such, a greater disparity existed with water supply services than sanitation services. This disparity was skewed, however, with the number of municipalities below the 50 line notably less for the water supply than the sanitation statistics. The 98 municipalities below the 50 line *in 2011 for sanitation*, was still greater than the 51 municipalities below the 50 line *in 2001 for water supply services*. While Cluster 9 for water supply in 2011 consisted of 2 LMs, the final cluster for sanitation in 2011 – Cluster 7 – consisted of 35 LMs and it was the cluster with the third largest membership. As such, there was still a significant number of LMs with inadequate sanitation service, further illustrating the reality that sanitation services lagged behind water supply.

Cluster 1 was always the cluster with the largest number of municipalities for any given year. For water supply, Cluster 1 changed from 57 LMs in 2001 - which is 1 municipality greater than the cluster with the second largest membership - to almost 5 times that of the second largest cluster, with 118 municipalities in 2011. For sanitation, Cluster 1 changed from 49 municipalities in 2001 – almost 1.5 times greater than the cluster with the second largest membership – to just over 1.6 times greater with 79 municipalities in 2011.

Group 1 for water supply and sanitation were not the same. For water supply, the number of clusters increased from 2 to 3 clusters; only Cluster 1 was in Group 1 for sanitation. The number of municipalities in Group 1 for water supply was in the majority for all years. For sanitation, however, Group 1 had the majority of LMs for 2007; Group 4 had the majority in 2001 and Group 3 had the majority in 2011. This indicates that water supply was consistently improving notably even for favourable municipalities; sanitation growth, however, was less evident between 2007 and 2011.

The last cluster, for water supply, the number of LMs decreased, and last cluster remained in Group 4 in 2011 with 2 LMs from Eastern Cape. The last cluster for sanitation, the number of LMs increased, and the change in *adequate* LOS for last cluster much more notable than for water supply (no Group 4 in 2011). The progress in severely backloged LMs was greater for sanitation than for water supply. The decline in *meagre* LOS for sanitation was enough to shift a large number of LMs in Cluster 10 in 2001 to Cluster 7 in 2007 (and not Cluster 8). Most municipalities tended to stay in clusters with the same LOS distribution. The shifting from LMs in the last cluster, for water supply, was always to the last two clusters; this was not the same for sanitation. This further illustrates that sanitation progress was more irregular than water supply.

There is clearly a spatial aspect associated with access to adequate services; the LMs that bordered favourable provinces such as Western Cape and Gauteng showed better access than the rest of the municipalities in province: the eastern part of the Eastern Cape, eastern Mpumalanga, the western part of the North West, the southern part of the Northern Cape, and the Free State.

Progress Findings and Analysis

Progress statistics were calculated for three periods: 2001-2007, 2007-2011 and 2001-2011 (overall). The variables were calculated as the change in the percentage of households with access to adequate services. The figures below illustrate the cluster analysis results of progress variables. The bubble size and labels show the number of LMs in the cluster.

Water Supply: Clusters had changed over the years (Figure 14). There were 7 clusters for both 2001-2007 and 2007-2011 periods; 9 clusters for the overall period. This would indicate that the progress for water supply services overall was much more disparate than for the other time periods.

A large number of the municipalities were found between -5% and 15%: 88% for the 2001-2007 period, 76% for the 2007-2011 period and 63% of the municipalities for the overall period. Also, the range between the outer cluster centres increased: 57.8% (-8.9% to 48.9%) for 2001-2007, 74.9% (-18.1% to 56.8%) for 2007-2011 and 87.4% (-18.3% to 69.1%) overall. Further indicating that progress for the overall period was much more disparate than for the other time periods

The nucleus (or centre of all the clusters in a time period) was largely centred, for all 3 time periods, near 5% along the x-axis.

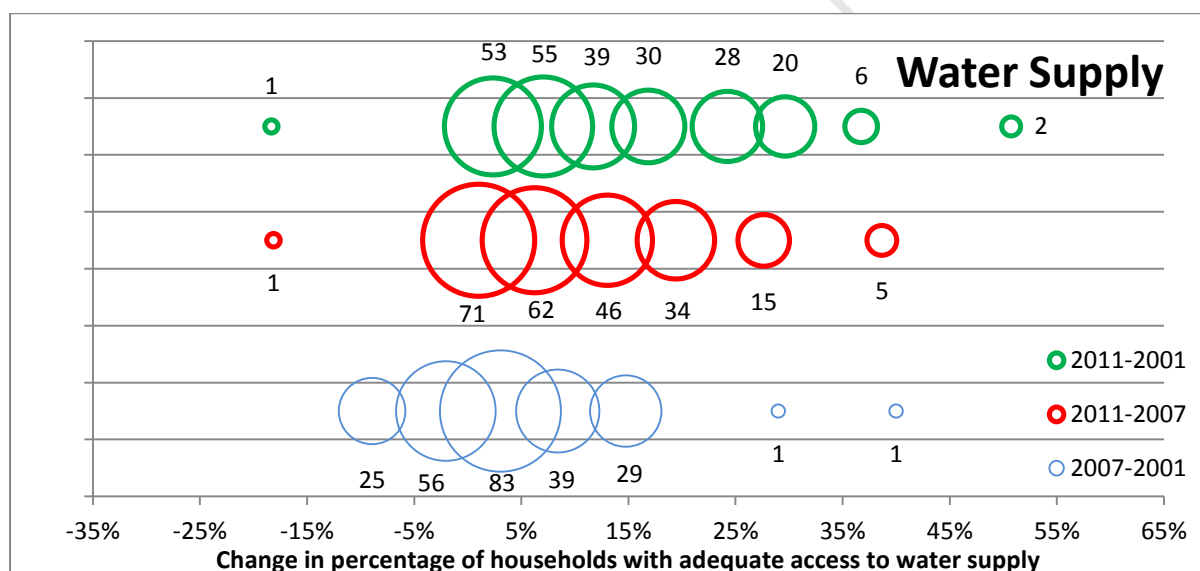


Figure 14: Cluster results of Water Supply progress for 2001-2007, 2007-2011 and 2001-2011

Sanitation: Clusters had changed over the years (Figure 15). There were 10 clusters for the 2001-2007 period, 11 for 2007-2011 period and 7 clusters for the overall period.

A large number of the municipalities can be found between -5% and 25%: 82% for the 2001-2007 period, 63% for the 2007-2011 period and 75% of the municipalities, overall. The range between the outer cluster centres increased: 67.8% (-21.0% to 46.8%) for 2001-2007, 73.9% (-31.2% to 42.7%) for 2007-2011 and 69.5% (-9.3% to 60.2%) overall.

The different number of clusters and ranges indicated irregular progress for the different time periods. There was an increase in disparity for the sanitation progress from the 2001-2007 period to the 2007-2011 period, decreasing for the overall period. The nucleus of the sanitation progress shifted; centred around 10% for the 2001-2007 and overall periods, and around -2% for the 2007-2011 period.

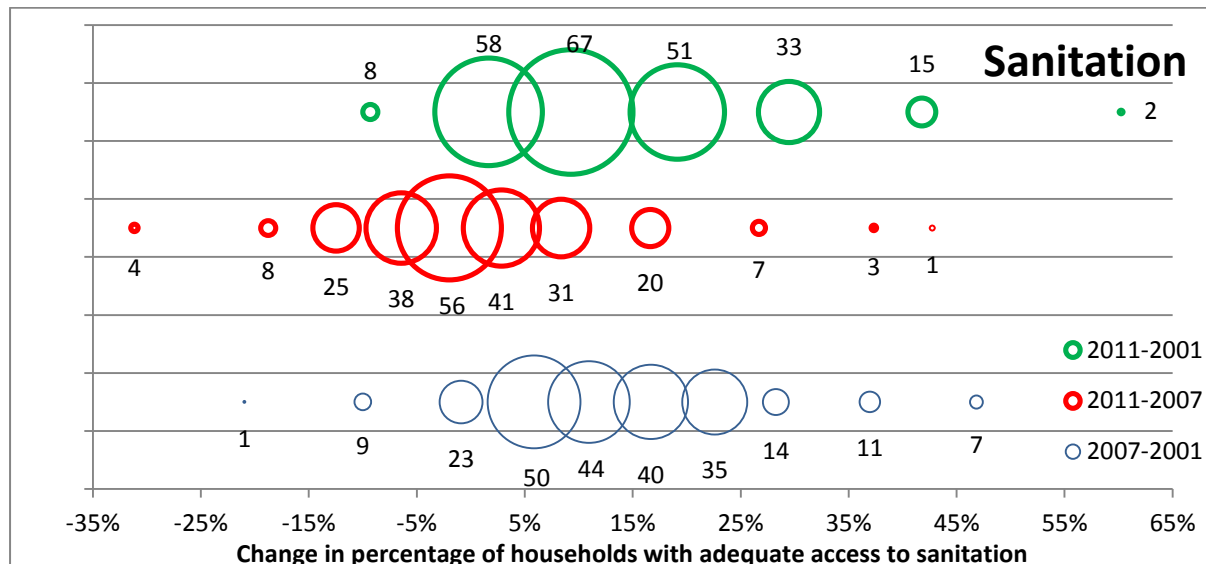


Figure 15: Cluster results of Sanitation progress for 2001-2007, 2007-2011 and 2001-2011

Combined: Water supply and sanitation progress graphs showed noticeable differences. The range, and therefore the general overall variability, was greater for water supply progress than for sanitation. For sanitation, the number of clusters was greater than for water supply. There were, however, also a greater number of small clusters - 6 out of 10 clusters for 2001-2007, 6 out of 11 clusters for 2007-2011 and 3 out of 7 clusters overall - with less than 23 municipalities (10% of all municipalities). These small clusters were also found on the periphery; outside of -5% to 25% on the x-axis. This indicates that there was a greater variety in sanitation progress in these peripheral values.

The differences in cluster nuclei show that the progress between water supply and sanitation had been dissimilar. For water supply, the cluster nucleus for all 3 time periods was around 5%. For sanitation, the cluster nucleus varies: around 11% for 2001-2007 and 2001-2011, and around -2% for 2007-2011. This indicates that sanitation progress, generally, was greater than water supply for 2001-2007 and overall; for the 2007-2011 period, however, water supply progress was greater than sanitation.

The dip in sanitation access for the 2007-2011 period is evident; such a notable dip was not found with the water supply. Thus, highlighting and reinforcing the point that sanitation services lagged behind that of water supply.

The following maps show the progress statistics spatially. The brown-orange colour scale shows municipalities with progress greater than 10%; the neutral (beige-sand) colour scale shows municipalities with progress between 10% and 0% and the blue colour scale shows municipalities with progress less than 0%

Water Supply: The water supply progress was not been consistent for the 3 time periods (Figure 16).

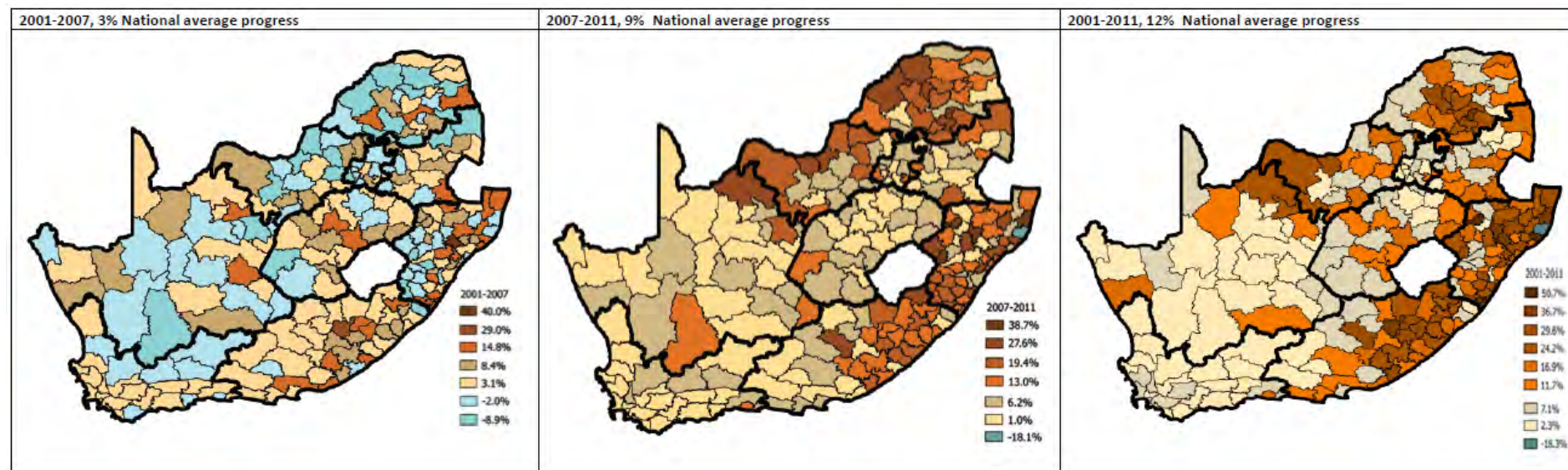


Figure 16: Water supply progress maps from cluster analysis: 2001-2007, 2007-2011 & 2001-2011

Negative progress was found for 35% of municipalities for 2001-2007. For the other time periods, only one LM was highlighted in blue: Mtubatuba LM, which is part of the Umkhanyakude District in KZN; progress after the 2001-2007 period was positive across the board.

For 2001-2007, municipalities with negative progress were found largely in 3 regions: in the North – in the North West, Limpopo and Gauteng; the West – in the Northern Cape and upper border of the Western Cape; and along the eastern border of KwaZulu Natal. The rest of the country, generally, displayed

progress between 0% and 10%. For 2007-2011, progress greater than 10% was found generally in 2 regions: along the eastern border - in the Eastern Cape and KwaZulu Natal and along the northern border – in the North West and Limpopo. The rest of the country displays progress between 0% and 10%. Overall, progress greater than 10% was largely found both along the eastern border: in the Eastern Cape, KwaZulu Natal and Mpumalanga, a noticeable group in Limpopo, and sporadically in parts of the Free State, North West and Northern Cape. The rest of the country displays progress between 0% and 10%.

LMs in the North West, Limpopo, Mpumalanga and KwaZulu Natal, which showed negative progress for 2001-2007, displayed greater than 10% progress for 2007-2011. The other municipalities went from negative progress to between 0% and 10%. This illustrates a greater increase in progress displayed in LMs in the aforementioned provinces than those in other provinces. The latter municipalities were located in the Western Cape, Northern Cape, Free State and Gauteng.

Sanitation: Sanitation progress, like water supply, was not been consistent for the 3 time periods (Figure 17).

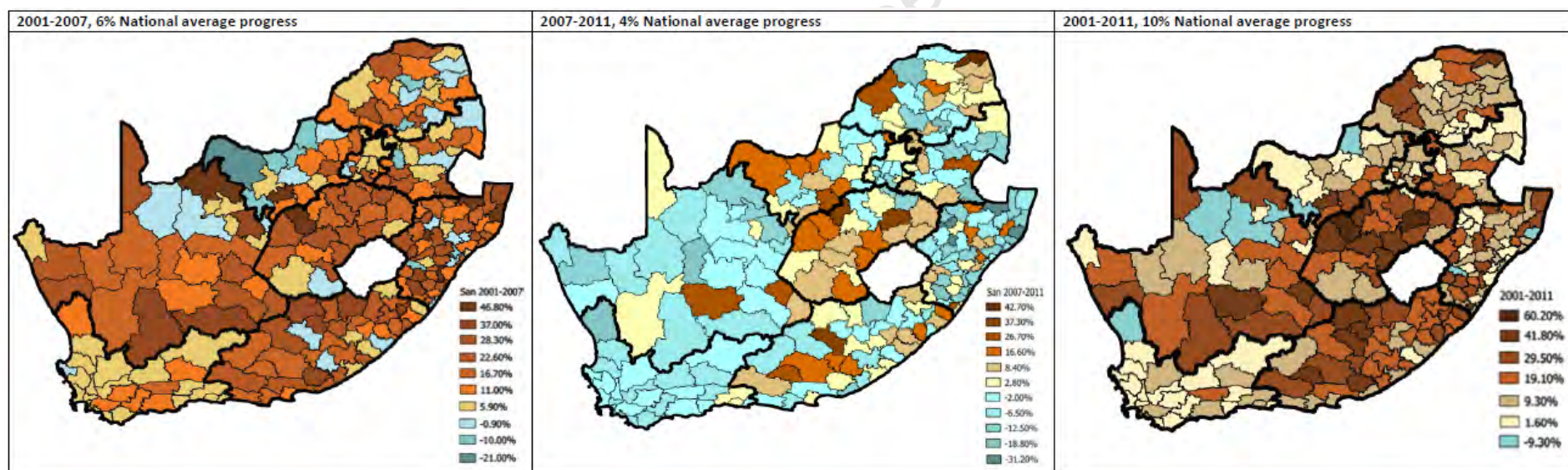


Figure 17: Sanitation progress maps from cluster analysis: 2001-2007, 2007-2011 & 2001-2011

Negative progress was found for a number of municipalities for 2007-2011; 56% of municipalities belonged to clusters with negative progress. For the other time periods, the progress was notably more positive. For 2001-2007, 75% of municipalities displayed progress greater than 10%. Overall (2001-2011) 3% of municipalities displayed negative progress, while 44% displayed greater than 10% progress.

For 2001-2007, the municipalities that displayed greater than 10% progress were largely located centrally; the majority of municipalities were from the Free State, Eastern Cape, KwaZulu Natal and the Northern Cape. Limpopo and Mpumalanga each had about half of the municipalities with greater than 10% progress. The Western Cape, North West, and Gauteng had few, sporadic occurrences of municipalities with greater than 10% progress. For 2007-2011, half of the LMs from Limpopo, Mpumalanga and the Eastern Cape displayed negative progress. The Free State and North West - centrally located provinces - displayed a minority of LMs with negative progress; the rest of the provinces – Western Cape, Northern Cape, KZN and Gauteng – displayed a majority of LMs with negative progress. For 2001-2011, greater than 10% progress was largely found in the Free State, Northern Cape and Eastern Cape; the rest of the provinces displayed a minority of LMs with negative progress.

Combined: Comparing water supply progress maps to the sanitation progress maps revealed notable differences. Similarities exist between the water supply 2001-2007 and sanitation 2007-2011 maps and the water supply 2007-2011 and sanitation 2001-2007 maps.

For the former set of maps - water supply 2001-2007 and sanitation 2007-2011 - a large number of municipalities displayed negative progress. The number of municipalities with negative sanitation progress was much greater than for water supply: 56% versus 35%. Another commonality between the maps is that the Free State and North West do not display a majority of LMs with negative progress. This indicates firstly, that the poor service delivery period - marked by a large number of municipalities with negative progress - was much worse for sanitation than for water supply; secondly, that the negative progress for water supply and sanitation did not affect a large majority of municipalities in the Free State and the North West; and thirdly, that the poor service delivery periods for water supply and sanitation did not occur concurrently.

For the latter set of maps- water supply 2007-2011 and sanitation 2001-2007 – the main commonality was absence of municipalities that displayed negative progress; 1 LM with negative progress for water supply and 9 LMs for sanitation. The number of municipalities with greater than 10% progress for sanitation far outweighed that for water supply: 75% versus 43%. The municipalities with greater than 10% progress were found to be commonly located, for both water supply and sanitation, only in KZN and the Eastern Cape. The other regions, which displayed a high number of municipalities with greater than 10% progress for the one service: North West and Limpopo for water supply, and Northern Cape and Free State for sanitation, were generally

municipalities with 0% to 10% progress for the other service. This indicates firstly, that the good service delivery period - marked by a large number of LMs with greater than 10% progress- was much better for sanitation than water supply; secondly, that only the Eastern Cape and KwaZulu Natal displayed greater than 10% progress for a large number of the LMs for both services and thirdly, that the good service delivery periods for water supply and sanitation did not occur concurrently.

Comparing the overall maps (2001-2011) commonalities exist for both services. Firstly, the majority of municipalities displayed positive progress; secondly, Mtubatuba LM which is part of the Umkhanyakude District in KwaZulu Natal had seen a decline in progress; thirdly, the majority of LMs in the Western Cape and Gauteng both displayed between 0% and 10% progress; and finally, the majority of LMs in the Eastern Cape displayed greater than 10% progress. The progress displayed in municipalities for the Northern Cape, Free State, North West, Mpumalanga and Limpopo – five of the nine provinces - was generally contradictory; greater than 10% progress in for the one service was usually 0% to 10% progress for the other service. The overall maps, despite being largely beige-brown in colour, essentially look the inverse of one another; only the Eastern Cape and Mtubatuba LM in KwaZulu Natal displaying similar progress for both water supply and sanitation.

Correlation

The following scatterplots show the overall national pattern of progress made and previous access for the municipalities in the various provinces.

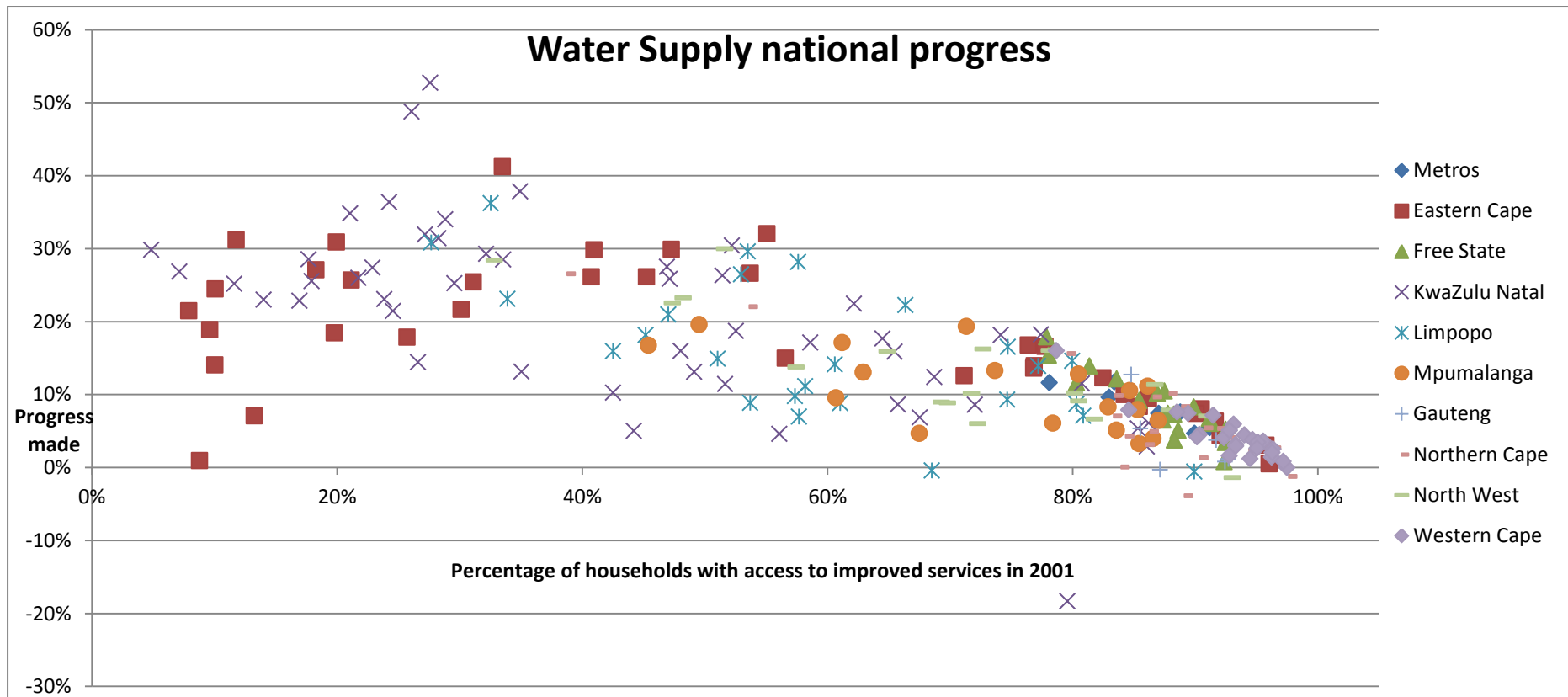


Figure 18: Water supply national progress

From the figure above, some provinces have municipalities close to each other – such as the Western Cape – and others do not – such as KwaZulu Natal. Water supply progress compared to household access in 2001 was different for different provinces.

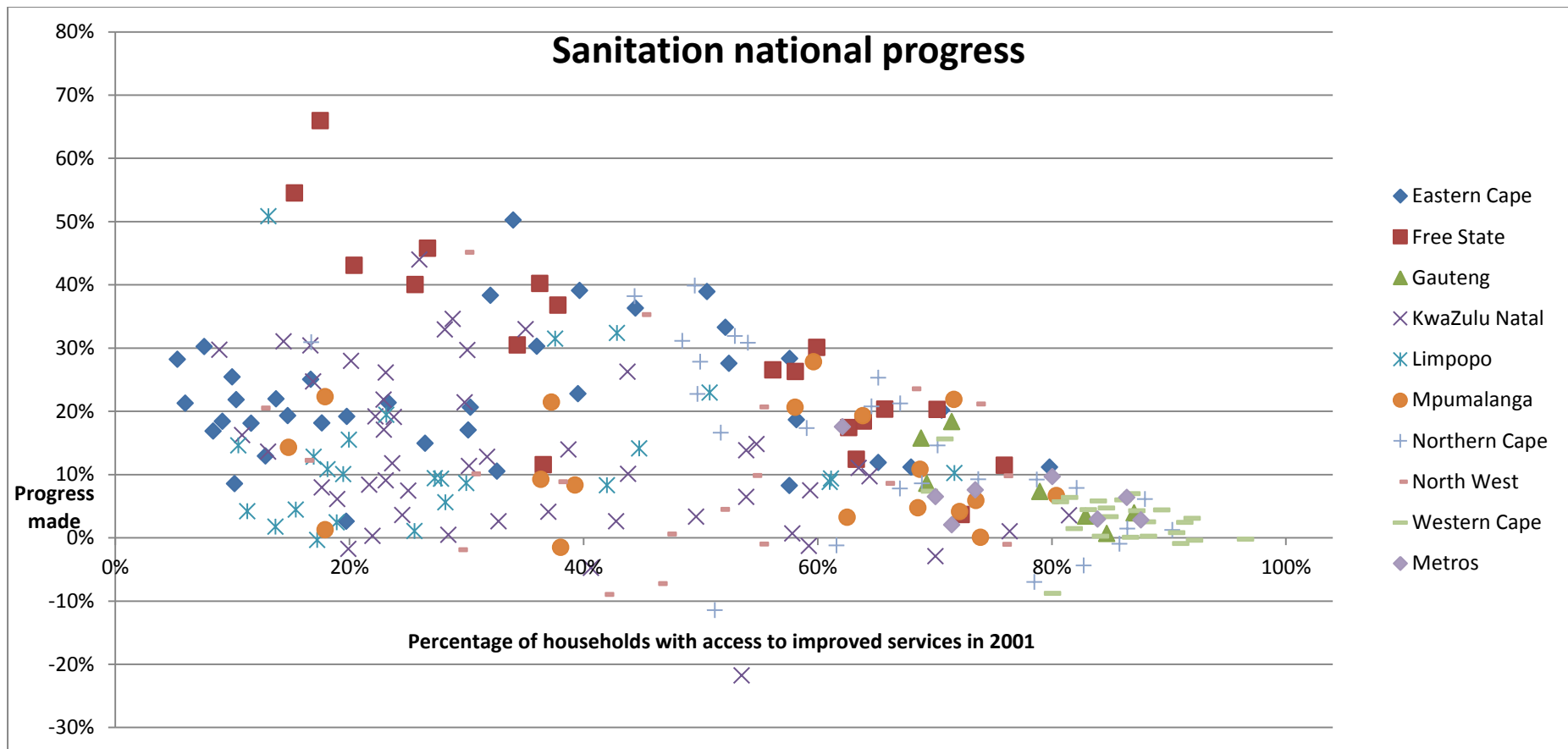


Figure 19: Sanitation national progress

From the figure above, some provinces have municipalities close to each other – such as the Western Cape – and others do not – such as KwaZulu Natal. Sanitation progress compared to household access in 2001 was different for different provinces. Furthermore, water supply was different to sanitation.

A two-tailed Pearson product-moment correlation test was run to determine if a correlation exists between progress made and previous access for the municipalities in the various provinces. The Figures (20, 21 & 22) below show the scatterplots of the various provinces for water supply. The x-axis represents the percentage of households that had access to adequate services in 2001; the y-axis represents the progress made – change in the percentage of households with adequate access - from 2001 to 2011. r represents the correlation coefficient, p the statistical significance or probability and n the sample size (in this case: the number of municipalities in the province).

Water Supply: For the provinces and the metros below, all the municipalities had more than 50% household access to adequate water supply services in 2001, and the range of progress was between -1% and 20% (Figure 20). All cases, except Gauteng, showed a very strong, significant, negative correlation between household access in 2001 and progress made (r is between -0.9 and -0.93, $p < 0.01$). For Gauteng, the probability is greater than 0.05 – indicating that the probability of the results occurring by chance are greater than 5% - therefore r is not statistically significant and a linear relationship between the variables cannot be established.

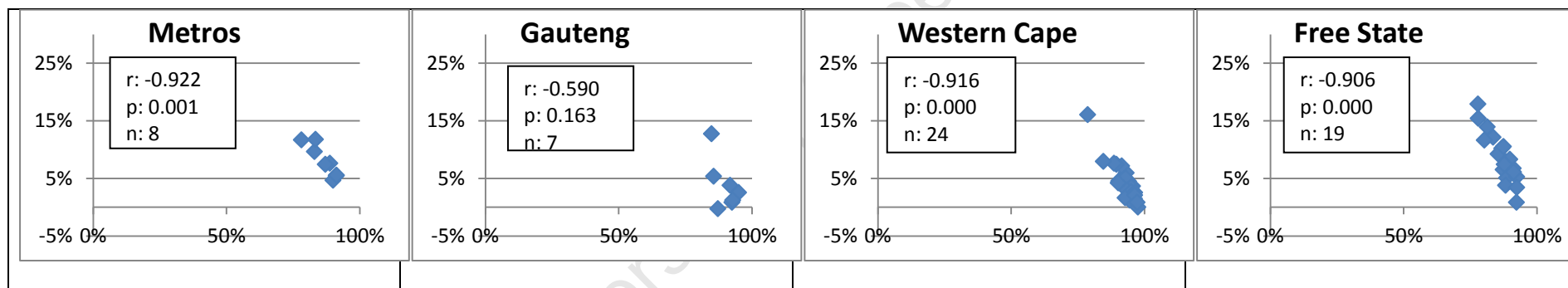


Figure 20: Scatterplot and Pearson correlation results of previously favourable provinces for Water Supply

The provinces below all had a few municipalities with less than 50% household access to adequate water supply services in 2001, and the range of the progress was between -5% and 35% (Figure 21). Northern Cape and North West showed a strong, significant, negative correlation between household access in 2001 to progress made (r is between -0.85 and -0.88, $p < 0.01$). For Mpumalanga, the significant correlation was moderate ($r = -0.675$, $p < 0.01$).

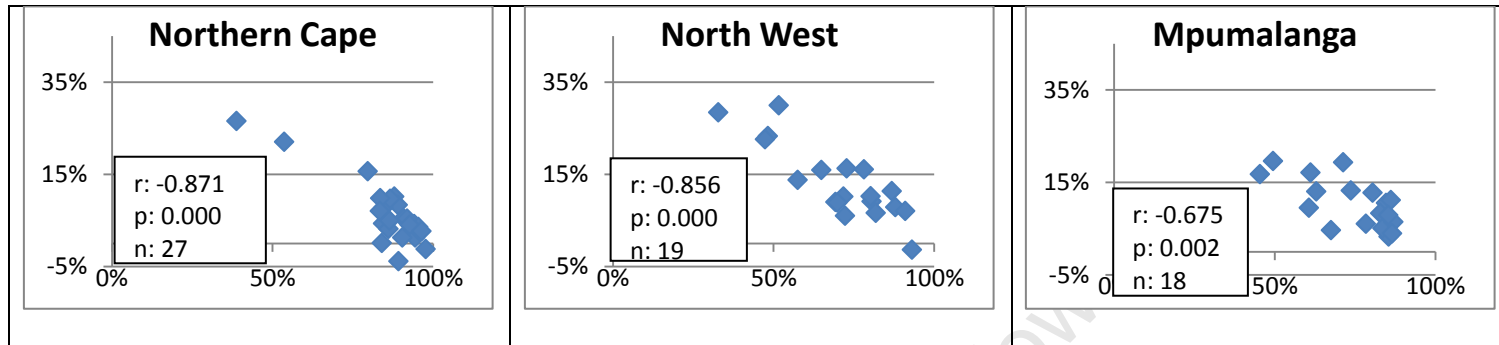


Figure 21: Scatterplot and Pearson correlation results of previously backlogged provinces for Water Supply

The provinces below all had a large number of municipalities with less than 50% household access to adequate water supply services in 2001, and the range of the progress was between -20% and 60% (Figure 22). The correlation that the provinces in this group was significant and moderate (r is between -0.54 and -0.68, $p < 0.01$).

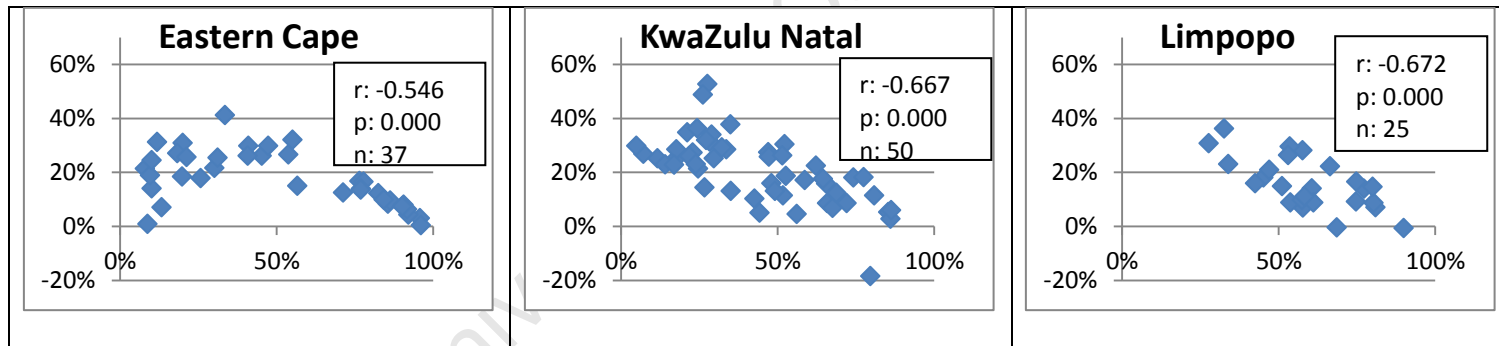


Figure 22: Scatterplot and Pearson correlation results of previously greatly backlogged provinces for Water Supply

The correlation coefficients were negative indicating that, within the provinces, municipalities that had a smaller percentage of households with access to adequate services in 2001 experienced more progress than the municipalities with a higher percentage. Gauteng was the only province where the results were not statistically significant.

4 out of 9 provinces showed a strong negative correlation between household access in 2001 and progress made. The Western Cape and Free State showed a stronger correlation than the Northern Cape and the North West. The former pair of provinces had no municipalities with less than 50% household access to adequate services; the latter pair had a few municipalities with less than 50% household access to adequate services. Metros also showed a very strong, negative correlation between household access in 2001 and progress made, and had no municipalities with less than 50% household access to adequate services. This would indicate that previously favourable provinces showed a strong negative correlation between household access in 2001 and progress made; provinces, where there were no municipalities with less than 50% household access to adequate services, showed the strongest correlation. These provinces also showed the smallest progress range when compared to other provinces. Mpumalanga showed a moderate correlation, akin to greatly backlogged provinces.

3 provinces, out of the 5 provinces that did not show a strong correlation, had a large number of municipalities with less than 50% household access to adequate services: namely, Eastern Cape, KwaZulu Natal and Limpopo (r is between -0.54 and 0.68, $p < 0.001$). This would indicate that provinces that were previously, notably backlogged did not show a strong correlation between *household access in 2001* and *progress made*. The progress range for these provinces is much larger than the other provinces, indicating that the progress has been made in these municipalities outweighed those in other provinces, in some cases.

The Eastern Cape was the only case where the trend in the scatterplot resembles an inverse parabola; the other scatterplots more or less resembled a straight line. The inverse parabola shows that there was no linear relationship between household access in 2001 and progress made. In essence, there are municipalities in Eastern Cape where large backlogs that existed in 2001 are still present due to the lack of prominent progress. A number of LMs outperformed LMs with lower percentage of household access to adequate service. One would assume that these previously backlogged LMs would have been targeted with the aim of ensuring progress. The lack of progress highlights that the water supply service delivery in some LMs in the Eastern Cape should be of concern. KwaZulu Natal data did not resemble a parabola, despite having more LMs with less than 50% household access to adequate services than the Eastern Cape, indicating that the water supply service delivery in KwaZulu Natal performed better than the Eastern Cape.

Sanitation: The Figures below (23, 24 & 25) show provincial scatterplots of *progress made* and *percentage of household access to adequate sanitation in 2001*, and the results of the two-tailed Pearson correlation test.

For the provinces and the metros below, all the municipalities had greater than 50% household access to adequate sanitation services in 2001; the range of progress was between -10% and 20% (Figure 23). The results for the Gauteng and Western Cape were significant with $p < 0.05$. Gauteng only has 7 LMs and thus Gauteng's results needed to be compared to the critical values table (Appendix 1) to determine if the results were significant for the small sample size. The critical value for $n = 7$ at a $p = 0.05$ is $r = 0.754$; the magnitude of r for Gauteng was greater than the critical value as such, Gauteng showed a strong, negative correlation ($r = -0.835$, $p < 0.05$, $n = 7$). The correlation found for the Western Cape was weak ($r = 0.487$, $p < 0.05$, $n = 24$). The results for Metros were not significant ($p > 0.05$); there was no linear relationship between progress and percentage of household access to adequate sanitation in 2001.

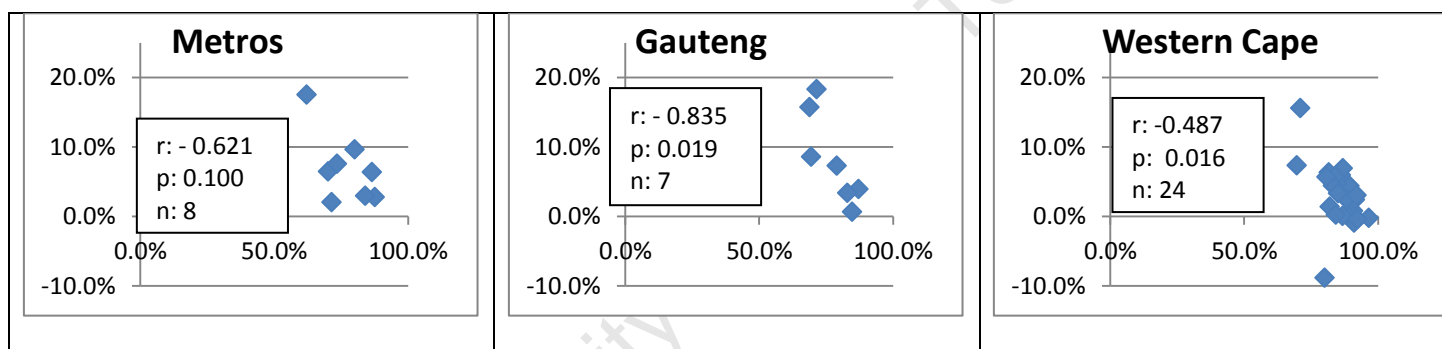


Figure 23: Scatterplot and Pearson correlation results of previously favourable provinces for Sanitation

The provinces below all have less than 50% of their municipalities with less than 50% household access to adequate sanitation services in 2001; the range of the progress for the Free State was between 0% and 65%, while the rest was between -15% and 35% (Figure 24). Northern Cape and Free State produced significant results ($p < 0.01$), while North West and Mpumalanga's results were non-significant ($p > 0.05$). The Free State showed a strong, negative correlation ($r = -0.851$, $p < 0.01$, $n = 19$), and the Northern Cape showed a moderate, negative relationship ($r = -0.677$, $p < 0.01$, $n = 27$).

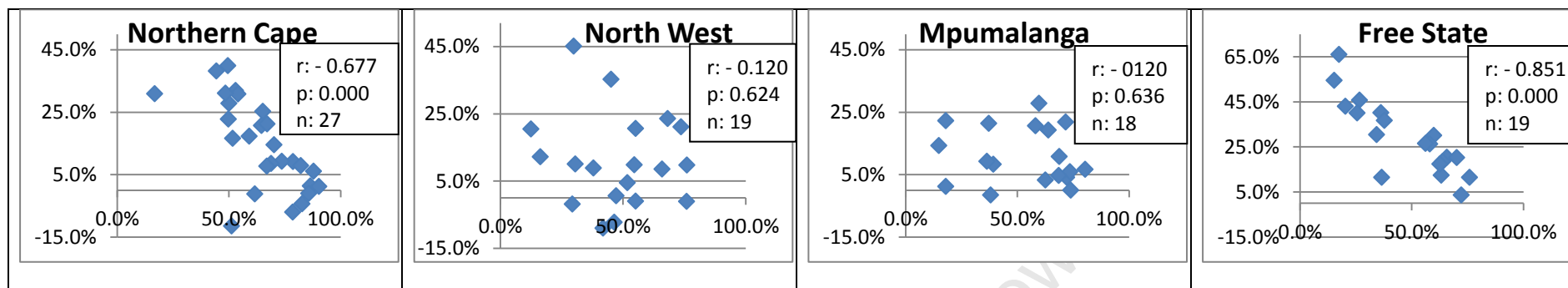


Figure 24: Scatterplot and Pearson correlation results of previously backloged provinces for Sanitation

The provinces below all have more than 50% of municipalities with less than 50% household access to adequate sanitation services in 2001; the range of the progress was between -25% and 55% (Figure 25). The results for KwaZulu Natal were significant ($p < 0.01$), while Eastern Cape and Limpopo's results were non-significant ($p > 0.05$). KwaZulu Natal showed a weak negative correlation ($r = -0.456$, $p < 0.01$, $n = 50$).

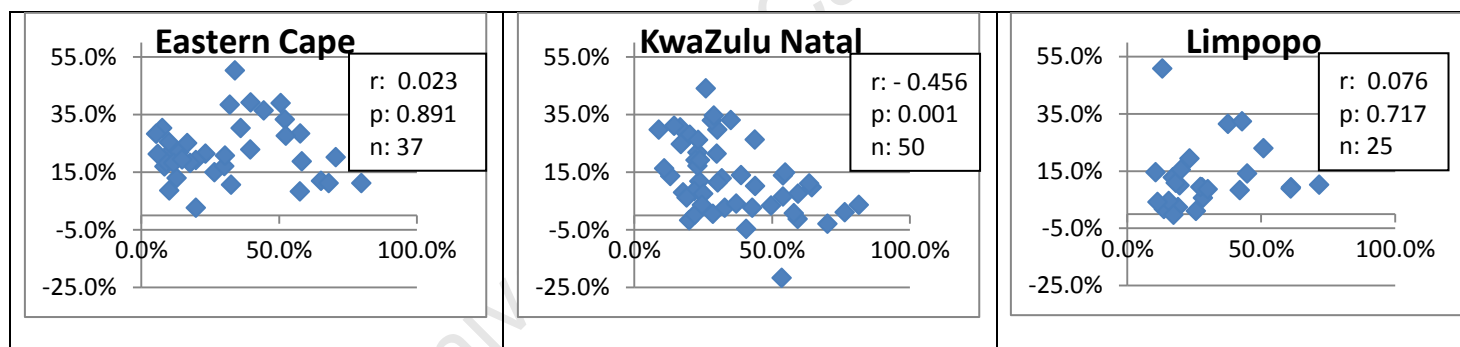


Figure 25: Scatterplot and Pearson correlation results of previously greatly backloged provinces for Sanitation

4 out of the 9 provinces – North West, Mpumalanga, Eastern Cape and Limpopo - and the Metros produced non-significant results, illustrating the absence of a linear relationship between *progress made* and *percentage of households with adequate sanitation services in 2001*. The lack of a noticeable trend in the scatterplots of these provinces supports this notion.

Of the 5 provinces with significant results, only 2: Gauteng and Free State, showed a strong negative correlation (r between -0.83 and -0.86); the probability of the former at a 95% level and the latter at a 99% level. Free State showed the strongest negative correlation, with the greatest value for r and significance at a 99% level. Free State belonged to the previously backlogged provinces while Gauteng belonged to the previously favourable provinces. The Northern Cape, which belonged to the previously backlogged provinces, showed a moderate correlation ($r = -0.677$) at a 99% level. Western Cape and KwaZulu Natal showed a weak correlation (r between -0.45 and -0.49) at a 95% and 99% level respectively; the former belonged to the previously favourable provinces and the latter to the previously greatly, backlogged provinces. This indicates that the strength of the correlation was not dependent on the whether or not province was previously favourable or backlogged.

Combined: More provinces showed a correlation between *progress made* and *prior access to adequate services* for water supply than for sanitation. Sanitation had 4 of the 9 provinces and the Metros that showed non-significant results; water supply had 1 province - Gauteng.

The only provinces that showed similar correlations for water supply and sanitation were Northern Cape, KwaZulu Natal and Free State. The strength of the correlation for sanitation was also less than water supply. For sanitation, the strength of correlation ranged from weak to strong; for water supply, the strength of correlation ranged from moderate to very strong.

Northern Cape showed a strong correlation for water supply and a moderate correlation for sanitation. KwaZulu Natal showed a moderate correlation for water supply and a weak correlation for sanitation. Free State showed a very strong correlation for water supply and only a strong correlation for sanitation. With the exception of the Free State, for water supply only, none of these provinces belong to the favourable provinces for water supply or sanitation. This would indicate that, for the backlogged provinces, service provision to eradicate previous backlog was achieved. The lesser the backlog however, the greater the correlation appears to be, with water supply always displaying a stronger correlation than sanitation. In terms of progress made water supply service delivery was better than sanitation.

The progress made within municipalities in the provinces was seldom the same for both services. Inconsistencies existed between water supply and sanitation. Gauteng showed a strong correlation for sanitation but was the only province that showed non-significant results for water supply. Western Cape showed a weak correlation for sanitation but a very strong correlation for water supply. This would allude to a contradiction in service delivery between water supply and sanitation for the two provinces.

The table below illustrates descriptive statistics of the provinces based on *progress made* (household access to adequate service in 2011-2001) of the municipalities in the provinces and metros. *Minimum* defined as the minimum progress value for the municipalities in a particular province. *Maximum* is defined similarly. Note: the *Average* is the average progress of the municipalities in the

respective provinces – and NOT the average provincial household access to adequate services. Green text highlights the maximum values within each column and the orange text, the minimum. The provinces are sorted in descending order according to *average* progress.

Table 16: Illustrating progress in the municipalities in the various provinces (in percentages)

Water supply			Sanitation				
	Minimum	Maximum	Average	Minimum	Maximum	Average	
				FS	3.3%	71.7%	32.3%
KZN	-27.9%	49.3%	19.2%	EC	3.3%	58.9%	21.9%
EC	2.0%	40.1%	18.4%	KZN	-16.6%	50.9%	14.4%
NW	2.0%	31.4%	15.8%	NC	-10.9%	37.6%	12.1%
LIM	-0.9%	38.8%	15.2%	MPU	0.4%	28.5%	11.5%
MPU	-5.1%	27.2%	13.5%	NW	-10.9%	51.8%	11.3%
FS	2.0%	21.4%	9.9%	LIM	-10.2%	26.3%	9.6%
Metro	2.0%	10.4%	7.2%	Metro	3.3%	19.1%	7.1%
NC	-5.1%	31.4%	5.3%	GAU	3.3%	19.1%	5.8%
GAU	-1.3%	10.4%	3.9%	WC	-10.9%	28.5%	4.4%
WC	2.0%	10.4%	2.7%				

The only provinces that did **not** have negative *minimum* progress values for both water supply and sanitation were the Eastern Cape, Free State and the Metros. The Northern Cape, Limpopo and KwaZulu Natal did have negative *minimum* values for both water supply and sanitation. KwaZulu Natal has the lowest *minimum* value for both water supply and sanitation. Negative *minimum* values indicated reduced access to adequate services, indicating that these provinces had problematic service delivery in some municipalities.

Only the Free State - for sanitation - was the entire row green; all values were larger than the other provinces, indicating that no municipality experienced negative sanitation growth and that one of the Free State municipalities showed that greatest sanitation progress. Sanitation provision in the Free State was notably good.

All *average* values are positive, indicating positive overall growth in provinces. The range of *averages* for sanitation services was greater than for water supply, indicating a greater disparity in progress of sanitation provision. The largest value for water supply was 19.2% for KZN, while sanitation had 2 provinces with *average* progress greater than 20% - for Free State and Eastern Cape, at 32.3% and 21.9% respectively. Lowest *average* progress values both belonged to the Western Cape at 4.4% and 2.7%, for sanitation and water supply respectively. Note again that the sanitation *average* progress was larger than the water supply average. It can be seen, for the *maximum* and *minimum* progress values, that the sanitation outdoes water supply, similarly.

Discussion

Analysis of the findings revealed that water supply and sanitation services had indeed improved; the improvement was disparate; water supply and sanitation services had improved differently; and more provinces showed a negative correlation between *progress made* (from 2001 to 2011) and *access to improved services in 2001*, for water supply than for sanitation.

Growth in the number of municipalities that belonged to clusters that had greater than 50% household access to both water supply and sanitation *adequate* services, showed there was an improvement in services. The decline in the number of clusters, especially for sanitation, and the decline in the cluster range between the first and last cluster, indicated that the overall municipal disparity regarding access to services had reduced.

The presence of Cluster 9 in 2011 for water supply, containing Ngquza Hill (from OR Tambo District) and Mbizana (from Alfred Nzo District), did however, reveal that outliers persist. Looking at the cluster movement of the other municipalities in OR Tambo District and Alfred Nzo District (Table 17), it is revealed that there was progress in Ngquza Hill and Mbizana despite being most backlogged in 2011. Ngquza Hill and Mbizana did not progress as substantially as the other municipalities in the district; this is despite other municipalities belonging to the same cluster in 2001. This indicates disparity in services, which occurred even for municipalities within the same district.

Table 17: Municipal movement of OR Tambo and Alfred Nzo municipalities

		Municipal category	2001	2011	Change in adequate LOS 2011 – 2001
O.R.Tambo District Municipality		C2			
EC153	Ngquza Hill	B4	9	9	9%
EC154	Port St Johns	B4	9	8	30%
EC155	Nyandeni	B4	9	8	30%
EC156	Mhlonlto	B4	8	7	26%
EC157	King Sabata Dalindyebo	B2	6	6	28%
Alfred Nzo District Municipality		C2			
EC441	Matatiele	B3	8	7	26%
EC442	Umzimvubu	B4	8	7	26%
EC443	Mbizana	B4	9	9	9%
EC444	Ntabankulu	B4	9	8	30%

For water supply in 2011, the provinces could be grouped into the following categories - based on the amount of municipalities that belonged to clusters with a great *improved* LOS:

Greatly favourable: Free State, Western Cape, Gauteng and Metros

Moderately favourable: Northern Cape, Mpumalanga and North West

Moderately backlogged: Limpopo and KwaZulu Natal

Severely backlogged: Eastern Cape

For sanitation in 2011, the provinces could be grouped into the following categories - based on the amount of municipalities that belonged to clusters with a great *improved* LOS:

Greatly favourable: Free State, Western Cape, Gauteng and Metros

Moderately favourable: Mpumalanga

Moderately backlogged: Eastern Cape and North West

Severely backlogged: Limpopo and KwaZulu Natal

The *greatly favourable* group is the same for both water supply and sanitation, while the other groups are not. This indicates that only the greatly favourable provinces (which included the Metros) had similar access to improved services for both water supply and sanitation.

Nnadozie (2011) found that provinces could be grouped into 3 groups with different trends in water supply provision.

Group A consisted of Gauteng, Free State and Western Cape. These provinces had a high percentage of households with access to basic water supply services in 1994 and are understood to be more technically capable of service provision. Provinces in Group A were characterized by an increasing trend in additional demand, due to in-migration. Water supply provision was characterised as increasing until access evens out at about 98% of households.

Group B consisted of Northern Cape, North West and KwaZulu Natal. These provinces had less favourable access to basic water supply services, compared to Group A. KwaZulu Natal had notably lower initial access. Water supply provision was characterized by rapid increase in access.

Group C consisted of Eastern Cape, Mpumalanga and Limpopo. These provinces had the least favourable access to basic water supply services and were former homeland states. Water supply provision was characterised by a slow decline in backlog which may be attributed to out-migration.

Comparing provincial groups from cluster analysis with the groups from Nnadozie (2011), Group A is equivalent to *greatly favourable* group; and Eastern Cape and Limpopo, from Group C, are *backlogged* provinces. Mpumalanga, however, was classified as Group C by Nnadozie (2011) but was found to be *moderately favourable* for both water supply and sanitation. This would indicate that Mpumalanga did not experience a slow decline in backlog as asserted by Nnadozie (2011).

Municipalities that belonged to Cluster 1 tended to remain in Cluster 1; the few municipalities that shifted out of Cluster 1 were shifted to one other cluster with access to *adequate* services for more than 70% of households in the municipalities. These clusters both had similar LOS distributions - a large majority of the households had access to *above basic* services. This trend was only true for Cluster 1, however; the municipalities belonging to the other clusters shifted irregularly. *Favourable* provinces, such as Western Cape, Gauteng, Free State, Northern Cape and Metros, had the majority of municipalities in Cluster 1 by 2011. This indicates that municipalities in these provinces shifted so that the municipalities became similar in terms of access to services; they therefore could be

grouped into one cluster. Some *backlogged* municipalities progressed more than the *favourable* municipalities in these provinces.

Progress

Water supply and sanitation services did not progress similarly. From analysis of progress made data, a number of municipalities showed negative progress for water supply for 2001-2007, while a larger number of municipalities showed negative progress for sanitation for 2007-2011. This indicates that growth in services for the different sectors occurred in different timeframes. Only Free State and North West did not have many municipalities with negative progress.

For 2001 to 2011, the majority of municipalities in the Western Cape and Gauteng (*favourable* provinces for both water supply and sanitation) both displayed progress between 0% and 10%. This corroborates with Nnadozie (2011) the notion of slow, steady progress of Group A provinces. Progress in other provinces was less similar. Despite access to improved sanitation being worse off than water supply, 6 of the 9 provinces had majority of municipalities with sanitation progress between 0% and 10%; this progress is similar to water supply progress of previously well-off provinces. This indicates that for majority of municipalities, the most progress did not occur for the more backlogged service: sanitation.

Mfolozi LM (from Uthungulu District) showed the greatest progress between 2001 and 2011 for water supply, and Tswelopele LM (from Lejweleputswa District) showed the greatest progress between 2001 and 2011 for sanitation (Table 18).

Table 18: Municipal movement of Uthungulu and Lejweleputswa municipalities

Municipality	Municipal category	Cluster in 2001	Cluster in 2011	Progress (%)
Uthungulu District				
Mfolozi	B4	6	2	54
uMhlathuze	B1	2	1	11
Ntambanana	B4	8	7	26
uMlalazi	B4	6	6	28
Mthonjaneni	B3	5	6	10
Nkandla	B4	8	6	40
Lejweleputswa District				
Masilonyana	B3	6	1	52
Tokoloko	B3	10	2	59
Tswelopele	B3	10	1	72
Matjhabeng	B1	3	1	29
Nala	B3	6	3	37

Mfolozi is a B4 local municipality and Tswelopele is a B3 local municipality. Both of these are rural municipalities but have different characteristics, given that they are from different provinces. Mfolozi is located in KwaZulu Natal and as such, was once part of the former homeland region. Tswelopele, on the other hand, is located in Free State, which is a favourable province with a high percentage of households with access to adequate services.

Mtubatuba (B3 local municipality in Umkhanyakude District) has seen a notable decline in progress for both water supply and sanitation. This district consists of 5 local municipalities and is the second largest district in KwaZulu Natal.

Table 19: Municipal movement of Umkhanyakude municipalities

Local Municipality	Category	Water Supply			Sanitation		
		Cluster 2001	Cluster 2011	Progress	Cluster 2001	Cluster 2011	Progress
Umhlabuyalingana	B4	8	6	34%	10	4	33%
Jozini	B4	8	6	34%	10	6	16%
The Big 5 False Bay	B3	6	4	39%	6	2	39%
Hlabisa	B4	8	6	34%	7	4	25%
Mtubatuba	B3	2	6	-28%	4	6	-17%

It is evident that KZN 275 – Mtubatuba LM – is the only LM within the District with reduced access (Table 19). Mtubatuba is classified as a B3 LM (National Treasury, 2012). B3 Local Municipalities are LMs “with small towns, with relatively small population and significant proportion of urban population but with no large town as a core” (COGTA 2009b).

“Economically weak municipalities in predominantly rural areas or former homelands are deeply impoverished places. They have the highest backlogs in services and infrastructure but people are mostly too poor to pay for services” (COGTA, 2009a: 8).

Mtubatuba is quintessentially a municipality described above in *The State of Local Government in South Africa Report* done in 2009. In this report, Umkhanyakude District was found to be one of the 10 most vulnerable districts based on administration capacity, socio-economics and backlog statistics (COGTA, 2009a: 25). Additionally, Umkhanyakude was on the financial distress list as determined by National Treasury, in 2009 (COGTA, 2009a: 79).

It is interesting to note that the municipalities that had both the greatest improvement and decline of services were rural municipalities.

The former homelands or Bantustan regions - poor, rural regions characterised by severe municipal backlog in 1994 - were largely located in the North West, Limpopo, KwaZulu Natal and Eastern Cape; this indicates that there was a spatial characteristic to the backlog. From Figures 1 and 2, water supply and sanitation backlog municipalities were largely located in former homelands. The North West, Limpopo, KwaZulu Natal and Eastern Cape had more municipalities showing notable progress - greater than 10% - for water supply services than for sanitation services. The greatest improvement in sanitation services was for the Free State, not a previous Bantustan region; over 50% of municipalities in the Free State had a more than 29% increase in improved services.

The Department of Water Affairs (DWA) estimates that 80% of all WSAs can be classified as “very high vulnerability” due to insufficient technical and financial capacity (DWA, 2012); this includes municipalities that are not located in former homelands.

Correlation

More provinces showed a correlation between *progress made* and *prior access to adequate services* for water supply than for sanitation. The strength of the correlation for sanitation was also less than water supply. The only provinces that showed similar correlations for water supply and sanitation were the Northern Cape, KwaZulu Natal and Free State.

With the exception of the Free State for water supply only, none of these provinces belong to the well-off provinces for water supply or sanitation. This would indicate that, for the backlogged provinces, service provision to eradicate previous backlog was achieved. The lesser the backlog however, the greater the correlation appears to be, with water supply always displaying a stronger correlation than sanitation.

A negative correlation would indicate that the pro-poor initiatives – that favour expansion of services to the previously backlogged municipalities – were successful.

Funding

Funding is a crucial aspect of service delivery; if a service is not adequately budgeted for, government cannot provide the service (Torres, 2000: 21).

Table 20: Water supply budgeted expenditure 2006-2013 (National Treasury, 2012: 132)

R million	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
	Outcome			Revised Estimate	Medium-term estimates		
Operating expenditure							
Category A (Metros)	6 807	6 844	9 038	6 027	14 254	14 554	15 976
Category B (Locals)	852	1 814	3 772	3 987	6 834	6 774	7 274
Secondary cities	658	1 541	2 272	2 468	3 680	3 852	4 208
Remainder	194	273	1 501	1 519	3 146	2 922	3 066
Category C (Districts)	42	94	1 689	1 067	3 757	3 688	3 984
Subtotal operating	7 702	8 752	14 699	11 081	24 844	25 027	27 234
Capital expenditure							
Category A (Metros)	470	1 050	2 945	3 087	1 889	2 335	2 320
Category B (Locals)	189	452	1 356	1 020	2 151	1 965	1 906
Secondary cities	118	293	602	579	824	788	880
Remainder	70	158	754	442	1 327	1 177	1 116
Category C (Districts)	—	11	1 528	2 409	3 128	3 569	4 189
Subtotal capital	659	1 513	5 829	6 516	7 168	7 869	8 505

Table 21: Sanitation budgeted expenditure 2006-2013 (National Treasury, 2012: 135)

Table 8.5 Budgeted sanitation expenditure by category of municipality, 2006/07 – 2012/13

R million	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
	Outcome			Revised Estimate	Medium-term estimates		
Operating expenditure							
Category A (Metros)	1 949	2 427	2 917	2 196	5 293	5 729	6 135
Category B (Locals)	367	805	1 865	2 186	3 281	3 114	3 204
Secondary cities	273	681	1 098	1 450	1 850	1 802	1 852
Remainder	94	145	767	725	1 441	1 312	1 352
Category C (Districts)	107	80	246	178	443	608	637
Subtotal operating	2 424	3 312	5 029	4 559	9 027	9 451	9 975
Capital expenditure							
Category A (Metros)	735	588	1 207	1 250	2 066	2 486	2 819
Category B (Locals)	170	548	1 208	645	1 894	1 993	2 029
Secondary cities	95	446	564	331	926	1 126	1 110
Remainder	75	102	644	313	968	864	919
Category C (Districts)	-	-	757	247	682	522	569
Subtotal capital	905	1 136	3 172	2 141	4 669	5 001	5 416

The budgeted water supply and sanitation expenditure between 2006 and 2013 showed that Metros had a higher capital expenditure than local and district municipalities combined, for sanitation but not for water supply (National Treasury, 2012). Rural municipalities, however, had a higher capital expenditure than other local municipalities for water supply and not for sanitation. This, in conjunction with the fact that more provinces showed a correlation between *progress made* and *prior access to improved services* for water supply than for sanitation, indicates that the pro-poor initiatives have been more successful in water supply services than in sanitation services.

The fact that failing infrastructure needs to be repaired, further adds to the burden of existing backlog.

*“The focus has been on **building of new water infrastructure**. Unfortunately this is frequently **at the expense of maintenance** or improvement of existing infrastructure; hence the sustainability of water services in many areas is in doubt... The DWA is struggling with serious capacity and funding problems, which cannot be overstressed. It has estimated that reinvestment of R1.4 billion annually is required to maintain current infrastructure”* (SAICE, 2011: 15).

Lag in sanitation

Sanitation provision was challenging. In 2009, the responsibility of sanitation provision was transferred from DWA to the Department of Human Settlements (DHS). The purpose of the transfer was done as a means to prioritize sanitation provision.

“According to the DHS the transfer process took over 10 months to complete and: delays in the movement posed serious challenges to the functioning of National Sanitation Programme as neither the Department of Water Affairs nor Department of Human Settlements was willing to accept

responsibility for the National Sanitation Programme during the preparatory stage of the move.” (Tissington, 2011: 61)

Evaluation of the National Sanitation Programme in 2011 revealed a number of constraints to sanitation provision, thereby contributing to the lag in sanitation provision (DHS, 2012). Challenges included lack of clarity on the roles and responsibilities of relevant institutions, inadequate budget allocations that do not consider topography of different area, and lack of special consideration for provision in informal settlements (DHS, 2012: 84).

*“Some Municipalities have failed due to budgetary or environmental constraints related to the acceleration of eradication of the bucket toilets in urban areas... The **lack of earmarked funding on sanitation provision** results in municipalities prioritizing other expenditure priorities at the expense of sanitation. Combination of sanitation and water budgets results in the disruption and prioritization of expenditure on water not provision of sanitation. There are insufficient budget allocations for operation and maintenance of sanitation facilities, systems and upgrades of bulk infrastructure”* (DHS, 2012: 70).

“Since 2007, government had identified rural development as one of the country’s major priorities” (PMG, 2011). In some rural areas, toilets were poorly built and needed restoration before providing sustainable service (DHS, 2012: 16).

*“Although these statistics reveal the rapidity of sanitation access, users are often not receiving the full benefit because of high failure rates for two main reasons. Firstly, most sanitation facilities are **not compliant with appropriate technical design standards**; hence they are built in a manner susceptible to quick failure and extreme maintenance difficulties. Secondly, there is a **consistent lack of communication** with users on why and how to use these facilities, compounding maintenance problems”* (SAICE, 2011: 16).

The lag in sanitation progress between 2007 and 2011 could be attributed to the fact that sanitation provision from 2007 was focussed in rural areas, which are demonstrably difficult to deliver services to; that poorly built toilets needed restoration, diverting funds from providing new facilities; and that transferring responsibility of sanitation provision from DWA to DHS in 2009 led to non-efficient functioning of the *National Sanitation Programme*.

Strengths and Limitations of the study

Strengths - Cluster Analysis

The use of cluster analysis allows natural divisions in the data to create optimal groupings. The reduction from 10 to 7 clusters for sanitation, between 2001 and 2011, indicates an increased similarity in the municipalities. Furthermore, in 2011, 6 of the 9 water supply clusters were for municipalities with *more than* 50% household access to improved services, while 4 of the 7 sanitation clusters were for municipalities with *less than* 50% household access to improved services. This indicates that the disparity within the two services is different. The greater disparity

for sanitation services are for poor municipalities with *less than* 50% household access to improved services; the converse is true for water supply services.

Additionally, municipalities were able to be grouped according to different levels of service (LOS). For sanitation, Clusters 2 and 3 in 2011, for example, have virtually the same percentage for household access to improved services – 73% - but have very different proportions. The percentage of households with access to a *basic* LOS was 35% for Cluster 2 and 7% for Cluster 3.

Using cluster analysis allowed for different groupings to be created and shows the disparity (and changes thereof) between municipalities. Analysis at municipal level showed that even supposedly similar municipalities, based on the B1-4 categories and within the same district municipality, progressed differently.

A number of assumptions made have presented a number of limitations to the study.

Percentage versus absolute backlog

It should be noted that calculating access as a percentage of total households obscures localised changes: access to a tap inside the dwelling in the Eastern Cape increased from 25% in 1996 to 33% in 2011 while access in the Western Cape decreased slightly from 76% in 1996 to 75% in 2011. Household numbers in the Eastern Cape increased from 1.3 million in 2001 (StatsSA, 1996) to 1.7 million in 2011 (StatsSA, 2012), while the Western Cape household numbers increased from 0.98 million to 1.6 million. The difference in household growth highlights the need for population growth to be considered when dealing with service delivery; 75% of households in the Western Cape equates to 1.2 million households in 2011, which is more than the 0.98 million households in the Western Cape in 2001. Consequently, more households received taps inside the dwelling despite the decrease in percentage of households with access.

Looking at household numbers, the municipalities with the greatest progress - Mfolozi LM and Tswelopele LM – both had a decline in the number of households from 2001 to 2011, by 6% and 9%, respectively. The municipality with the greatest decline in household access - Mtubatuba LM – had an increase in the number of households from 2001 to 2011, by 158%. The increase in household numbers in Mtubatuba LM would have further stressed the already vulnerable municipality and service delivery, evidently, has not been able to keep up.

The figure below illustrates the population growth from 2001 to 2011 (StatsSA)⁵.

⁵ <http://www.world-data-atlas.com/statssa/>
August 2013

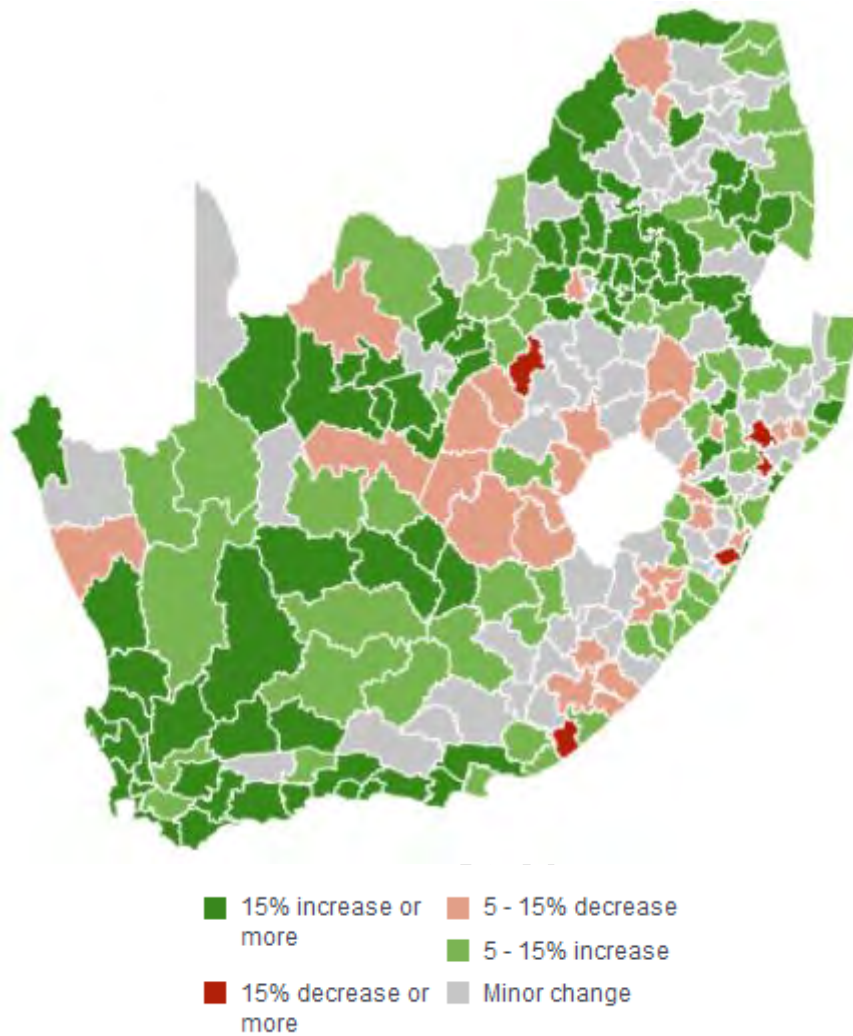


Figure 26: Population growth between 2001 and 2011

Change in population map shows that different municipalities experienced different population growth rates. The Free State, that had many municipalities with notable progress, also had a decrease in the population; the progress calculated is partly attributed to this decline.

The *SA National Infrastructure Programme* considers aspects of population migration for future plans. The figure below illustrates expected migration from under-serviced areas to metros. This migration would further stress service delivery in the economic centres in the country (PICC, 2012).

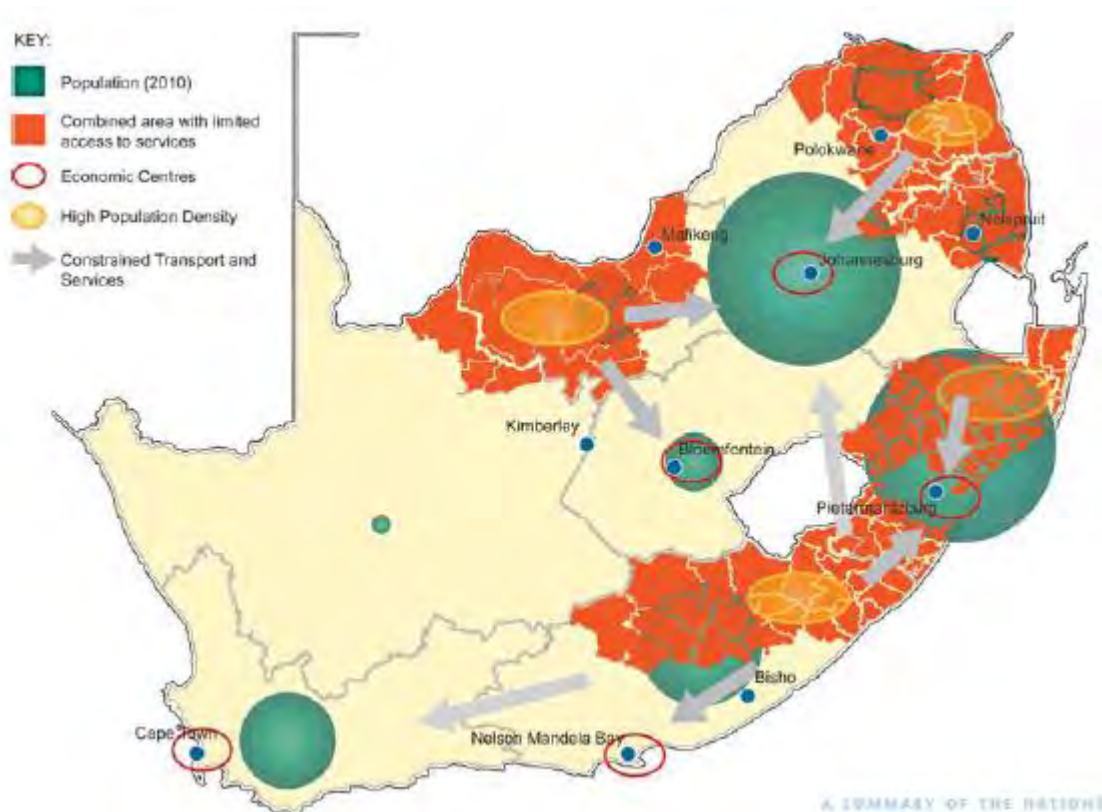


Figure 27: Expected population migration (source PICC, 2012: 11)

The advantage of measuring progress as a percentage of households highlights municipalities that have had notable household growth and therefore need to be prioritized in order to rectify the backlog. This highlights the fact that the pace of service delivery has to keep up with population and household growth.

Data

Gathering annual data would have been preferable instead of at three different points in time, with the time periods also not being equal. Annual data, which is available, is largely at provincial level and gathered through various sampling means.

As stated in the Methods chapter, the Community Survey was done using a two-stage stratified random sampling of 17 098 out of 80 787 Enumerator Areas. As such, it is subject to sampling errors. The sampling error in the Community Survey would certainly have affected the progress analysis (done for 2001-2007 and 2007-2011), but the exact quantitative impact is not possible to determine.

This study assumes that the improved facilities that were accessed were operational and sustainable. When accounting for microbial water quality and sanitary risk, the percentage of the global population accessing **unsafe** services in 2010 increased from 11% to 28% (Onda et al., 2012).

The water services infrastructure in South Africa was found to be of an unsatisfactory standard. Water supply and sanitation facilities were of a “satisfactory for now” standard in major urban areas,

while water supply and sanitation facilities in all other areas were “at risk” and “unfit for purpose”, respectively (SAICE, 2011:3). In essence, the facilities outside of the major urban areas are not coping with demand, are poorly maintained, and unsafe for public use.

Re-examination of access to water services taking into account the condition of the services would yield markedly different results.

Municipal level analysis

The geographical structure of the Census and Community Survey data are as follows:

“Level 1 – South Africa

Level 2 – Province

Level 3 – District Council (Category C) or Metropolitan Area (Category A)

Level 4 – Local Municipality (Category B), or District Management Area (DMA)

Level 5 – Main Place

Level 6 – Sub-place

Level 7 – Enumeration Area (EA)” (Census, 2001)

The EA is the smallest geographical unit, consisting of 100 to 250 visiting points (StatsSA, 1996).

The Modifiable Areal Unit Problem (MAUP) is based on the data aggregated to certain geographical boundaries, where the results yielded from the data will change if a different boundary is selected or the spatial scale is changed. This is closely linked to the ecological fallacy, which assumes homogeneity of *within* a population grouping and heterogeneity *between* population groupings. While smaller geographical units of analysis would be preferred in order to minimise the MAUP, the MAUP, however, would exist for all areal units.

Data at municipal level was used because of the sampling errors that exist with the Community Survey data. At municipal level, the values are more robust and reliable (StatsSA, 2007).

The analysis at a municipal level does, however, have limitations as it does not take into account the disparity within the local municipality. The situation in the metros is most notable because the high household access percentages obscure the disparity in services between urban areas and informal settlements. Under-5 mortality in informal settlements for example, can be up to 5 times higher than in the urban areas in cities (Martinez et al., 2008).

eThekweni Metro in KwaZulu Natal, particularly, has informal settlements and rural areas within its boundaries. Urban areas receive full pressure water services and flush toilets, rural areas use a variety of water LOS and VIP toilets, and informal settlements use communal taps and sanitation is either absent or provided through Pit Latrines (Sutherland & Lewis, 2012: 2). This disparate situation will further regress as migration into metros is expected in future, due to growing urbanisation in the country (PICC, 2012).

Future research

Looking forward, it would be worthwhile combining other data related to water supply and sanitation in the cluster analysis, such as Blue& Green Drop scores, MIG expenditure and operation and maintenance data. Future research could also analyse absolute backlog instead of percentage backlog. Blue and Green Drop reports have also only been done since 2009. Operation and maintenance, and state of infrastructure data are not widely available at municipal level.

“No record could be found of any formal broad-based audits or studies of the state of municipal infrastructure. Some services authorities, among them some municipalities, have in the past performed audits in respect of their own infrastructure. Other studies and audits have been undertaken on an ad-hoc basis. Particularly lacking is any overview of trends in the state and performance of municipal infrastructure and its maintenance.” (CSIR and cidb, 2007: 1)

Furthermore, it would be useful to perform the cluster analysis on yearly data. Annual data at a municipal level is difficult to collect. Most bodies monitor the access to water and sanitation at a provincial level given that it is an arduous process to collect data at municipal level. “The yearly delivery [of municipal] data are very erratic and this clearly illustrates the difficulty of undertaking a year by year monitoring and evaluation of delivery of basic services in numerical terms” (Nnadozie, 2009: 341). The annual data would be gathered, most likely, through sampling methods and, therefore, subject to error.

Another topic for future research is quantifying the spatial correlation between municipalities using a spatial autocorrelation test. Moran’s I test⁶, for example, determines the correlation of nearby locations based on chosen values. The results from spatial statistical tests allow spatial relationships to be quantified and can attribute to a better understanding of their significance.

There are other iterative clustering methods, besides k-means, that can be used to group the municipalities. The ISODATA algorithm, for example, is able to test for a range of clusters, while k-means request the number of clusters prior to execution. Using a different method would lead to different results; determining whether or not they would have worked better would have to be investigated.

Intended users

A study of this nature could assist in strategic water services planning, done by DWA, provincial and local government. Future Water Service Plans, interventions and goals can be targeted to similarly performing municipalities, and not merely based on the municipal categorisation.

*“As government strives to achieve universal access to basic services for all households by 2014, understanding our current status in the delivery of basic services is critical both in terms of reporting accurately to the nation and in developing appropriate strategies and interventions. **The diverse***

6

http://resources.esri.com/help/9.3/ArcGISEngine/dotnet/Gp_ToolRef/spatial_statistics_tools/how_spatial_autocorrelation_colon_moran_s_i_spatial_statistics_works.htm

nature of our municipalities, notably their financial and human capacity, requires a differentiated and targeted set of interventions and strategies to reduce service delivery backlogs and to cope with the demand for new services.” (COGTA, 2009: 5)

Conclusions

Overall, there has been notable progress in water supply and sanitation provision. This progress, however, has been disparate; only provinces with favourable access to improved services previously, such as Western Cape, Gauteng and the Metros, showing similar progress between municipalities. KwaZulu Natal - largely consisting of former homeland regions and previously backlogged - for example, had the municipality with the greatest growth in access to improved water supply services as well as the municipalities with greatest decline in access to both improved water supply and sanitation services. The disparate progress means that inequalities in access to improved services will persist.

The progress between water supply and sanitation provision was dissimilar, with growth occurring in different timeframes. The poor service delivery period - marked by a large number of municipalities with negative progress - was much worse for sanitation than for water supply; the negative progress for water supply and sanitation did not affect a large majority of municipalities in the Free State and the North West; and the poor service delivery periods for water supply and sanitation did not occur concurrently. For, the good service delivery period - marked by a large number of LMs with greater than 10% progress- sanitation was much better than water supply; only the Eastern Cape and KwaZulu Natal displayed greater than 10% progress for a large number of the LMs for both services; and the good service delivery periods for water supply and sanitation did not occur concurrently.

Comparing the overall progress maps (2001-2011) commonalities exist for both services. Firstly, the majority of municipalities displayed positive progress; secondly, Mtubatuba LM which is part of the Umkhanyakude District in KwaZulu Natal had seen a decline in progress; thirdly, the majority of LMs in the Western Cape and Gauteng both displayed between 0% and 10% progress; and finally, the majority of LMs in the Eastern Cape displayed greater than 10% progress. The progress displayed in municipalities for the Northern Cape, Free State, North West, Mpumalanga and Limpopo – five of the nine provinces - was generally contradictory; greater than 10% progress in for the one service was usually 0% to 10% progress for the other service. The overall maps, despite being largely beige-brown in colour, essentially look the inverse of one another; only the Eastern Cape and Mtubatuba LM in KwaZulu Natal displaying similar progress for both water supply and sanitation.

More provinces showed a correlation between progress made between 2001 and 2011, and prior access to *adequate* services for water supply than sanitation. This coupled with the fact that rural municipalities had a greater capital expenditure than other local municipalities for water supply and not for sanitation, indicates that the pro-poor initiatives have been more successful in water supply than in sanitation. This highlights that sanitation provision has been challenging and slow.

The lag in sanitation progress between 2007 and 2011 could be attributed to the fact that sanitation provision from 2007 was focussed in rural areas, which are demonstrably difficult to deliver services to; that poorly built toilets needed restoration; and that transferring responsibility of sanitation provision from DWA to DHS in 2009 led to non-efficient functioning of the *National Sanitation Programme*.

Major limitations of the study exist due progress being calculated as a percentage, and assuming that the facilities access are operational.

Calculating access as a percentage of total households obscures localised changes: access to a tap inside the dwelling in the Eastern Cape increased from 25% in 1996 to 33% in 2011 while access in the Western Cape decreased slightly from 76% in 1996 to 75% in 2011. Household numbers in the Eastern Cape increased from 1.3 million in 2001 (StatsSA, 1996) to 1.7 million in 2011 (StatsSA, 2012), while the Western Cape household numbers increased from 0.98 million to 1.6 million. The difference in household growth highlights the need for population growth to be considered when dealing with service delivery; 75% of households in the Western Cape equates to 1.2 million households in 2011, which is more than the 0.98 million households in the Western Cape in 2001. Consequently, more households received taps inside the dwelling despite the decrease in percentage of households with access.

The water services infrastructure in South Africa was found to be of an unsatisfactory standard. Water supply and sanitation facilities were of a “satisfactory for now” standard in major urban areas, while water supply and sanitation facilities in all other areas were “at risk” and “unfit for purpose”, respectively (SAICE, 2011:3). In essence, the facilities outside of the major urban areas are not coping with demand, are poorly maintained, and unsafe for public use.

Re-examination of access to water services taking into account the condition of the services would yield markedly different results.

Looking forward, it would be worthwhile combining other data related to water supply and sanitation in the cluster analysis, such as Blue& Green Drop scores, MIG expenditure and operation and maintenance data. Future research could also analyse absolute backlog instead of percentage backlog. Blue and Green Drop reports have also only been done since 2009. Operation and maintenance, and state of infrastructure data are not widely available at municipal level.

References

- BESG, 2008. *Review of Local Government Report 2008: Service Delivery*. URL: <http://www.besg.co.za/downloads/Service_delivery_and_local_government_review_2008.pdf> [Accessed: 7 April 2012].
- Blashfield, R.K., 1976. Mixture Model Tests of Cluster Analysis : Accuracy of Four Agglomerative Hierarchical Methods. *Psychological Bulletin*, 83(3), pp.377–388.
- Bond, P., 1999. Basic infrastructure for socio-economic development, environmental protection and geographical desegregation: South Africa's unmet challenge. *Geoforum*, 30(1), 43–59.
- Burns, Robert & Burns, Richard, 2008. Chapter 23 Cluster Analysis. In *Business Research Methods and Statistics using SPSS*. SAGE, pp. 552–567. URL: <<http://www.uk.sagepub.com/burns/chapters.htm>> [Accessed: 21 October 2012].
- Clatworthy, J. et al., 2005. The use and reporting of cluster analysis in health psychology: a review. *British journal of health psychology*, 10(Pt 3), pp.329–58.
- COGTA, 2009a. *Basic Services Publication: Comparative Information on Basic Services*. URL: <www.gov.za/documents/download.php?f=110099> [Accessed 31 August 2012].
- COGTA, 2009b. *State of Local Government in South Africa: Overview Report*. URL: <<http://www.info.gov.za/view/DownloadFileAction?id=110100>> [Accessed: 28 February 2012].
- CSIR and cidb, 2007. The state of municipal infrastructure in South Africa and its operation and maintenance; an overview. URL: <http://www.cidb.org.za/Documents/KC/cidb_Publications/Ind_Reps_Other/ind_reps_state_of_municipal_infrastructure.pdf> [Accessed 20 November 2013].
- Deininger, K. & Mpuga, P., 2005. Does Greater Accountability Improve the Quality of Public Service Delivery? Evidence from Uganda. *World Development*, 33(1), pp.171–191.
- DHS, n.d. *Rural Household Infrastructure Programme*. URL: <www.dhs.gov.za/uploads/Rural_Housing_Infrastructure_Programme.pdf> [Accessed 12 November 2013].
- DHS, 2012. *Ministerial Sanitation Task Team Report: July 2012. Review, Investigation and Evaluation of the National Sanitation Programme - Towards Continuous Improvement*. URL: <http://www.dhs.gov.za/uploads/reports/Sanitation_Task_Team_Report_July2012.pdf> [Accessed 11 November 2013].
- DWA, 2013. *Strategic Overview of the Water Sector in South Africa 2013*. URL: <<http://nepadwatercoe.org/wp-content/uploads/Strategic-Overview-of-the-Water-Sector-in-South-Africa-2013.pdf>> [Accessed 11 August 2013].

- DWA, 2012a. *Blue Drop Report 2012, Chapter 3: Eastern Cape Province* (p. 20 – 69). URL: <www.dwaf.gov.za/Documents/BD2012/EC.pdf> [Accessed 26 July 2012].
- DWA, 2012b. *Blue Drop Report - Chapter 8: Mpumalanga Province*, Available at: <http://www.dwaf.gov.za/Documents/BD2012/Mpumalanga.pdf>.
- DWA, 2012c. *Sanitation Services – Quality of Sanitation in South Africa Report on the Status of sanitation services in South Africa Executive Summary*, Available at: [http://www.sahrc.org.za/home/21/files/Quality of sanitation - Exec Summary \(Fin\).pdf](http://www.sahrc.org.za/home/21/files/Quality%20of%20sanitation%20-%20Exec%20Summary%20(Fin).pdf) III.pdf.
- DWAF, 2005. *Water and Sanitation Business - The Roles and Responsibilities of Local Government and Related Institutions*. URL: <<http://www.dwaf.gov.za/IO/Docs/CMA/WMI%20Poster%20Booklets/Roles%20&%20Responsibilities%20of%20Local%20Government%20and%20Related%20Institutions.pdf>> [Accessed 12 November 2013].
- DWAF, 2004. *A history of the first decade of Water Service delivery in South Africa 1994 to 2004*. URL: <www.dwaf.gov.za/documents/Publications/firstdecade.pdf> [Accessed 10 July 2012].
- DWAF, 1994. *Water Supply and Sanitation Policy White Paper*. Cape Town. URL: <<http://www.dwaf.gov.za/Documents/Policies/WSSP.pdf>> [Accessed 7 April 2012].
- Elhiraika, A.B., 2007. *Fiscal Decentralization and Public Service Delivery in South Africa*. URL: <[http://www.uneca.org/atpc/work in progress/58.pdf](http://www.uneca.org/atpc/work%20in%20progress/58.pdf)> [Accessed: 11 July 2012].
- Esfahani, H.S., 2005. Alternative public service delivery mechanisms in Iran. *The Quarterly Review of Economics and Finance*, 45(2-3), pp.497–525.
- Heleba, S., 2011. The right of access to sufficient water in South Africa: How far have we come? *Law, Democracy and Development*. 15 (2011), pp. 244–278.
- Heller, P., 2001. Moving the State: The Politics of Democratic Decentralization in Kerala, South Africa, and Porto Alegre. *Politics & Society*, 29(1), pp.131–163.
- Hope, R.A., 2006. Evaluating Water Policy Scenarios Against the Priorities of the Rural Poor. *World Development*, 34(1), pp.167–179.
- Hutton, G. & Haller, L., 2004. *Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level*. Geneva: WHO. URL: <www.who.int/water_sanitation_health/wsh0404.pdf> [Accessed 10 July 2012].
- IBM, 2011. *IBM SPSS Statistics 19 Statistical Procedures Companion - Chapter 17 Cluster Analysis*, pp. 375-404. URL: <www.norusis.com/pdf/SPC_v19.pdf> [Accessed 24 February 2013].
- Khosa, M.M., 2000. Facts, Fiction and Fabrication? Service Delivery in South Africa under Mandela. *Urban Forum*, 13(1), pp. 38–66.

- Lane, J., 2004. *Ghana, Lesotho, and South Africa: Regional Expansion of Water Supply in Rural Areas*. Washington D.C.: The World Bank. URL: <<http://documents.worldbank.org/curated/en/2004/05/5450119/ghana-lesotho-south-africa-regional-expansion-water-supply-rural-areas>> [Accessed 10 July 2012].
- Levin, R.M., 2007. Leadership And Service Delivery In The South African Context. In: *African Association For Public Administration And Management, 29th AAPAM Annual Roundtable Conference*, Mbabane, Swaziland, 3th – 7th September 2007. URL: <<http://unpan1.un.org/intradoc/groups/public/documents/AAPAM/UNPAN028746.pdf>> [Accessed 7 April 2012].
- Manase, G. et al., 2009. Using water and sanitation as an entry point to fight poverty and respond to HIV/AIDS: The case of Isulabasha Small Medium Enterprise. *Physics and Chemistry of the Earth, Parts A/B/C*, 34(13-16), pp. 866–873.
- Martinez et al., 2008. Trends in urban and slum indicators across developing world cities, 1990 - 2003. *Habitat International*, 32 (2008), pp. 86-108.
- May, J., 1998. *Poverty and Inequality in South Africa*. University of Natal. URL: <<http://www.info.gov.za/otherdocs/1998/poverty/presentation.pdf>> [Accessed: 10 July 2012].
- Mooi, E. & Sarstedt, M., 2011. *A Concise Guide to Market Research*. In Berlin, Heidelberg: Springer Berlin Heidelberg. URL: <<http://www.springerlink.com/index/10.1007/978-3-642-12541-6>> [Accessed March 4, 2013].
- Municipal Demarcation Board. (2012). *Municipal Capacity Assessment 2011 – National Trends in Municipal Capacity*. URL: <<http://www.demarcation.org.za/Webpage%20upload/Capacity%20Assessment%20%20Report%20All%20Provinces%202011/Final%20Municipal%20Capacity%20Assessment%20National%20Trends%20Report%2020121001.pdf>> [Accessed 17 August 2013].
- National Treasury, 2012. *2011 Local Government Budgets and Expenditure Review: 2006/7 - 2012/13*. URL: <<http://www.treasury.gov.za/publications/igfr/2011/lg/>> [Accessed 17 August 2013].
- Nattrass, N. & Seekings, J., 2001. Democracy and distribution in highly unequal economies: the case of South Africa. *The Journal of Modern African Studies*, 39(03), pp.471–498.
- Nnadozie, R., 2011. Access to adequate water in post-apartheid South African provinces: An overview of numerical trends. *Water SA*, 37(3), pp. 339–347.
- Onda et al., 2012. Global Access to Safe Water: Accounting for Water Quality and the Resulting Impact on MDG Progress. *International Journal of Environmental Research and Public Health*, 9 (2012), p 880-894.

- PICC, 2012. *A summary of the South African National Infrastructure Plan*. URL: <<http://www.economic.gov.za/communications/.../202-piccc.../download>> [Accessed 12 November 2013].
- PMG, 2011. *Report of the Portfolio Committee on Human Settlements on the Rural Household Infrastructure Programme, dated 1 July 2011*. [online] URL: <<http://www.pmg.org.za/docs/2011/comreports/110810pcsettlerreport2.htm>> [Accessed 12 November 2013].
- Ruger, J.P. & Kim, H.-J., 2006. Global health inequalities: an international comparison. *Journal of Epidemiology and Community Health*, 60(11), pp.928–936.
- SAICE 2011. *SAICE Infrastructure Report Card for South Africa*. URL: <http://www.csir.co.za/enews/2011_jun/download/infrastructure_report_card_sa_2011.pdf> [Accessed 20 November 2013].
- Saint-Arnaud, S. & Bernard, P., 2003. Convergence or Resilience? A Hierarchical Cluster Analysis of the Welfare Regimes in Advanced Countries. *Current Sociology*, 51(5), pp.499–527.
- Schwella, E., 2001. Public Sector Policy In The New South Africa: A Critical Review. *Public Performance & Management Review*, 24(4), pp.367–388.
- Smith, J., 2009. *Social policy, welfare in urban services in South Africa. A case study of free basic water, indigency and citizenship in Eastwood, Pietermaritzburg, KwaZulu-Natal (2005-2007)*. Ph.D. Rhodes University. URL: <<http://eprints.ru.ac.za/1578/1/Smith-PhD-TR09-115.pdf>> [Accessed 7 April 2012].
- Smith, L., 2004. The murky waters of the second wave of neoliberalism: corporatization as a service delivery model in Cape Town. *Geoforum*, 35(3), pp. 375–393.
- StatsSA, 2012. *Census 2011: Key results*. URL: <<http://www.statssa.gov.za/Census2011/Products.asp>> [Accessed 13 March 2013].
- StatsSA, 2007. *Cautionary note*. URL: <<http://www.datafirst.uct.ac.za/catalogue3/index.php/catalog/101>> [Accessed 11 November 2013].
- StatsSA, 2001. *Census 2001: Community Profile Databases, SuperCROSS Training Manual*. URL: <www.statssa.gov.za/census01/html/CommProfilesTraining.pdf> [Accessed 3 September 2012].
- StatSA, 1996. *The People of South Africa Population Census, 1996 - Census in Brief*. Statistics South Africa. URL: <www.statssa.gov.za> [Accessed: 02 October 2012].
- Sutherland and Lewis, 2012. *Water and Sanitation Service Delivery in eThekweni: a Spatially Differentiated Model*. Chance2Sustain. URL: <<http://www.chance2sustain.eu/46.0.html>> [Accessed 12 November 2013].

- Tissington, K., 2011. *Basic Sanitation in South Africa : A Guide to Legislation, Policy and Practice*. SERI. URL: <http://www.escri-net.org/usr_doc/SERI_Guide_on_Basic_Sanitation_in_SA.pdf> [Accessed: 10 July 2012].
- Torres, L., 2000. "We are emerging; emerging slowly and painfully!" *Infrastructure Delivery in South Africa*. Oslo: Fafo Institute for Applied Social Science. URL: <<http://www.nedlac.org.za/media/11174/336-innm.pdf>> [Accessed 10 July 2012].
- UNICEF & WHO, 2012. *Progress on Drinking Water and Sanitation*. URL: <<http://www.unicef.org/media/files/JMPReport2012.pdf>> [Accessed: 28 August 2013].
- Van Niekerk, S., 1998. Private gain, public loss : Service delivery in the new South Africa. *Southern Africa Report*, 12(4), pp.1–7.
- Vázquez, S.T. & Sumner, A., 2012. IDS WORKING PAPER Volume 2012 No 404 Beyond Low and Middle Income Countries : What if There Were Five Clusters of Developing Countries ? *Institute of Development Studies*. Brighton. 2012 (404). URL: <<http://www.ntd.co.uk/idsbookshop/details.asp?id=1300>> [Accessed 18 December 2012].
- Wheater, C.P. & Cook, P.A., 2000. *Using Statistics to Understand the Environment*, London and New York: Routledge, Taylor & Francis Group. URL: <<http://enforester.persiangig.com/using-statistics-to-understand-the-environment.pdf>> [Accessed: 16 August 2013].
- WHO, 2013a. *The top 10 causes of death*. URL: <<http://who.int/mediacentre/factsheets/fs310/en/index.html>> [Accessed 11 November 2013].
- WHO, 2013b. *Diarrhoeal Disease*. URL: <<http://www.who.int/mediacentre/factsheets/fs330/en/>> [Accessed 11 November 2013].
- WSP (Water and Sanitation Program), 2007. *Water Utilities in Africa: Case Studies of Transformation and Market Access*. URL: <www.wsp.org/userfiles/file/Water_Uilities_Africa.pdf> [Accessed 10 July 2012].

Appendices

Appendix 1 – Changes in Census and Community Survey data

NAME CHANGES

- Name change in Western Cape: Breede River/Winelands to Langeberg
- KZN: all LMs in DM 5a changed names to DM 43

BOUNDARY CHANGES

- Provincial boundary movement: Merafong City LM from NW to GT (NW 405 to GT 484)
- North West: Kagisano/Molopo LMs combined (NW 391 and NW 395 to NW 397)
- Eastern Cape: Mbizana, Ntanbankulu (EC 151 & EC 152) along with Matatiele and Umzimvubu (EC 05b 2& EC 05b 3) now form LMs in DM 44 (EC 443, EC 444, EC 441 & EC 442, respectively)
- Free State DM 17 disbanded Naledi (FS 171) became FS 164 and Mantsopa (FS 173) became FS 196
- Gauteng: Nokeng tsa Taemane LM and Kungwini LM join with Tshwane metro

CATEGORY CHANGES

- Free State: Buffalo City LM became a metro (EC 125 to BUF)
- Free State: Mangaung (FS 172) to a metro (MAN)

Thirdly, District Management Areas (DMA) were not included in the analysis because these areas are not residential but refer to “special interest” areas such as conservation areas.

For consistency – Census 1996 not included in analysis

Appendix 2 – Critical Values Table for small sample sizes

Table D.5 Values of Pearson's product moment correlation coefficient (r). The results are significant if the calculated value of r is higher than the table value

df ($n - 2$)	r		df ($n - 2$)	r	
	$P = 0.05$	$P = 0.01$		$P = 0.05$	$P = 0.01$
1	0.997	1.000	16	0.468	0.590
2	0.950	0.990	17	0.456	0.575
3	0.878	0.959	18	0.444	0.561
4	0.811	0.917	19	0.433	0.549
5	0.754	0.874	20	0.423	0.537
6	0.707	0.834	21	0.413	0.526
7	0.666	0.798	22	0.404	0.515
8	0.632	0.765	23	0.396	0.505
9	0.602	0.735	24	0.388	0.496
10	0.576	0.708	25	0.381	0.487
11	0.553	0.684	26	0.374	0.479
12	0.532	0.661	27	0.367	0.471
13	0.514	0.641	28	0.361	0.463
14	0.497	0.623	29	0.355	0.456
15	0.482	0.606	30	0.349	0.449

(Extracted from Wheater & Cook, 2000: 200)

Appendix 3 – 2001 Water Supply k-means cluster membership

Determining the Number of Clusters

Hierarchical cluster analysis produced an agglomeration schedule and the following scree plot was created, where the distances at which the mergers take place are plotted against the number of formed clusters.

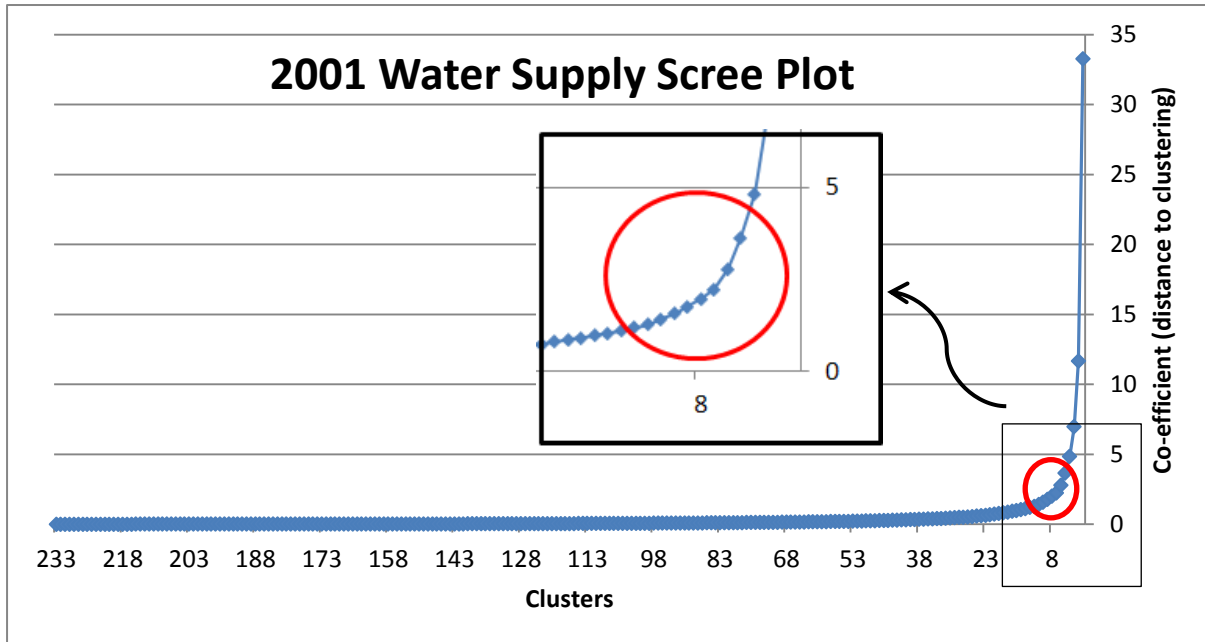


Figure 28: Illustrating Scree Plot for water supply 2001

Using the ‘elbow’ method, “where an additional combination of two clusters occurs at a greatly increased distance” (Vazquez & Sumner, 2012: 18), the Scree plot shows that the suitable number clusters lays between 5 and 13 clusters. The elbow method (however is not very accurate and is instead used as a rough guide. The Variance Ratio Criterion, proposed by Calinski and Harabasz (1974), was used to better determine the number of clusters that maximizes the between-cluster variation and minimizes the within-cluster variation (Vazquez & Sumner, 2012: 20).

Table 22: Variance Ratio Criterion for water supply 2001

Number of clusters	VRC	w_k
6	1514.17	-
7	1575.53	-53.21
8	1583.67	152.16
9	1743.98	-190.10
10	1714.19	64.96

The variance test involves selecting the cluster with the smallest w_k . The number of selected clusters is 9, which was used in the k-means analysis.

Table 23: Cluster membership for water supply 2001

	Cluster								
	1	2	3	4	5	6	7	8	9
CPT	EC102	EC105	EC123	EC138	EC157	EC124	EC442	EC121	
EC101	EC104	EC106	EC127	KZN216	KZN245	EC126	EC441	EC137	
EC103	EC108	BUF	EC132	KZN221	KZN253	EC136	EC122	EC443	
EC107	EC109	EC128	MP324	KZN226	KZN266	EC142	EC135	EC444	
EC131	EC144	EC134	MP325	KZN227	KZN273	KZN235	EC141	EC153	
EC133	ETH	EC143	NC452	KZN233	KZN281	KZN236	EC156	EC154	
EKU	FS161	FS183	LIM331	KZN261	KZN284	KZN242	KZN211	EC155	
FS162	FS163	FS191	LIM332	KZN262	KZN293	KZN254	KZN214	KZN213	
FS201	FS164	FS194	LIM333	KZN263	KZN431	NC451	KZN215	KZN244	
FS203	MAN	KZN212	LIM342	KZN285		LIM474	KZN265	KZN294	
FS204	FS196	KZN224	LIM343	KZN291		LIM475	KZN271		
FS205	FS181	KZN232	LIM344	MP301		NW381	KZN272		
GT421	FS182	KZN234	LIM351	MP303			KZN274		
GT481	FS184	KZN252	LIM352	MP316			KZN283		
GT482	FS185	KZN292	NW371	LIM471			KZN286		
GT484	FS192	KZN432	NW375	LIM472			KZN434		
JHB	FS193	MP304	NW382	LIM353			KZN435		
LIM366	FS195	MP322	NW385	LIM355			LIM473		
NC061	GT422	MP323	NW394	LIM367					
NC062	GT423	LIM334	NW397	NW383					
NC065	GT483	LIM335							
NC066	KZN222	LIM341							
NC067	KZN223	LIM354							
NC072	KZN225	LIM361							
NC073	KZN241	LIM362							
NC074	KZN275	LIM365							
NC075	KZN282	NW372							
NC077	KZN433	NW373							
NC082	MP302	NW384							
NC085	MP305	NW393							
NC086	MP306	NW401							
NC091	MP307	NW404							
NC093	MP311								
NC453	MP312								
NW403	MP313								
WC011	MP314								
WC012	MP315								
WC013	MP321								

Table 23 continued

WC014	NC064
WC015	NC071
WC022	NC076
WC023	NC078
WC024	NC081
WC025	NC083
WC026	NC084
WC031	NC092
WC032	NC094
WC033	NMA
WC034	LIM364
WC041	NW374
WC042	NW392
WC043	NW396
WC044	NW402
WC045	TSH
WC051	WC047
WC052	WC048
WC053	

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Appendix 4 – 2007 Water Supply k-means cluster membership

Determining the Number of Clusters

Hierarchical cluster analysis produced an agglomeration schedule and the following Scree plot was created. The distances at which the mergers take place are plotted against the number of formed clusters.

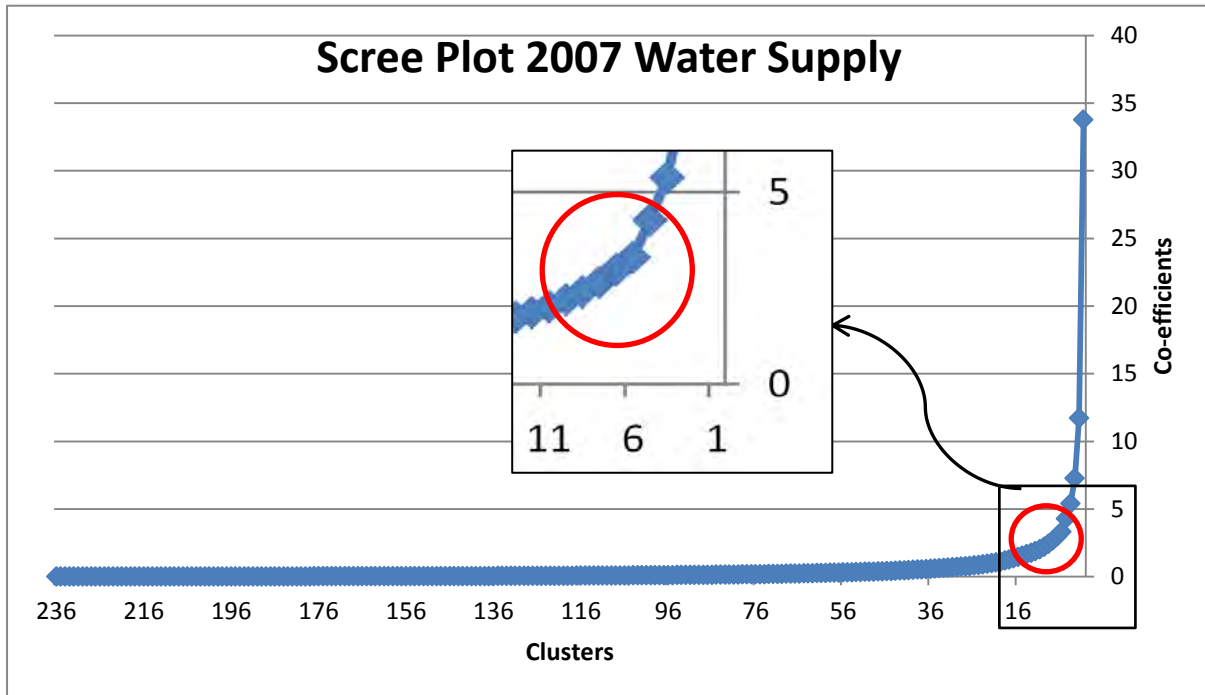


Figure 29: Illustrating Scree Plot for water supply 2007

The Scree plot shows that the suitable number clusters lays between 5 and 12 clusters. The elbow method however is not very accurate and is instead used as a rough guide. The Variance Ratio Criterion, proposed by Calinski and Harabasz (1974), was used to better determine the number of clusters that maximizes the between-cluster variation and minimizes the within-cluster variation (Vazquez & Sumner, 2012: 20).

Table 24: Variance Ratio Criterion for water supply 2007

Number of clusters	VRC	w_k
5	1253.63	-
6	1255.46	-119.02
7	1138.27	430.94
8	1452.02	-449.12
9	1316.65	178.42
10	1359.71	-118.02
11	1284.74	48.74

The variance test involves selecting the cluster with the smallest w_k . The number of selected clusters is 8, which was used in the k-means analysis.

Table 25: Cluster membership for water supply 2007

	Cluster							
	1	2	3	4	5	6	7	8
CPT	BUF	EC123	KZN221	EC126	EC142	EC122	EC121	
EC101	EC128	EC124	KZN224	EC136	EC441	EC135	EC153	
EC102	EC134	EC127	KZN226	KZN215	EC442	EC137	EC154	
EC103	EC143	EC132	KZN232	NC451	KZN242	EC141	EC443	
EC104	ETH	EC138	KZN233	NW381	KZN254	EC155	KZN244	
EC105	FS161	KZN212	KZN234	NW394	LIM342	EC156	KZN265	
EC106	FS193	KZN216	KZN245		LIM351	EC157	KZN294	
EC107	FS194	KZN227	KZN253		LIM473	EC444		
EC108	GT423	KZN291	KZN261		LIM474	KZN211		
EC109	GT483	KZN292	KZN262		LIM475	KZN213		
EC131	GT484	LIM331	KZN263		MP325	KZN214		
EC133	KZN222	LIM332	KZN266		NW383	KZN235		
EC144	KZN223	LIM333	KZN281		NW397	KZN236		
EKU	KZN252	LIM335	KZN285			KZN271		
FS162	KZN275	LIM343	KZN286			KZN272		
FS163	KZN433	LIM344	KZN432			KZN273		
FS164	LIM341	LIM352	LIM353			KZN274		
FS181	LIM361	LIM354	LIM355			KZN283		
FS182	LIM364	LIM362	MP316			KZN284		
FS183	LIM366	LIM367				KZN293		
FS184	MAN	LIM471				KZN431		
FS185	MP301	MP324				KZN434		
FS191	MP302	NC452				KZN435		
FS192	MP303	NW371				LIM472		
FS195	MP304	NW375						
FS196	MP306	NW382						
FS201	MP311	NW385						
FS203	MP312							
FS204	MP321							
FS205	MP322							
GT421	MP323							
GT422	NC064							
GT481	NC082							
GT482	NC084							
JHB	NC085							
KZN225	NC092							

Table 25 continued

Clusters	
1	2
KZN241	NC094
KZN282	NW372
LIM334	NW373
LIM365	NW374
MP305	NW384
MP307	NW396
MP313	NW401
MP314	TSH
MP315	WC048
NC061	
NC062	
NC065	
NC066	
NC067	
NC071	
NC072	
NC073	
NC074	
NC075	
NC076	
NC077	
NC078	
NC081	
NC083	
NC086	
NC091	
NC093	
NC453	
NMA	
NW392	
NW393	
NW402	
NW403	
NW404	
WC011	
WC012	
WC013	
WC014	
WC015	
WC022	

Table 25
continued 2

Cluster
1
WC023
WC024
WC025
WC026
WC031
WC032
WC033
WC034
WC041
WC042
WC043
WC044
WC045
WC047
WC051
WC052
WC053

University of Cape Town

Appendix 5 – 2011 Water Supply k-means cluster membership

Determining the Number of Clusters

Hierarchical cluster analysis produced an agglomeration schedule and the following scree plot was created. The distances at which the mergers take place are plotted against the number of formed clusters.

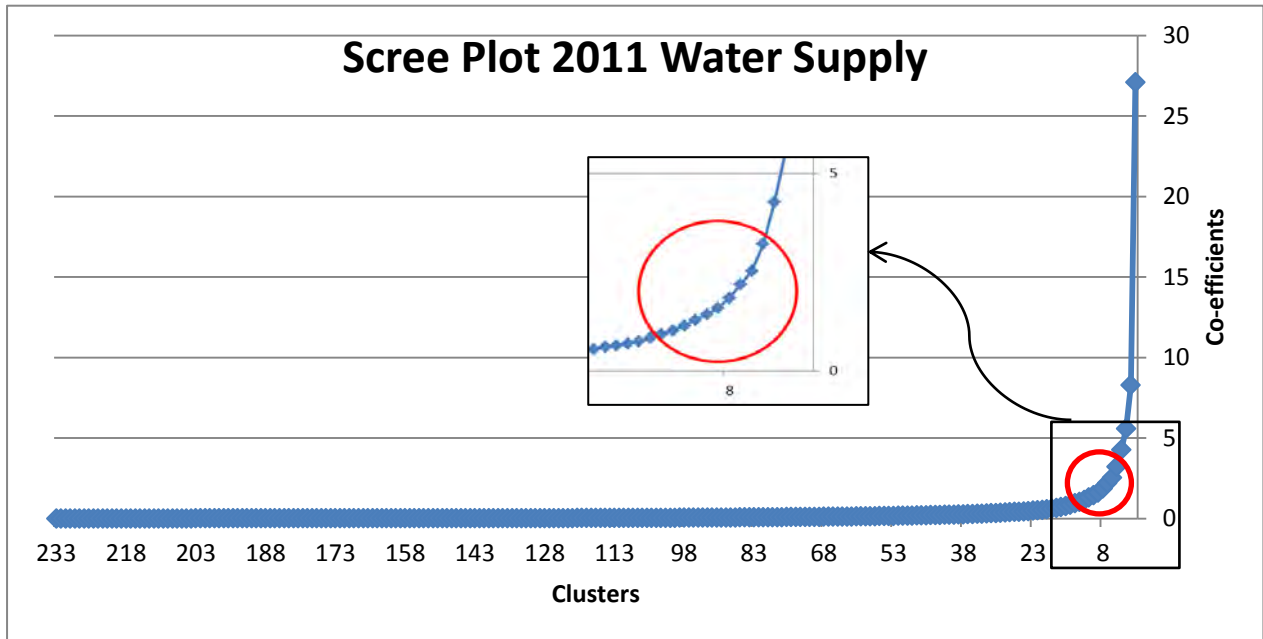


Figure 30: Illustrating Scree Plot for water supply 2011

The Scree plot shows that the suitable number clusters lays between 5 and 11 clusters. The elbow method however is not very accurate and is instead used as a rough guide. The Variance Ratio Criterion, proposed by Calinski and Harabasz (1974), was used to better determine the number of clusters that maximizes the between-cluster variation and minimizes the within-cluster variation (Vazquez & Sumner, 2012: 20).

Table 26: Variance Ratio Criterion for water supply 2011

Number of clusters	VRC	w_k
5	1406.73	-
6	1316.56	173.89
7	1400.28	27.14
8	1511.13	-52.24
9	1569.75	-196.88
10	1431.49	180.19
11	1473.42	-

The variance test involves selecting the cluster with the smallest w_k . The number of selected clusters is 9, which was used in the k-means analysis.

Table 27: Cluster membership for water supply 2011

	Clusters								
	1	2	3	4	5	6	7	8	9
CPT	BUF	EC106	EC123	EC126	EC157	EC122	EC121	EC153	
EC101	EC132	KZN221	EC124	EC136	KZN226	EC135	EC141	EC443	
EC102	EC134	KZN223	EC127	KZN214	KZN233	EC137	EC154		
EC103	GT483	KZN232	EC138	KZN215	KZN245	EC156	EC155		
EC104	KZN224	KZN234	EC142	LIM342	KZN253	EC441	EC444		
EC105	KZN281	KZN261	KZN212	NC451	KZN262	EC442	KZN213		
EC107	KZN291	KZN263	KZN216	NW381	KZN266	KZN211	KZN244		
EC108	KZN433	KZN432	KZN227	NW394	KZN271	KZN235	KZN265		
EC109	LIM352	LIM341	KZN242		KZN272	KZN236	KZN294		
EC128	LIM354	LIM353	KZN254		KZN274	KZN283	KZN435		
EC131	LIM362	LIM361	KZN273		KZN275	KZN434			
EC133	LIM367	LIM471	KZN292		KZN284	LIM473			
EC143	NW375	MP301	LIM331		KZN285	LIM475			
EC144	NW383	MP302	LIM332		KZN286				
EKU	NW384	MP303	LIM335		KZN293				
ETH	NW385	MP316	LIM343		KZN431				
FS161	NW401	MP322	LIM344		LIM333				
FS162		MP323	LIM351		LIM355				
FS163		MP324	LIM474		LIM472				
FS164		NC078	MP325						
FS181		NC084	NC452						
FS182		NW371	NW382						
FS183		NW372	NW397						
FS184		NW393							
FS185									
FS191									
FS192									
FS193									
FS194									
FS195									
FS196									
FS201									
FS203									
FS204									
FS205									
GT421									
GT422									
GT423									

Table 27
continued

Cluster
1
GT481
GT482
GT484
JHB
KZN222
KZN225
KZN241
KZN252
KZN282
LIM334
LIM364
LIM365
LIM366
MAN
MP304
MP305
MP306
MP307
MP311
MP312
MP313
MP314
MP315
MP321
NC061
NC062
NC064
NC065
NC066
NC067
NC071
NC072
NC073
NC074
NC075
NC076
NC077
NC081
NC082

Table 27
continued 2

Cluster
1
NC083
NC085
NC086
NC091
NC092
NC093
NC094
NC453
NMA
NW373
NW374
NW392
NW396
NW402
NW403
NW404
TSH
WC011
WC012
WC013
WC014
WC015
WC022
WC023
WC024
WC025
WC026
WC031
WC032
WC033
WC034
WC041
WC042
WC043
WC044
WC045
WC047
WC048
WC051

**Table 27
continued 3**

Cluster
1
WC052
WC053

University of Cape Town

Appendix 6 – 2001 Sanitation k-means cluster membership

Determining the Number of Clusters

Hierarchical cluster analysis produced an agglomeration schedule and the following scree plot was created, where the distances at which the mergers take place are plotted against the number of formed clusters.

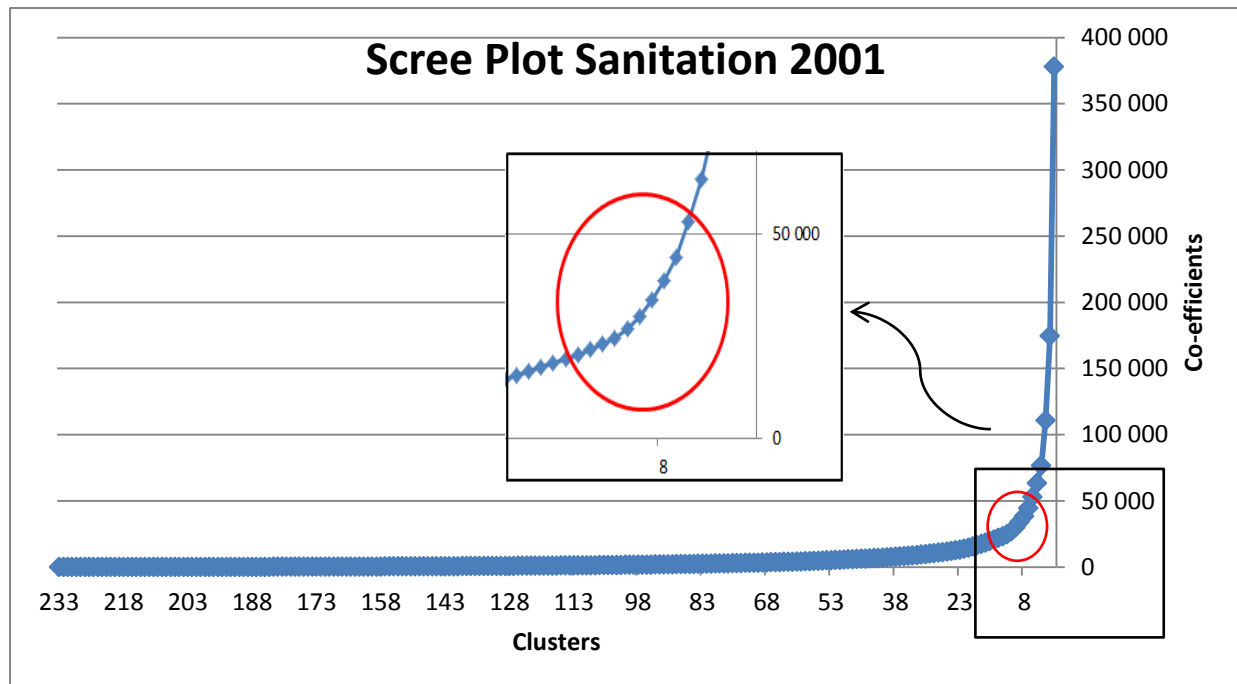


Figure 31: Illustrating Scree Plot for sanitation 2001

Using the ‘elbow’ method, “where an additional combination of two clusters occurs at a greatly increased distance” (Vazquez & Sumner, 2012: 18), the Scree plot shows that the suitable number clusters lays between 6 and 12 clusters. The elbow method (however is not very accurate and is instead used as a rough guide. The Variance Ratio Criterion, proposed by Calinski and Harabasz (1974), was used to better determine the number of clusters that maximizes the between-cluster variation and minimizes the within-cluster variation (Vazquez & Sumner, 2012: 20).

Table 28: Variance Ratio Criterion for sanitation 2001

Number of clusters	VRC	w_k
6	1048.76	-
7	1016.59	-1.94
8	982.49	32.90
9	981.28	101.22
10	1081.30	-167.23
11	1014.09	4.70
12	951.58	-

The variance test involves selecting the cluster with the smallest w_k . The number of selected clusters is ten, which was used in the k-means analysis.

Table 29: Cluster membership for sanitation 2001

	Clusters									
	1	2	3	4	5	6	7	8	9	10
CPT	BUF	EC102	EC106	FS194	EC103	EC138	EC124	EC126	EC121	
EC101	EC105	EC107	KZN212	KZN221	EC104	EC142	EC127	KZN236	EC122	
EKU	EC109	EC108	KZN216	KZN224	EC123	EC153	EC441	KZN254	EC132	
FS162	EC134	EC131	KZN232	KZN227	EC128	EC156	EC442	KZN431	EC135	
GT421	ETH	EC133	KZN245	KZN432	EC144	EC443	KZN211	KZN435	EC136	
GT423	FS201	EC143	KZN263	LIM355	EC157	KZN215	KZN213	LIM472	EC137	
GT481	FS204	FS161	KZN275	LIM367	FS181	KZN233	KZN214	LIM473	EC141	
GT482	GT422	FS163	KZN282	MP301	FS185	KZN242	KZN226	MP315	EC154	
GT484	GT483	FS164	KZN285	MP322	FS191	KZN253	KZN235	MP316	EC155	
JHB	KZN222	FS184	KZN291	NW372	FS195	KZN261	KZN293	NW371	EC444	
KZN241	KZN225	FS192	KZN292	NW383	FS196	KZN262	KZN294	NW375	FS182	
MP307	KZN234	FS203	LIM354	NW385	KZN273	KZN266	KZN434	NW381	FS183	
MP313	KZN252	FS205	LIM362	NW394	NC074	KZN274	LIM332		FS193	
NC061	KZN433	KZN223	LIM365		NW393	KZN281	LIM333		KZN244	
NC062	LIM361	LIM334	MP303		NW404	KZN284	LIM343		KZN265	
NC067	LIM364	LIM341	NC452			KZN286	LIM344		KZN271	
NC077	LIM366	MAN	NW373			LIM335	LIM352		KZN272	
NC083	MP302	MP305	NW382			LIM342	LIM353		KZN283	
NC085	MP304	MP306	NW384			LIM351	LIM471		LIM331	
NC086	MP311	MP321	NW397			MP324	LIM474			
NC091	MP312	NC064	NW401				LIM475			
NC093	MP314	NC065					MP325			
NC453	MP323	NC066					NC451			
NMA	NC082	NC071								
NW392	NC094	NC072								
NW402	NW374	NC073								
NW403	TSH	NC075								
WC011	WC048	NC076								
WC012		NC078								
WC013		NC081								
WC014		NC084								
WC015		NC092								
WC022		NW396								
WC023		WC041								
WC024										
WC025										
WC026										

Table 29
continued

Clusters

1

WC031

WC032

WC033

WC034

WC042

WC043

WC044

WC045

WC047

WC051

WC052

WC053

University of Cape Town

Appendix 7 – 2007 Sanitation k-means cluster membership

Determining the Number of Clusters

Hierarchical cluster analysis produced an agglomeration schedule (see Appendix _) and the following Scree plot was created. The distances at which the mergers take place are plotted against the number of formed clusters.

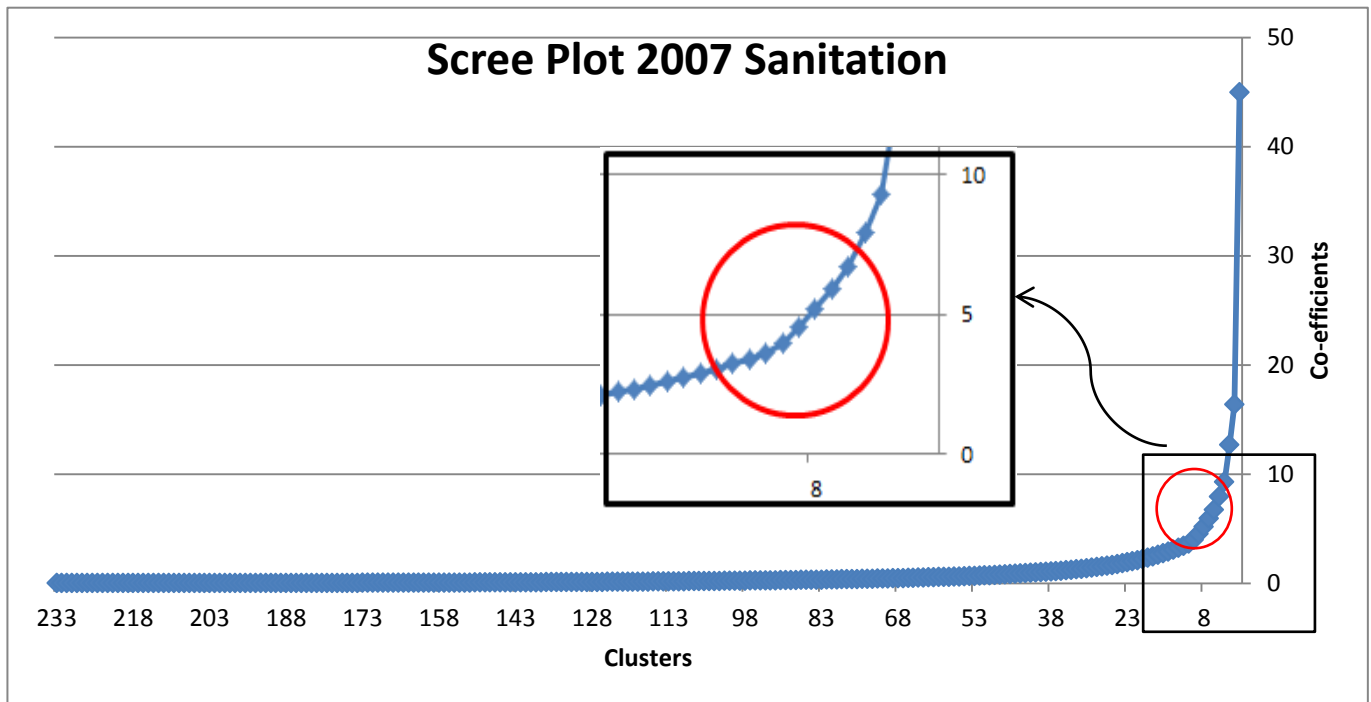


Figure 32: Illustrating Scree Plot for sanitation 2007

Using the ‘elbow’ method, “where an additional combination of two clusters occurs at a greatly increased distance” (Vazquez & Sumner, 2012: 18), the Scree plot shows that the suitable number clusters lays between 5 and 11 clusters. The elbow method (however is not very accurate and is instead used as a rough guide. The Variance Ratio Criterion, proposed by Calinski and Harabasz (1974), was used to better determine the number of clusters that maximizes the between-cluster variation and minimizes the within-cluster variation (Vazquez & Sumner, 2012: 20).

Table 30: Variance Ratio Criterion for sanitation 2007

Number of clusters	VRC	w_k
5	1184.73	-
6	1070.30	79.87
7	1035.73	53.78
8	1054.94	-118.30
9	955.85	15.59
10	872.34	122.81

The variance test involves selecting the cluster with the smallest w_k . The number of selected clusters is thus eight, which was used in the k-means analysis.

Table 31: Cluster membership for sanitation 2007

	Clusters							
	1	2	3	4	5	6	7	8
CPT	BUF	EC142	EC103	EC124	EC126	EC121	EC441	
EC101	EC105	KZN226	EC123	EC127	EC138	EC122	KZN214	
EC102	EC106	KZN233	EC128	FS194	EC141	EC132	KZN224	
EC104	EC134	KZN262	FS163	KZN216	EC442	EC135	KZN293	
EC107	ETH	KZN266	FS181	KZN253	KZN211	EC136	KZN294	
EC108	FS161	KZN271	FS183	KZN285	KZN213	EC137	LIM332	
EC109	GT483	KZN273	FS185	KZN291	KZN215	EC153	LIM343	
EC131	KZN212	KZN281	FS191	KZN432	KZN221	EC154	LIM344	
EC133	KZN222	KZN283	FS195	LIM354	KZN227	EC155	LIM352	
EC143	KZN223	NC451	FS196	LIM362	KZN235	EC156	LIM353	
EC144	KZN225		NC074	LIM367	KZN236	EC157	LIM355	
EKU	KZN232		NC075	MP322	KZN254	EC443	LIM471	
FS162	KZN234		NW404	NC452	KZN261	EC444	LIM472	
FS164	KZN245			NW372	KZN274	FS182	LIM473	
FS184	KZN252			NW382	KZN431	FS193	LIM474	
FS192	KZN263			NW383	KZN434	KZN242	LIM475	
FS201	KZN275				KZN435	KZN244	MP301	
FS203	KZN282				LIM333	KZN265	MP315	
FS204	KZN292				LIM335	KZN272	MP316	
FS205	KZN433				LIM342	KZN284	MP325	
GT421	LIM334				LIM351	KZN286	NW371	
GT422	LIM341				MP324	LIM331	NW375	
GT423	LIM361				NW394		NW381	
GT481	LIM365				NW397		NW385	
GT482	MAN							
GT484	MP303							
JHB	MP304							
KZN241	MP312							
LIM364	MP321							
LIM366	MP323							
MP302	NC064							
MP305	NC066							
MP306	NC072							
MP307	NC078							
MP311	NC081							
MP313	NC082							
MP314	NC084							

Table 31 continued

Clusters	
1	2
NC061	
NC062	NW373
NC065	NW374
NC067	NW384
NC071	NW401
NC073	TSH
NC076	
NC077	
NC083	
NC085	
NC086	
NC091	
NC092	
NC093	
NC094	
NC453	
NMA	
NW392	
NW393	
NW396	
NW402	
NW403	
WC011	
WC012	
WC013	
WC014	
WC015	
WC022	
WC023	
WC024	
WC025	
WC026	
WC031	
WC032	
WC033	
WC034	
WC041	
WC042	
WC043	

Table 32
continued 2

Cluster
1
WC044
WC045
WC047
WC048
WC051
WC052
WC053

University of Cape Town

Appendix 8 – 2011 Sanitation k-means cluster membership

Determining the Number of Clusters

Hierarchical cluster analysis produced an agglomeration schedule (see Appendix _) and the following cree plot was created. The distances at which the mergers take place are plotted against the number of formed clusters.

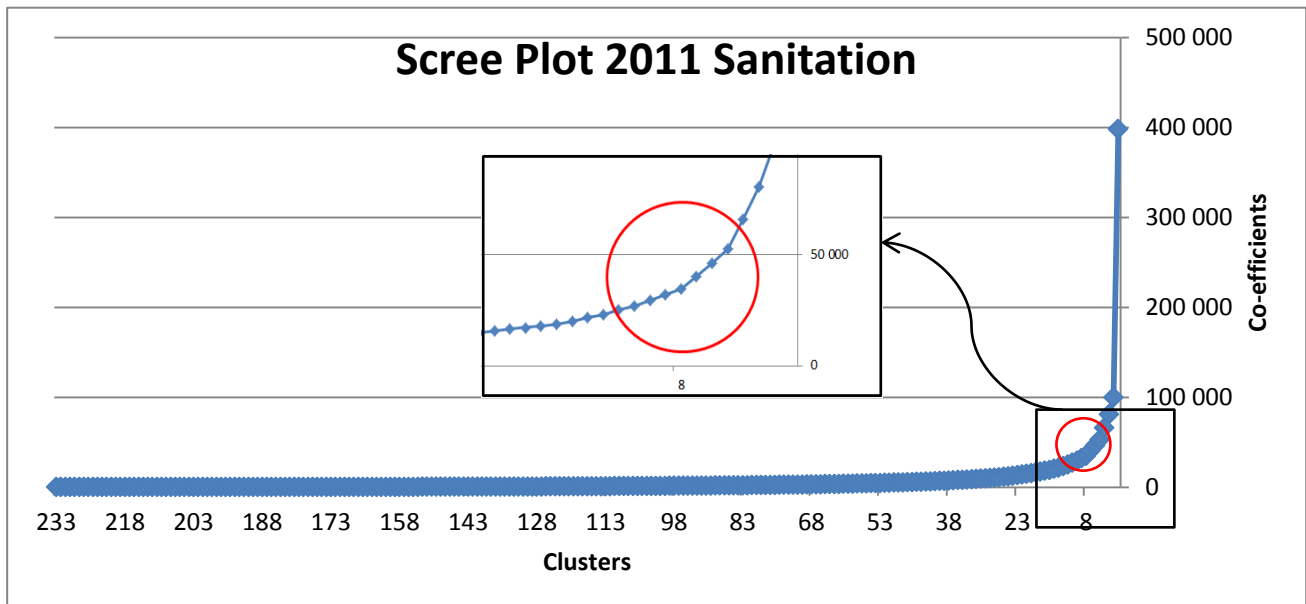


Figure 33: Illustrating Scree Plot for 2011 Sanitation

The Scree plot shows that the suitable number clusters lays between 5 and 11 clusters. The elbow method however is not very accurate and is instead used as a rough guide. The Variance Ratio Criterion, proposed by Calinski and Harabasz (1974), was used to better determine the number of clusters that maximizes the between-cluster variation and minimizes the within-cluster variation (Vazquez & Sumner, 2012: 20).

Table 32: Variance Ratio Criterion for 2011 Sanitation

Number of clusters	VRC	w_k
5	1329.82	-
6	1149.93	453.48
7	1423.53	-457.88
8	1239.25	58.81
9	1113.78	95.37
10	1083.69	198.10
11	1251.69	-

The variance test involves selecting the cluster with the smallest w_k . The number of selected clusters is 7, which was used in the k-means analysis.

Table 33: Cluster membership for sanitation 2011

	Clusters					
	1	2	3	5	6	7
CPT	EC132	BUF	EC123	EC121	EC126	
EC101	FS182	EC104	EC124	EC122	EC153	
EC102	KZN261	EC105	EC127	EC135	EC442	
EC103	KZN273	EC106	EC157	EC136	KZN213	
EC107	LIM362	EC128	FS194	EC137	KZN214	
EC108	NC064	EC134	KZN216	EC138	KZN211	
EC109	NC066	ETH	KZN212	EC141	KZN224	
EC131	NC081	FS163	KZN285	EC154	KZN286	
EC133	NW401	FS185	KZN245	EC155	KZN281	
EC143		FS191	KZN253	EC156	KZN435	
EC144		FS193	KZN263	EC444	KZN254	
EKU		FS195	KZN291	KZN272	KZN294	
FS161		FS196	KZN292	KZN275	KZN293	
FS162		FS204	LIM334	KZN284	LIM332	
FS164		GT483	LIM354	KZN262	LIM333	
FS181		KZN222	LIM367	KZN265	LIM335	
FS183		KZN223	MP303	KZN266	LIM343	
FS184		KZN225	MP322	LIM331	LIM344	
FS192		KZN232	NW372		LIM351	
FS201		KZN234	NW382		LIM352	
FS203		KZN252	NW383		LIM353	
FS205		KZN282	NW384		LIM355	
GT421		KZn432	NC452		LIM471	
GT422		KZN433			LIM472	
GT423		LIM341			LIM473	
GT481		LIM361			LIM474	
GT482		LIM364			LIM475	
GT484		LIM365			MP315	
JHB		MAN			MP316	
KZN241		MP302			MP325	
LIM366		MP304			NW371	
MP305		MP312			NW375	
MP306		MP321			NW381	
MP307		MP323			NW385	
MP311		NC074			NW394	
MP313		NC076				

Table 33 continued

Clusters	
1	3
MP314	NC077
NC061	NC078
NC062	NC082
NC065	NC084
NC067	NC085
NC071	NC092
NC072	NC094
NC073	NW373
NC075	NW374
NC083	NW392
NC086	NW393
NC091	WC011
NC093	
NC453	
NMA	
NW396	
NW402	
NW403	
NW404	
TSH	
WC012	
WC013	
WC014	
WC015	
WC022	
WC023	
WC024	
WC025	
WC026	
WC031	
WC032	
WC033	
WC034	
WC041	
WC042	
WC043	
WC044	
WC045	
WC047	
WC048	

Table 33
continued 2

Cluster
1

WC051

WC052

WC053

University of Cape Town