A Planning Framework to Position Rural Water Treatment in South Africa for the Future

Christian D Swartz

TT 419/09

WATER RESEARCH COMMISSION

A PLANNING FRAMEWORK TO POSITION RURAL WATER TREATMENT IN SOUTH AFRICA FOR THE FUTURE

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Report to the
Water Research Commission

by

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WRC Report No. TT 419/09

September 2009

Obtainable from

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The publication of this report emanates from a research project entitled *A Planning Framework to Position Rural Water Treatment in South Africa for the Future* (WRC Project No. K8/736)

ISBN 978-1-77005-889-7
Printed in the Republic of South Africa

EXECUTIVE SUMMARY

Drinking water supply in South African rural areas is mostly not sustainable. There are still millions of people without access to an adequate supply of safe drinking water. The *quantity* of water available for drinking purposes is seriously impacted upon by global climate change (which contributes to severe droughts in certain areas of the sub-continent, while increased frequency and extent of flooding is causing considerable damage in other areas), population growth and urbanisation. The *quality* of existing water resources is also deteriorating, resulting in ever increasing problems with finding suitable and sustainable treatment technologies to produce adequate quantities of safe water for household use.

When considering the effects and implications of all of the above global and local factors on sustainable development in rural South Africa, it is evident that a rethink of the current situation and effective planning is required to develop strategies to cope with these factors in future. In order to do this, it is necessary to develop support systems and tools that can be incorporated in a planning framework to position rural water treatment in South Africa for the future. Developing the framework should entail a consideration of the existing rural water treatment situation in the country, and identification of those factors (both global and local) that impact on the efficiency and sustainability of rural drinking water supply. Adaptive strategies should be developed to counteract or minimize the impact of each of these driving forces. These driving forces and adaptive strategies can then be integrated in a planning framework that can be used for strategic planning purposes. The support tools should consist of decision support systems and management information tools for application of the decision support systems.

This consultancy project was therefore undertaken to study these factors impacting on rural water treatment in South Africa, propose adaptive strategies to address these impacts, and develop a planning framework that can be used to position rural water treatment for the future.

The following procedure, based partially on methodology used in the Techneau project (Techneau, 2006), was followed in developing the framework for rural water treatment in South Africa:

E1. <u>Map the current situation</u>
Assess the current situation (problems and challenges) with respect to rural water supply options, resources and water treatment in South Africa.

E2. <u>Identify driving forces</u>
Based on the above mapping of the present situation, identify all the driving forces that will have an impact on future drinking water supply in rural South Africa. The driving factors (global and local changes impacting on water treatment) include aspects such as climate change, new emerging contaminants and pathogens, increasing vulnerability (reliability – old and failing distribution systems; security – deliberate contamination), consumer acceptance and trust, impact of HIV/AIDS and availability and quality of resources due to increasing conflicts with other economical demands such as urbanisation, agriculture and nature conservation.

E3. <u>Develop adaptive strategies</u>
With the driving factors known, perform a SEPTEDOR analysis (*i.e.* **S**ocio-cultural, **E**conomic, **P**olitical, **T**echnological, **E**cological, **D**emographic, **O**rganisational, **R**isk factors) to predict possible future water supply scenarios and drinking water supply problems in South Africa, and thereby developing adaptive strategies.

E4. <u>Development of the Knowledge-based Planning Framework</u>
Develop a knowledge-based framework based on the information obtained (driving forces), to enable positioning and planning for rural water supply projects for the future, and for evaluation of adaptive strategies to address rural water supply problems.

E5. Validation and Testing of the Framework

A case study (Ilembe Water Supply Scheme of Umgeni Water) was done to evaluate whether the adaptive strategies that were developed are realistic and can provide the expected solutions. This site has been selected in collaboration with Umgeni Water and the Techneau project.

E5.1 Methodology and results

E5.1a. Map the current situation

A review of the current water supply situation in South Africa, with specific emphasis on rural water supply and treatment, was undertaken to assess the current situation (problems and challenges) with respect to different water supply options, resources and water treatment. The review indicated that major challenges exist in rural water treatment, and if these challenges are not addressed as a matter of high priority, will result in further degradation of service delivery and sustainability of rural treatment systems. Major challenges relate lack of capacity for not only operation and maintenance of the treatment systems, but also management of the water supply function within the Water services Providers (WSPs); lack of and/or mismanagement of funds in this sector; lack of planning (maintenance plans and asset management plans); deterioration in source water quality; and deteriorating infrastructure.

E5.1b. Identify driving forces

The main source for identifying and prioritising the driving forces was the results of a workshop that was held in Windhoek (Namibia) during March 2006 on *Science and Technology-based Scenarios for sub-Saharan Africa* (Swartz, 2006), as well as studies as part of the Techneau project (Swartz and Offringa, 2006) . From the trends, the ten most important ones impacting on drinking water supply in South Africa and Sub-Saharan Africa were identified as:

- Population Growth
- Urbanisation
- Degradation of Source Water Quality
- Climate Change: Water Resource Quantity (Water Stress)
- Life-style Choices: Point-of-use Systems and Bottled Water
- Increasing Cost of Energy
- Better Access to Communication Technology and Information
- Increase in Water-borne Diseases
- Degradation of Infrastructure
- Political Tensions over Water

These driving forces are discussed in detail in the report.

E5.1c. Develop adaptive strategies

Possible adaptive strategies were considered for each of the key factors (driving forces) (internal and external) that were identified, using a SEPTEDOR analysis (*i.e.* **S**ocio-cultural, **E**conomic, **P**olitical, **T**echnological, **E**cological, **D**emographic, **O**rganisational, **R**isk factors).

E5.1d. Development of the Knowledge-based Planning Framework

In mapping the current rural water treatment situation in South Africa and identifying the driving factors that have an influence on the rural water supply, both now but especially in the future, it soon became apparent that these factors and their impacts or potential impacts form a complex situation. This is compounded by the inter-relationships between these factors. Adding to this the adaptive strategies that were identified and considered for possible application to provide solutions for eradicating or minimizing the negative impacts, it creates a multi-factor situation that is difficult to analyse by manual methods or simple models. It is therefore necessary to apply more sophisticated software to analyse the situation and present the iterations and outputs visually, to facilitate the drawing of conclusions, and to use it as a tool for presentations to key stakeholders (the Department of Water Affairs and Forestry (DWAF), Development Bank of Southern Africa (DBSA) and the Water Research Commission (WRC) in this instance). This confirms the perceived need for such software during the planning stages of this project.

In the project proposal, it was indicated that the Think Tools decision support system would be used, as this was the software that would fulfil such requirements and was used and supported by the Centre for Knowledge Dynamics and Decision-making of the University of Stellenbosch (US). However, since then the software program has changed ownership and also its name, and is now called Parmenides EIDOS, or just EIDOS for short. DWAF and the DBSA are license-holders of the software, and the US Centre of Knowledge Dynamics and Decision-making still supports the software and its use by students, researchers and clients.

The EIDOS program was thus used in developing the planning framework for rural water treatment as product of this consultancy research project.

The methodology for the overall development of the planning framework is described briefly below, and in more detail in Chapter 5.

Decision architecture: mapping the reasoning process

Developing the decision architecture consisted of a mapping of the reasoning process to be followed when using the program. It allows visualisation of the overall task flow for the process.

Goals Assessment

The process consisted firstly of assessing the goals for rural water treatment in South Africa. In settling these goals, three time frames ("views") were considered, viz. 1 year (2010), 3 years (2012) and 10 years (2019). The following goals and sub-goals were set for developing the rural water framework:

i. Institutional capacity
- national level
- local level

ii. Skilled and qualified human resources
- technical
- management

iii. Social acceptance
- affordable
- community participation

iv. Safe drinking water

v. Cost-effective
- capital cost
- operating cost

vi. Appropriate technologies

- energy efficient
- easy to operate and maintain

vii. National plans for sustainable rural water supply

For each of the goals and sub-goals, relevance values were then allocated for each of the three time frames. These relevance values weigh the importance of each of the goals with each other.

The goals (also referred to as criteria) are then used later in the program to evaluate the chosen strategies and establishing how they will fulfil each of the goals that were set.

Situation Analysis

The situation analysis helps to identify all the problems in the situation (in this case rural water supply), all the factors that make up and contribute to the problem, hence understand the nature of the problems and the relationships between the factors. This allows grouping of the factors into important factors and less important factors.

For rural water supply in general, a magnitude of factors have been identified that could affect the sustainability of the supply. Webster (1999) drew up a diagram showing some of the factors applicable in South Africa (see Figure 2.1).

The situation analysis makes a distinction between internal factors (those over which the local water sector have some measure of control, albeit indirectly in certain instances), and external factors (those determined by forces over which the policy makers have little or no control over, and which are mostly on a global scale).

Option Development

From the analysis of relationships between the internal and external factors, the five most important factors in each case were identified. These most important factors (or key factors) in each case were then used to develop alternative options that could be possible, both now and in the future. It therefore constituted a scenario analysis, which was done separately for the internal factors (the internal scenario) and for the external factors (the external scenario). The key factors formed the dimensions of the options space, and possible alternatives (options) were identified for each of these (two to four alternatives in each case). To rate consistency of alternatives in the option space, a Consistency Matrix was used. Consistency measures the logical fit of two alternatives. A higher consistency level indicates better coexistence of the two alternatives. A lower consistency rating indicates a greater degree of friction between the alternatives.

After completing the consistency ratings, the option space was then calculated to generate strategies or scenarios. Option Development computes all possible strategies and lists the top 100 strategies or scenarios, sorted by the consistency value.

<u>Option Evaluation: Strategy Evaluation</u>

The Option Evaluation step uses weighted criteria to evaluate strategy options in multiple views. The step generates rankings and represents them visually, leading to a more thorough comparison and improved decision-making.

The weighted criteria that were used are the goals that were set in the beginning of the process. The relative importance between the seven goals that were set, and over the different time scales considered in development of the framework (*i.e*. 1 year, 3 years and 10 years), was set as weights in this tool, which is then used in the calculation of the performance of each of the strategies that were considered.

Three strategies were evaluated as an example in this project (in using the planning framework for planning purposes in the water sector many other strategies can also be evaluated) are the following:

Centralised Water Supply

In this strategy, the population is supplied with drinking water from large, centralised water treatment plants. The treated water is piped to all the communities in the geographical area served by the treatment plant, thus requiring an extensive pipe network, so as to reach even the most remote communities. The treatment plants could be managed and operated by the larger municipalities or, more likely, by the Water Boards in that region. Generally, these plants should be well managed and operated effectively due to availability of sufficient O&M funds and qualified human resources.

Decentralised Water Supply, using Small Scale Systems

Here the rural communities will each have their own small scale water treatment that will supply that community with drinking water. The plants will generally be small scale plants and can be managed and operated by the local authority in that area (municipality) or, again, the Water Board, or it can be outsourced to a private company. The treatment plant personnel should ideally come from within the community, which will ensure community participation and ownership. This could be under supervision or mentorship from the municipality or Water Board, who will provide thorough training to the plant process controllers. The treatment systems could be either high-tech (e.g. membranes) or low-tech (e.g. slow sand filtration), and could be package plants or systems built by the communities themselves.

Decentralised Water Supply, using mainly household-scale systems (Point-of-Use or POU systems)

In this strategy, communities are capacitated to make large scale use of household-scale water treatment systems or devices. These devices are also referred to as point-of-use water treatment systems (POU). It comprises technologies or devices that can supply enough safe drinking water for a single or up to three households. Examples of POU systems are boiling water systems, solar water disinfection, chemical disinfection systems, UV disinfection, media filtration (slow sand, gravity rapid sand), which sometimes includes activated carbon filtration), and a range of household membrane filtration systems (microfiltration, ultrafiltration and reverse osmosis).

The results of analysis of the three decentralised versus centralised treatment scenarios shows that at present, centralised water supply is still being applied most and the supply system of choice. The main reason for this would be lack of capacity in local communities to operate and maintain decentralised treatment plants effectively so as to ensure good performance and sustainability of the plants. There are also not any clear guidelines in existence for selection, implementation and management (including on institutional level) of decentralised water treatment systems, resulting in larger centralised treatment plants rather be used, in which the WSAs have more confidence in.

With considerable focus currently on research on and developing guidelines for decentralised systems (including wastewater treatment systems), the results show that in the three year time frame, small scale treatment systems will have gained popularity with DWAF, WSAs and design engineers, and that there will be more or less the same number of people supplied with water from centralised plants as from decentralised plants. Treatment systems for individual households (the home treatment devices or POUs) will also be used more, but not to the same extent as the small scale systems.

After 10 years, small scale systems will have become even more popular as the water supply route of choice in preference to centralised treatment plants, with home treatment devices also increasing its share in the rural treatment market, albeit substantially less than the community-sized small-scale systems.

E5.1e. Validation and Testing of the Framework

To test whether the adaptive strategies that were developed in this Planning Framework are realistic and whether it can be applied in rural South Africa, a case study was selected in consultation with Umgeni Water, one of the end-users in the Techneau project. During a project workshop with members of Umgeni Water's planning and operational departments, it was proposed that the Ilembe District Municipality Bulk Water Supply Scheme be used for the case study, as this was a current rural water supply project where many of the issues and driving factors identified in the project were also matters of concern for the Ilembe Scheme.

E6 Conclusions and Recommendations

E.6.1 Conclusions

a. Regulation and support functions for rural water treatment plants can best be performed on a regional (provincial) basis rather than from national or local perspective.
b. Decentralised small-scale treatment systems (for a number of households or a whole community) will in the medium to long term present a better drinking water supply option to rural areas. Home treatment systems will be used in very remote areas, but to a lesser extent in other rural areas where small-scale systems are applied.
c. Water Boards have an important role to play in the operation and maintenance function of rural water treatment plants. They can provide this service on a contractual agreement basis. Current institutional arrangements prevents municipalities to provide service delivery to the required standards.
d. Automated high-tech treatment technologies for rural plants present a more efficient and sustainable solution where this is done under contract by a PSP or Water Board, or with technological support by reputable water treatment companies. Membrane systems in particular offer an attractive treatment option because of efficiency of these systems and the barriers that they present against pathogens and pollutants.

E.6.2 Recommendations

a. Extend the Planning Framework to a decision-making model, allowing inputs by strategic planning departments for specific regions or development projects, and obtaining as output a list of best options with details for implementation and sustainable operation and maintenance.
b. Coordinate and fast-track all capacity building initiatives in the water sector, and make clear distinction between the needs of rural water treatment plants and larger plants (in the metropolitan areas and large towns).
c. To ensure process controllers of high-standard, qualified and competent are employed in the water sector (for municipalities, water boards or PSPs), formal technical training institutions and courses should be re-introduced for the water care discipline. These formal training courses will produce best results when performed in conjunction with a mentorship programme, so that the learner can receive guidance for performing his duties, as well as for career planning. At the end of the training and mentorship programme, the mentee should be suitably qualified and competent to take over from the mentor.
d. Draw up guidelines for WSAs for selection, evaluation, implementation and management of decentralised treatment systems on institutional level.
e. Explore the establishment of franchising systems for management, operation and maintenance of decentralised water treatment systems in rural areas.

ACKNOWLEDGEMENTS

The research in this report emanated from a project funded by the Water Research Commission entitled "A Planning Framework to Position Rural Water Treatment in South Africa for the Future".

The financing of the project by the Water Research Commission is acknowledged gratefully.

The project was only possible with the co-operation of a number of individuals and institutions. The author therefore wishes to record his sincere thanks to the following:

- Messrs Peter Thompson and Shabbir Habib of Umgeni Water for valuable inputs on operational and management aspects of rural water treatment

- Mr David Stephen of Umgeni Water for his interest in the project and support, and valuable inputs and information on planning aspects of rural water treatment

- Dr Hans Müller of the Centre of Knowledge Dynamics and Decision-making of the University of Stellenbosch

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July 2009

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Drinking water supply in South African rural areas is mostly not sustainable. There are still millions of people without access to an adequate supply of safe drinking water. The *quantity* of water available for drinking purposes is seriously impacted upon by global climate change (which contributes to severe droughts in certain areas of the sub-continent, while increased frequency and extent of flooding is causing considerable damage in other areas), population growth and urbanisation. The *quality* of existing water resources is also deteriorating, resulting in ever increasing problems with finding suitable and sustainable treatment technologies to produce adequate quantities of safe water for household use.

When considering the effects and implications of all of the above global and local factors on sustainable development in rural South Africa, it is evident that a rethink of the current situation and effective planning is required to develop strategies to cope with these factors in future. In order to do this, it is necessary to develop support systems and tools that can be incorporated in a planning framework to position rural water treatment in South Africa for the future. Developing the framework should entail a consideration of the existing rural water treatment situation in the country, and identification of those factors (both global and local) that impact on the efficiency and sustainability of rural drinking water supply. Adaptive strategies should be developed to counteract or minimize the impact of each of these driving forces. These driving forces and adaptive strategies can then be integrated in a planning framework that can be used for strategic planning purposes. The support tools should consist of decision support systems and management information tools for application of the decision support systems.

This consultancy project was therefore undertaken to study these factors impacting on rural water treatment in South Africa, propose adaptive strategies to address these impacts, and develop a planning framework that can be used to position rural water treatment for the future.

1.2 Aims of the project

The aims of the project were:

a. To identify the driving forces and develop adaptive strategies for managing the impacts of these driving forces on rural water supply in South Africa.
b. To develop a knowledge-based planning framework (consisting of a decision support system) that can be used to steer future rural water supply planning in rural areas.

1.3 Approach to the development of the Planning Framework

The following procedure, based partially on methodology used in the Techneau project (Techneau, 2006), was followed in developing the framework for rural water treatment in South Africa:

a. <u>Map the current situation</u>
Assess the current situation (problems and challenges) with respect to rural water supply options, resources and water treatment in South Africa.

b. <u>Identify driving forces</u>
Based on the above mapping of the present situation, identify all the driving forces that will have an impact on future drinking water supply in rural South Africa. The driving factors (global and local changes impacting on water treatment) include aspects such as climate change, new emerging contaminants and pathogens, increasing vulnerability (reliability – old and failing distribution systems;

security – deliberate contamination), consumer acceptance and trust, impact of HIV/AIDS and availability and quality of resources due to increasing conflicts with other economical demands such as urbanisation, agriculture and nature conservation.

c. Develop adaptive strategies

With the driving factors known, perform a SEPTEDOR analysis (*i.e.* **S**ocio-cultural, **E**conomic, **P**olitical, **T**echnological, **E**cological, **D**emographic, **O**rganisational, **R**isk factors) to predict possible future water supply scenarios and drinking water supply problems in South Africa, and thereby developing adaptive strategies.

d. Development of the Knowledge-based Planning Framework (decision support systems and tools)

Develop a knowledge-based framework based on the information obtained (driving forces), to enable positioning and planning for rural water supply projects for the future, and for evaluation of adaptive strategies to address rural water supply problems.

e. Validation and Testing of the Framework

A case study (Ilembe Water Supply Scheme of Umgeni Water) was done to evaluate whether the adaptive strategies that were developed are realistic and can provide the expected solutions. This site has been selected in collaboration with Umgeni Water and the Techneau project.

CHAPTER 2
MAPPING THE CURRENT RURAL WATER SUPPLY SYSTEM IN SOUTH AFRICA

2.1 Introduction: Problem Statement

Being a water-stressed country, South Africa needs progressively to find innovative ways of managing water resources to ensure that the basic needs of its citizens are met, that social and economic development are not restricted through lack or poor quality of water, and that sustainability of water resources and of water-dependent ecosystems is secured (WRC, 2005).

Southern Africa remains threatened by water shortages. In a warmer and drier future, the competition for freshwater will increase sharply, and the equitable sharing of the water resource will demand considerable skill. With the current rates of urbanisation and population growth in the country, new sources will have to be developed, including the use of aquifers and desalination (Midgley *et al.,* 2005). At the same time, water quality issues are becoming more acute and climate change may result in a higher frequency of extreme events, such as droughts and floods. The management of water resources will have to adapt constantly with such changing circumstances. According to the WRC (2005), the challenges posed by the integrated management of both the resource and its uses are overwhelming.

The majority of growth in world population over the next twenty years will be in countries that are semi-arid or arid. There is an urgent need to increase the attention paid to these regions and to tackle the underlying problems through a combination of standards development, basin planning, resource development, knowledge acquisition and new technologies (IWA, 2005).

A number of recent studies (WRC Projects 738; 1531; 1599) have shown that serious problems currently exist with the treatment of drinking water for non-metro areas. These problems are particularly acute in rural areas, and include lack of capacity, poor operation and maintenance, lack of management involvement, commitment and resources, as well as a general lack of knowledge and understanding of the importance of effective drinking water treatment. Other barriers to achieving sustainable household water supply are a general lack of trust and transparency at sector levels, funding structures being too short term for the sector to be sustainable, and insufficient levels of funding/margins.

The situation is expected to deteriorate, rather than improve, over both the short and long term. This poses serious challenges to the countries on the sub-continent to ensure that sufficient quantities of safe drinking water will be available to meet future needs, so as not to result in major catastrophes.

2.2 Rural water supply in South Africa: Current Situation

2.2.1 Institutional Framework for Water Services Provision In Rural Areas

Vermeulen (2002) provides a comprehensive overview of the Institutional Frameworks for Water Services Provision in rural areas in South Africa. The overview is presented here directly as was contained in the workshop paper by Vermeulen and also included in the report by Swartz and Ralo (2004).

"In 1994, South Africa had its first democratic election after which a new system of Government was established. In 1996, the Constitution of South Africa was finalised and roles and functions were assigned to the three spheres of government, national, provincial and local.

2.2.1.a. Legal Framework

Various pieces of legislation concerning the water and local government sectors have been finalised over the past few years. The most important are:

- The Constitution of South Africa, 1996, assigns responsibility of ensuring access to water services to local government. The role of the national and provincial spheres of government is to support, monitor and regulate local government.
- The Water Services Act, 1997, further defines the municipal functions of ensuring water services provision
- The National Water Act, 1998, defines a new way of managing South Africa's scarce water resources. This act states that water is an indivisible national resource for which national government is the custodian.
- The Local Government : Municipal Demarcation Act, 1998, provides a legal framework for defining and implementing a post-transitional system of local government.
- The Local Government : Municipal Structures Act, 1998, defines types and structures of municipalities. Three categories of municipalities exist in South Africa after demarcation: Category A (Metropolitan), Category B (Local), Category C (District).
- The Local Government : Municipal Systems Act, 2000, defines how local government should operate and allows for various types of partnership arrangements a municipality may enter into to ensure delivery of services.
- The Local Government : Municipal Structures Amendment Act, 2000, places the function of ensuring access to water services (as well as Health and Electricity) at a district level, unless a local municipality is authorised to perform this function

2.2.1.b. A New Municipal System

On 5 December 2000, the second democratic local government elections were held to implement the new local government system. The new system reduced the number of local government structures from 843 to 284 as follows:

- six metropolitan municipalities (Metros - 'Unicities' with no sub structures)
- 47 district municipalities covering the whole country; and
- 231 Local Municipalities located within the areas of the district municipalities.

A district municipality may typically contain three to six local municipalities. A local municipality usually includes two to three towns as well as surrounding rural areas.

The new local government structures are faced with many challenges, including amalgamation of old administrations (up to nine) as well as the challenge posed by rural areas and parts of the former homelands. The division of powers & functions between district and local municipalities have been a major issue to resolve, but the line departments have reached an agreement with Provincial and local government about a position – this will be announced soon.

2.2.1.c. Background of water services

In 1994, all former homeland water services schemes became the responsibility of the national Department of Water Affairs & Forestry (DWAF) for the interim. These schemes now have to be transferred to WSAs (local government). The Government also embarked on the Reconstruction and Development Program (RDP) and since 1994, DWAF has overseen the implementation of approximately 200 new water schemes, which also have to be transferred to WSAs.

Further to that, it is estimated that another 7 million people do not have access to basic water supply and 18 million do not have access to an appropriate sanitation service. It is clear that the challenge facing the sector is huge.

2.2.1.d. Institutional Arrangements for Water Services

The primary responsibility for water services provision rests with local government. In terms of Section 84 of the Municipal Structures Act, the responsibility for providing water services rests with district and metropolitan municipalities. However, the Act allows the Minister of Provincial and Local Government Affairs to authorise a local municipality to perform these functions or exercise these powers. The district (or authorised local) municipality is the water services authority as defined in the Water Services Act. There can only be one water services authority in any specific area (that is, water services authority areas cannot overlap). Water services authorities have the following primary responsibilities:

- Realisation of the right to access to basic water services: ensuring progressive realisation of the right to basic water services subject to available resources (that is, extension of services), the provision of effective and efficient ongoing services (performance management, by-laws) and sustainability (financial planning, tariffs, service level choices, environmental monitoring).
- Planning: preparing water services development plans (integrated financial, institutional, social, technical and environmental planning) to progressively ensure efficient, affordable, economical and sustainable access to water.
- Selection of water services providers: selection, procurement and contracting water services providers (including itself).
- Regulation of water service provision and water services providers (by-laws, contract regulation, monitoring, performance management).
- Communication: consumer education and communication (health and hygiene promotion, water conservation and demand management, information sharing, communication, and consumer charters).

There must be a clear separation of authority and operation functions. Within this framework, the water services authority is essentially the regulator of the service and is responsible to ensure that services are provided effectively, efficiently, sustainably and affordably. The operational function is undertaken by the water services provider, the institution that actually provides the service. There must always be a contract between the water services authority and the water services provider.
A water services authority may either provide water services itself (internal mechanism), or contract a water services provider to provide water services (external mechanism). For an internal mechanism, the water services authority must manage and account separately for the two functions. In practical terms this might mean that a municipal manager, acting on behalf of the municipality, contracts (as the water services authority) with the manager of the water services department to provide water services in terms of a performance contract with the municipality. In the second case, the WSA must regulate the WSP according to the contract specifying clearly the allocation of roles and responsibilities between the regulator and the provider.

2.2.1.e. Water Services Providers

Duties of water services providers
The main duty of water services providers is to provide water services in accordance with the Constitution, the Water Services Act and the by-laws of the water services authority, and in terms of any specific conditions set by the water services authority in a contract.
A water services provider must publish a consumer charter which is consistent with by-laws and other regulations, is approved by the water services authority, and includes the duties and responsibilities of both the water services provider and the consumer, including conditions of supply of water services and payment conditions.

Types of water services providers
The most common "types" of water services providers are described below for the purposes of illustration. This listing is both brief and incomplete. This is because the definition of water services provider is broad and a variety of possible organisational forms for water services providers exist.

Both the content of the contract between a water services authority and water services provider and its enforceability (that is, the ability to perform the service effectively) are more important than the type of water services provider.

- Municipalities. As already mentioned, a water services authority can also be a water services provider, both within its own area as well as by contract with another water services authority or water services provider.
- Municipal entities. These are municipal-owned and controlled public providers which can be set up in terms of either a by-law or the Companies Act.
- Water boards. These are water services providers whose primary function is the provision of water services to other water services institutions.
- Community-based organisations. A community-based organisation (CBO), acting as a water services provider, is a not-for-profit organisation within a specific community providing a municipal service to that community with the mandate of that community, where the organisation is acting in the overall interests of the community. A more specific detailed definition of a CBO, together with a discussion of CBOs acting as water services providers, is given below.
- Private operators. These can vary from small, medium and micro enterprises (SMMEs) to more established larger private operators. They could be locally or foreign owned and can include multinational corporations.
- Other types of water services providers. In some cases water user associations, industries and mines provide water services to or on behalf of municipalities (but not as an intermediary – see section below). In these cases, the organisation is a water services provider even though the provision of water services is not the main business of the organisation and the provision of water services is undertaken for the purposes of assisting municipalities who have limited alternatives. The relationship between the water services provider and the water services authority must be defined in terms of an appropriate contract.

Internal and external water services providers – some examples

The Municipal Systems Act defines “internal” and “external” service delivery mechanisms. The Municipal Systems Act sets out a process to be followed when selecting an external service delivery mechanism (see section 0). For the sake of clarity, examples of internal and external water services providers are given in the table below.

Table 2.1: Examples of internal and external water services providers

Internal water services providers	External water services providers
• The municipality itself • A department within the municipality • A ring-fenced business unit within a municipality	• A municipal entity • A community-based organisation • Another municipality • A water board • A private company (including SMMEs) • Any other arrangement

Service provision across water services authority boundaries

Where regional water supply systems cross water services authority boundaries, water services authorities must co-operate with one another to establish arrangements to manage the cross border infrastructure. There are three broad options available to these water services authorities:

- Service agreements. The authority reliant on a service from a neighbouring municipality may enter into a service delivery agreement (contract) with its neighbour who would then be a water services provider in relation to this authority.
- Water board or municipal entity. The water services authorities may contract with an existing external water services provider (for example, a water board) or establish an external water services provider (for example, a municipal entity) to serve the region. Each water services authority will then contract separately with this external water services provider.

- multi-jurisdictional municipal service district (MJMSD). The water services authorities concerned may establish a MJMSD which implies the delegation of the water services authority function to this MJMSD. The MJMSD could then be the water services provider for the combined municipal area itself or it could contract other services providers.

Regional co-operation based on a services delivery agreement
Municipality A is a water services authority but is reliant on a bulk water supply system located in neighbouring Municipality B. Municipality A contracts with Municipality B in terms of a service delivery agreement to provide Municipality A with bulk water at the point there the pipeline crosses the municipal boundary. In this context Municipality B is a bulk water services provider to Municipality A.

Regional co-operation based on the establishment of a municipal entity
Two municipalities agree that there are practical and economy-of-scale advantages to operating their water services at regional scale. After considering various options, as required under the Municipal Systems Act, they decide to set up a municipal entity in the form of a company with each municipality a shareholder. They decide that this entity will be the water services provider for their whole area, taking responsibility for bulk and retail services. (This arrangement could apply to bulk water services only.)

Regional co-operation through a water board
A water board provides water services to (or on behalf of) a grouping of municipalities in terms of service delivery agreements, but ownership and control of the water board rests with national government.

Choosing water services providers

Preference for public sector provision. The "Framework for the Restructuring of Municipal Service Provision" (concluded between SALGA and COSATU on 11 December 1998) includes a set of guiding principles which state that public sector provision of municipal services is the preferred option. This preference arises from two primary concerns:
- the concern that the profit motive, an important motivating factor within the private sector (in addition to good service), will result in unaffordable services and lack of focus on servicing people without access to basic services; and
- the concern that private sector participation in the operation of water services could result in the loss of jobs, specifically public sector jobs.

As a result of this agreement, the Section 78 process in the Municipal Systems Act prescribes a procedure for the selection of the mechanism of municipal service provision in which *municipal provision of services is to be considered first*. The Water Services Act also incorporates a *preference for public sector provision* by requiring that public sector provision options are considered prior to the consideration of provision of water services by the private sector.

Protecting the public interest. It is important to bear in mind that protection of the public interest should be the primary consideration when selecting a water services provider and that there needs to be a balancing of interests between public sector workers on the one hand and consumers on the other. In a context of resource and capacity co vate sector in the provision of water services could result in the more effective and efficient provision of water services in some instances and that this would promote the public interest more effectively than a service provided wholly by the public sector which is inefficient and/or ineffective. The ultimate test is the protection and promotion of the public interest. For this reason, there is scope for private sector participation in the provision of water services notwithstanding the government's stated preference for public sector provision.

Choosing external water services providers. Water services authorities may choose to contract with external (including private) sector operators as water services providers provided that (1) they follow a defendable process and have applied their minds to the respective merits of available choices, (2) they are able to show the merits of choosing an external water services provider over and above an internal water services provider, (3) they employ best practice with respect to entering into contracts with external water services providers, and (4) they use competitive procurement when entering into contracts with private water services providers.

In practical terms, this means the following:

- A water services authority must have applied its mind to the merits of providing water services itself prior to making a decision to consider other service delivery options. It should take into account (1) the implications of providing the service itself (that is, the "costs and benefits" which are defined broadly to include financial, environmental, social and economic factors), (2) the municipality's current and future capacity to effectively provide the service, and (3) general trends in the sustainable provision of municipal services.
- A water services authority must have compared the respective merits of public versus private provision of the service, taking into account the factors listed above. It should be able to make a rational and sound case for the operation of the service by a private water services provider, including a motivation for the strategic and operational benefits for the water services authority.
- Furthermore, the water services authority must report on the respective forms of private sector involvement considered and account for the selection of the proposed form.
- When choosing a private water services provider, the water services authority must employ a competitive tendering process and be able to show that the contract will provide value for money, be affordable to the institution and transfer appropriate technical, operational and financial risk to the private party.
- The *extent of consideration* referred to above in the case of the choice of a private water services provider will depend on the extent and nature of the contract. It is obvious that the extent of consideration should be related to the level and complexity of the function being contracted.

Form and content of contracts. Whenever a water services authority chooses a water services provider to operate water services on its behalf, it must enter into a written contract with the water services provider. This contract should follow best practice contracting guidelines. In general, and where practical, it *is preferable for a water services authority to enter into a single contract with one water services provider who assumes full responsibility for the provision of the full service in a specific geographic area*, or alternatively into separate contracts for bulk and retail services. It is also preferable that these contracts include sanitation so as to promote integrated water and sanitation planning.

Community-based organisations as water services providers

Definition. A community-based organisation means a not-for-profit organisation situated within a defined community that is mandated by that community to provide a specific municipal service to that community on behalf of the municipality, provided that (1) all members of the governing body of the organisation are nominated members of the community and are permanently resident within the community; (2) all employees of the organisation are members of the community and are permanently resident within the community; and (3) the area constituting the community is defined by the municipality.

Legal form. A community-based organisation must be a legal entity. There are various ways of forming a legal entity, but a voluntary association is the most appropriate legal form for CBOs providing water services at a relatively small scale in rural communities.

Establishment and support of CBOs. Ideally, CBOs should be established as a result of a broadly participative community process. It is likely that this establishment process will require support. This support (which may need to be ongoing) could be undertaken directly by the water services authority or by an agency on behalf of the water services authority.

Criteria for choosing a CBO as WSP. There are two key criteria that a water services authority must take into account when considering entering into a service agreement with a community-based organisation to provide water services:

- the appropriate legal status and
- the ability to provide water services as (or more) cost-effectively compared to other alternatives.

Process for selecting CBOs. The Municipal Systems Act classifies CBOs acting as water services providers as an external mechanism. This means that the selection of CBOs as water services providers requires a competitive tendering process. This is not appropriate and a recommendation to change the Municipal Systems Act will be made.

A water services authority may undertake a “generic process” (in terms of Section 78 of the Municipal Systems Act) which identifies the general conditions where the selection of CBOs as water services providers is appropriate. This means that a water services authority does not need to undertake a Section 78 process for every decision to appoint a CBO as a water services provider.

Selection of CBOs and the Water Services Act. The feasibility of CBOs acting as water services providers should be considered prior to engaging with private operators in terms of the Water Services Act.

Water services intermediaries and the provision of services on private land

A water services intermediary is any person who is obliged to provide water services to another in terms of a contract where the obligation to provide water services is incidental to the contract (as per the Water Services Act). This means that the intermediary must have a contract with the consumer for a purpose other than the provision of the water services (for example an employment or property lease contract) in order for it to be recognised as an intermediary rather than a service provider.

Where a person providing water services does not have a primary contract with the consumer for a purpose other than providing water services, but continues to provide water services, the person providing services is not an intermediary but a water services provider. This is the case irrespective of whether the provision of such services is incidental to the main purpose of that institution. Water services authorities must ensure that appropriate contracts are in place between itself and these water services providers.

The central objective of water services policy is to promote access to basic services by the poor. Intermediaries have a key role to play in this regard, considering that approximately 8% of South Africans live on commercial farms and probably another 2% or so live in “private towns” run by mines, Eskom and other big companies. Under this policy water services intermediaries are required to provide services to these people and the water services authority must ensure that this is done. The water services authority may regulate water services provided by intermediaries in terms of municipal by-laws.

Examples of intermediaries:

- Farmers: Where farm workers (and their families) receive water services (usually associated with accommodation) as part of their employment contract with the farmer, the farmer is an intermediary to his workers. This also applies to retired workers and their families. Where there are other people living on the farm who are not linked through a current or former employee relationship, and where the farmer agrees to provide services to these people, the farmer becomes a water services provider.
- Mines and other industries: Where employees receive water services (usually associated with accommodation) as part of their employment contract with the mine or industry, the mine or industry is a water services intermediary to these employees and not a water services provider.

- However, if there are people living in the town that are not employed (or no longer employed) by the mine/industry and the mine/industry decides to provide these people with water services, then the mine is acting as a water services provider.
- Where a mine/industry provides bulk and/or retail water services to a neighbouring town on behalf of a water services authority, the mine/industry is a water services provider.
- Sectional title or lease of property: Where co-owners or tenants receive water services as part of their contract for management of the total property or lease of a property, the owner/landlord/body corporate is an intermediary to the co-owners or tenants.
- Water user associations: Where employees receive water services (usually associated with accommodation) as part of their employment contract with the water user association (WUA), the WUA is an intermediary to its employees."

2.2.2 Current Water Supply Perspective

The current situation regarding drinking water supply to the population in South Africa is shown in Figure 2.1 below (also showing the improvement from March 2003 to March 2004).

2.2.2.a. The role of regulatory governance

Overall regulation of the water services sector is the responsibility of DWAF. As clearly set out in the Strategic Framework for Water Services (DWAF, 2003) (see below), DWAF plays a cooperative and regulatory governance role in assisting local and provincial government via supportive interventions and the development of the necessary guiding policies. In this regard, initiatives include development of a national drinking water regulatory strategy (see Section4), Regional Information Centres, effective communication procedures, reporting frameworks, and monitoring and evaluation protocols. Implementation of such initiatives will enable sustainable delivery and management of water services.

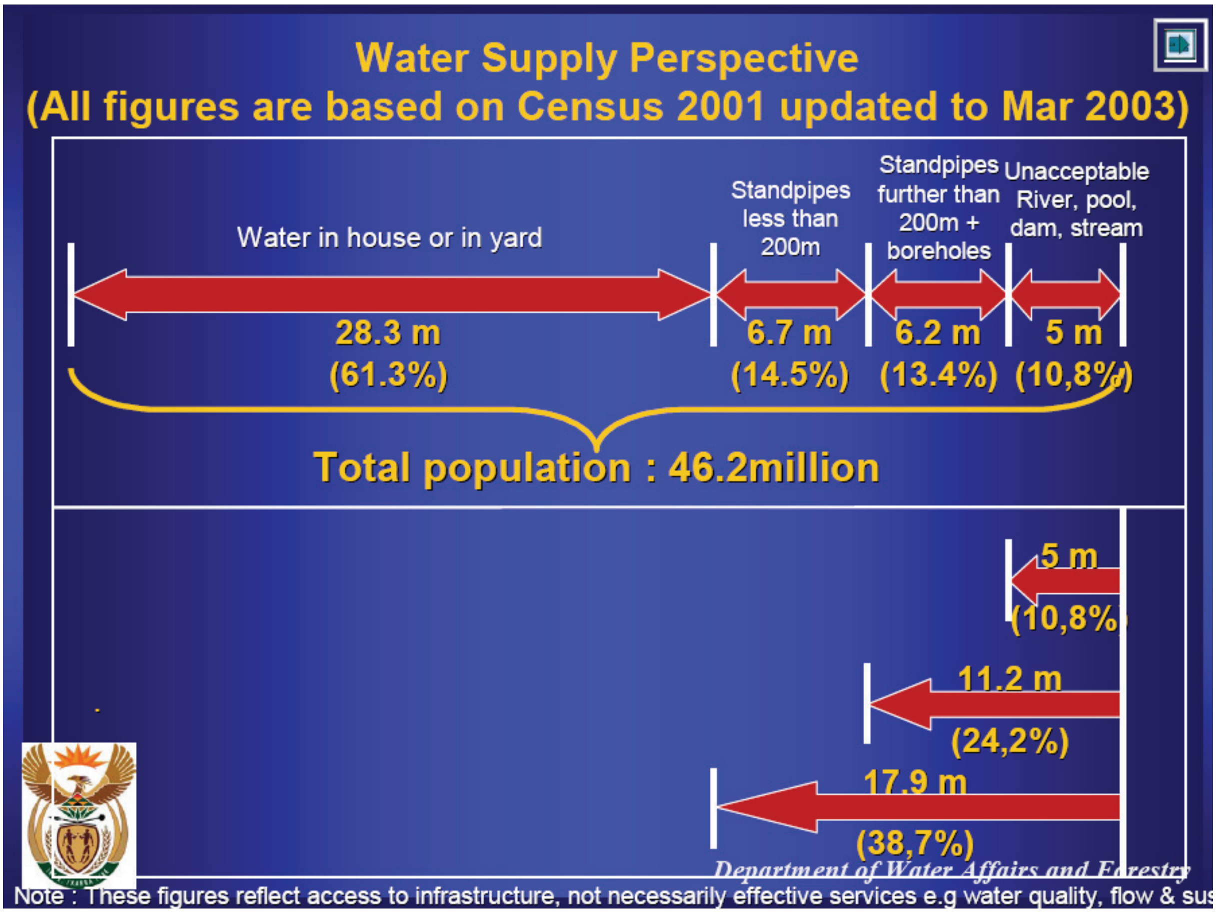
2.2.2.b. Strategic Framework for Water Services (SFWS)

The Strategic Framework for Water Services, approved by Cabinet on 17 September 2003, sets the scene for a new phase of water supply and sanitation delivery over the next ten years. It puts municipalities firmly in the driving seat and will see the National Department of Water Affairs and Forestry focusing on support, monitoring and regulation rather than direct service delivery.

The Framework, developed in close consultation with SALGA (the South African Local Government Association) and other key stakeholders, provides a comprehensive review of policy with respect to the provision of water supply and sanitation services in South Africa. It outlines the vision, goals and specific targets for the water services sector in South Africa as well as the changes in approach needed to achieve the country's policy goals as a result of the establishment of democratic local government and the progress in the sector since 1994.

The Framework develops further the 1994 Water Services White Paper, which had been overtaken by progress in other areas. Most important were the Local Government elections in 2000, which established democratic Local Government across the country as well as last year's assignment to Municipalities of specific powers and functions by the Minister of Provincial and Local Government.

In the new phase, Municipalities will assume full operational responsibility for water and sanitation services as required by the Constitution of South Africa.



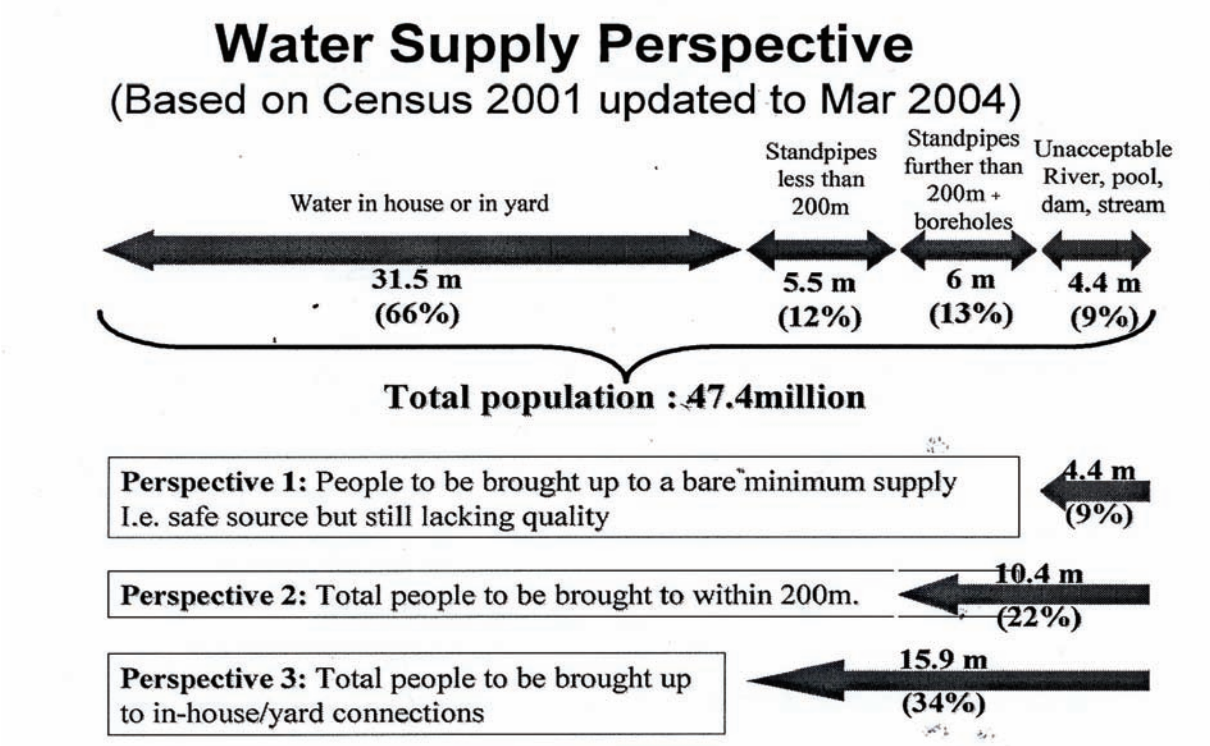


Figure 2.1: Water supply perspective (census 2001: updated March 2004).

Other key features of the Framework are:

- A comprehensive framework for all water services reflecting the latest municipal legislation;
- Confirmation that Municipalities, as Water Services Authorities, have primary responsibility for the delivery of water services;
- Focus of the Department of Water Affairs and Forestry to change from direct service delivery to sector policy, support and regulation;
- Provision for a process of institutional reform of water services provision focusing on a review of regional water service arrangements, including the role of Water Boards;
- Consolidation of national government funding for water services through the equitable share of revenue, a single Municipal Infrastructure Grant and the Capacity Building Grant directly to Municipalities;
- The vision of a "water ladder" which promises all people the opportunity to move up the ladder to higher levels of service beyond the current basic service level of communal taps.
- Emphasis on sustainability, financial viability and efficiency;
- Consumer protection, particularly to ensure continued access to a minimum free basic water supply and procedures to be followed by Municipalities before domestic water supplies are restricted;
- Transfer of thousands of water schemes from the national Department to Municipalities together with the relevant staff and budgets.

The framework addresses the full spectrum of water and sanitation services (not only basic services) as well as the overarching policy issues pertaining to institutional, regulatory and financial frameworks, and integrated planning. It has been informed by a set of guiding principles that reflect international best practice, grouped under the following headings: (i) social; (ii) economic and financial; (iii) environmental and technological; and (iv) institutional and management.

These principles may be summarised as follows (Stephen, 2003):

Social principles

- Everybody has a right to basic water supply and sanitation.
- A strong and active civil society has an important role to play in the water sector.
- Women should play a central role in the planning, provision and management of
- water services.
- Education is a vital component of water services in achieving and sustaining health and quality-of-life benefits.

Economic and financial principles

- Water services infrastructure to be publicly owned.
- Water services must be provided in accordance with sound business principles in order to ensure sustainability.
- Water tariffs and effective credit control are important components of any strategy to support sustainability.
- Demand management should be given as much attention as supply expansion in planning of water services and water resources planning.
- Water services should be provided and managed in such a way as to maximise their potential to support local economic development.

Environmental and technological principles

- Water services should take into account their impact on the natural environment and seek through remedial measures to minimise any negative impacts.

- Technology should be chosen rationally and appropriately.

Institutional and management principles

- Roles and responsibilities for government should be clearly defined.
- Regulatory and operational responsibilities should be separated.
- User and community participation is important.
- Ongoing capacity building is necessary.
- Information should support monitoring and evaluation.
- The public sector is the preferred provider of water services; nevertheless, the private sector has an important role to play.
- The strategic framework clarifies the roles, responsibilities and interrelationships between the various players within the water sector, provides a financial framework within which to work, and includes sections on planning, delivery and sustainability, and a chapter on support, monitoring and regulation.

2.2.2.c. Financial management of rural water supply schemes

South Africa is not the only country re-examining the approach to the pricing of water and its role in water management. Under the pressure of development and population growth, many countries have begun to experiment with approaches that can sustain their water use into the future. Financial management at the treatment plant level in South Africa is no exception from this. Treatment plants at the rural areas are failing to meet the require standards of water quality because of lack of funds and financial management (Morgan 1992 from Momba *et al.* (2008)).

The Municipal Financial Management Act (MFMA*)* aims to modernise budget and financial management practices by placing local government finances on a sustainable footing. It also aims to put in place a sound financial governance framework by clarifying and separating the roles and responsibilities of the mayor, executive and non-executive councillors and officials. It consequently serves to maximize the capacity of municipalities to deliver services to all its residents, customers, users and investors (Government Gazette, 2004).

The municipal financial management Act is also aimed at securing sound and sustainable management of the financial affairs of the municipality and other institutions in local spheres of government; to establish treasury norms and standards for the local spheres of the government; and to provide matters connected therewith.

2.2.2.d. Budget

According to Voortman and Reddy (1997) considerable variations in the capital costs of water treatment plants are mainly due to variations in capacity and variations in water treatment technologies. When the capital costs are normalised for plant capacity, they range from R 6000/ (m^3/day) for the smaller capacity, high technology unity to approximately R 200/ (m^3/day) for the lager capacity, lower technology processes. Operation costs were estimated from the sum of the energy, chemical and maintenance costs. Labour costs were estimated at a rate of R 7, 00/ hour while actual costs were used wherever possible to estimate the energy, chemical and maintenance costs (Voortman and Reddy, 1997). The capital costs quoted in Voortman and Reddy's studies are based on the manufacturer's 1994 ex-factory price, excluding VAT. The cost of delivery, raw water provision, electricity supply and civil works at the treatment plant site was not included.

The budget of the local Authority over water treatment works should cover the following: i) infrastructure (equipment, etc), ii) operations (consumable chemicals; and laboratory), iii) working conditions (salaries; medical; pension fund: housing; etc), iv) maintenance (need for preventative maintenance) and v) monitoring (raw water; treatment water plant; distribution network).

2.2.2.e. Asset management

One of the important issues identified, as part of the Water Service Development Plan is the lack of proper asset management strategy. This has inevitably leads to the deterioration of infrastructure and service provision. Water services is now focusing growing its "asset management maturity" with the implementation of a strategic municipal asset management programme (SMAM), facilitated through the creation of an asset centre (ACC). The ACC is being managed through a bureau arrangement with asset performance management specialist PRAGMA Africa since March 2004.

The water services sector in South Africa has infrastructure of a replacement value of several hundred billion rand. During the next decade a lot of more infrastructure will be provided, "yet many Water Services Authorities, do very little infrastructure asset management, and do not budget sufficiently for it" (DWAF, 2005). The Strategic Framework of Water Services requires that Water Services Authorities (WSAs) to maintain a register of Water Services infrastructure assets and put in place a system to manage these assets in terms of a maintenance and rehabilitation plan. This plan must be based on the principle preventative maintenance and must be part of the Water Services Development Plan. Asset must be rehabilitated and/or replaced before the end of their economic life and the necessary capital funds must be allocated for this purpose (DWAF, 2005)

According to DWAF (2005), the loss of the "intellectual assets" is a very major threat to effective infrastructure management and hence to compliance. The loss of key technical staff, and their non-replacement, or replacement by others less qualified, is inhibiting infrastructure management and in many cases can be identified as the main reason for breakdown of service. In addition to this shortage of technical capacity, there is also a lack of appropriate technical guidelines, and in some cases norms and standards, for infrastructure asset management.

2.2.3 The Stages of Rural Water Supply Projects

As for most other projects, rural water supply projects also follow the route from conceptualisation through to planning, implementation and management. There are a number of distinct stages in the life-time of such projects. Stephen (2000) describes these stages, together with the activities associated with them, as follows:

- **Identification and preparation** comprise the pre-investment planning stages.
- **Approval** is the stage at which decision-makers, including financiers, determine whether or not a project will become a reality.
- **Implementation** is the stage at which detailed designs are completed and the project facilities are built and commissioned; supporting activities such as staff training are also undertaken.
- **Operation** is the stage when the project facilities are integrated with the existing system to provide improved services.
- **Evaluation**, the final stage, determines what lessons have been learned so that future projects can be improved accordingly.

2.3. Overview of challenges in the rural water supply sector

2.3.1 Overall challenges in the water sector in South Africa (Stephen, 2003)

According to Stephan (2003), the main challenges relate to:

a. Increase the rate of infrastructural delivery in order to reduce the backlogs in water and sanitation
b. Provide ongoing water and sanitation services in a sustainable manner
c. Improve people's health and their quality of life
d. Reduce poverty
e. Improve food security

2.3.2 The non-metropolitan (or rural) drinking water quality challenge

There has been good progress in the provision of improved water services. In 2004, some 10 million additional people had been supplied with basic water supply, and it is predicted by DWAF that there will be universal coverage within five years (Mvula Trust, 2006). A significant challenge now exists for WSAs in the provision and maintenance of basic water services. An important component is providing acceptable *quality* drinking water at point-of-distribution. In this regard, the adoption and use of simple Drinking Water Quality Management procedures can make a significant contribution to both drinking water quality and legislative compliance.

2.3.3 Sustainability

There are several factors that have an effect on the sustainability of water supply schemes and that should be considered in the development of these schemes (Webster, 1999). These include:

<u>Ecologically Sustainable Supplies</u>: The supply or water source must not be exploited at a rate greater than its ability to be recharged from the environment and the environment must not be unacceptably affected by the introduction of the water supply scheme.

<u>Socially Sustainable</u>: The system must be accepted and “owned “ by the community . The process of development must be demand driven in order to satisfy this condition. Ownership is considered important with responsibility and acceptance by the community which is essential for cooperation in operating and maintaining the scheme, particularly in rural areas. It is also said to prevent vandalism.

<u>Technologically Sustainable</u>: This means that the technology employed must be appropriate to the needs and skills of the community to operate and maintain. Higher levels of technology require higher levels of skills and management to operate and maintain.

<u>Energy Sustainability</u>: The best possible, most efficient and most economic and energy efficient technologies should be used, taking into account employment of renewable energies as the ultimate goal.

<u>Institutionally Sustainable</u>: This is by far the most difficult condition to satisfy .It involves the building of capacity at a governance level and the training of staff at the operational, maintenance, monitoring and administration level.

<u>Financial Sustainability</u>: The objective should be full cost recovery for operational, maintenance and replacement costs i.e. recurrent cost expenditure recovery.

Figure 2.2 shows a summary by Webster (1999) of factors affecting sustainability of rural water supply projects in South Africa.

2.3.4 Operation and Maintenance

<u>2.3.4.a. International challenges with O&M of rural water treatment plants</u>

Numerous reports reflect on the record of poor operation and maintenance and the following list highlights the main constraints (McPherson, 1990; Ittissa, 1991; Wyatt, 1988; Roark, 1993):

- The low profile and hence low priority given to O&M by policy makers.
- There is a need for clear policies, appropriate legal frameworks and a well defined division of responsibilities to support O&M in the sector. Centralised government departments are often unable to respond efficiently to the maintenance of scattered rural supplies. Governments, therefore, need to adopt workable policies which devolve responsibility to autonomous agencies and communities.
- Political interference makes sustainability that much more difficult to achieve. The political decision to provide free water means users do not contribute funds for the upkeep of supplies.

Political influences can determine technologies (e.g. tied to aid) or result in sub-standard systems. Such influences can be reduced by devolving management responsibilities away from government.

- A focus on capital construction and expansion by governments and external support agencies neglects the maintenance of existing supplies.
- Overlapping responsibilities of staff and departments can divert skills, funds and equipment away from O&M. This often happens when operational staff is redeployed to construction work as a new project is started. New projects benefit while existing projects are neglected.
- Inappropriate design and technology choice creates unnecessary operation and maintenance difficulties and increases costs. Initial design must consider long term O&M. Poor design is often compounded by inadequate supervision of construction.
- A lack of community involvement in project development can lead to inappropriate designs. Poor user understanding of how to correctly operate systems can result in the misuse and damage of facilities.
- Some communities are disadvantaged by their remoteness or difficult access. This adds to the cost and problems of maintenance and requires special attention.
- There is often inadequate data for planning O&M. Data is required, for example, on the cause of breakdowns and the maintenance and repair costs involved. O&M can then be planned based on field experience.
- The state of national and regional economies can have a crippling effect on O&M as high inflation and fluctuating exchange rates can significantly increase O&M costs. For example, the operation of powered pumps and maintenance crew transport is especially affected by fuel prices increases.
- Water supply facilities are often poorly managed. Some of the management constraints, such as unskilled staff, may be a result of underfunding but are often also due to poor management. O&M responsibilities are rarely delegated to individuals and this can result in a lack of sense of responsibility for the proper use and upkeep of facilities. Management supervision of operation and maintenance may be virtually absent in many cases.
- A lack of training and understanding of maintenance procedures leads to the poor performance of O&M staff (operators, mechanics, caretakers, etc.).
- Insufficient and inefficient use of funds for O&M restricts the availability of spare parts, tools and the recruitment and training of competent staff. A lack of accountability in many maintenance departments leads to inefficient use of maintenance funds.

2.3.5 Operation and maintenance challenges in South Africa

Surveys by a number of researchers (Swartz, 2000; Momba *et al.,* 2006; Swartz *et al.,* 2007) have revealed that serious problems and challenges exist with performance and sustainability of rural water treatment plants in South Africa. These problems include both technical and non-technical (management – the so-called "soft issues") aspects related to operation, maintenance and management of these non-metro treatment plants. The problems are particularly acute at some of the remote rural treatment plants, and include:

- no flow measurement
- lack of trained and skilled water treatment personnel (often also on supervisory level)
- poor communication
- ineffective process control and quality control (in particular chlorination)
- inadequate budgeting and financial control
- lack of proper maintenance programs
- plants overloaded and upgrading not forthcoming

In the recent study (Swartz *et al.,* 2007) to identify operation and maintenance challenges and needs at small water treatment plants in South Africa, the general problems found in all the plants audited can be categorised into staffing, documentation, operation, maintenance, monitoring and health and safety aspects. Above these aspects was a general problem of management's concern and involvement in the status and running of small water treatment plants.

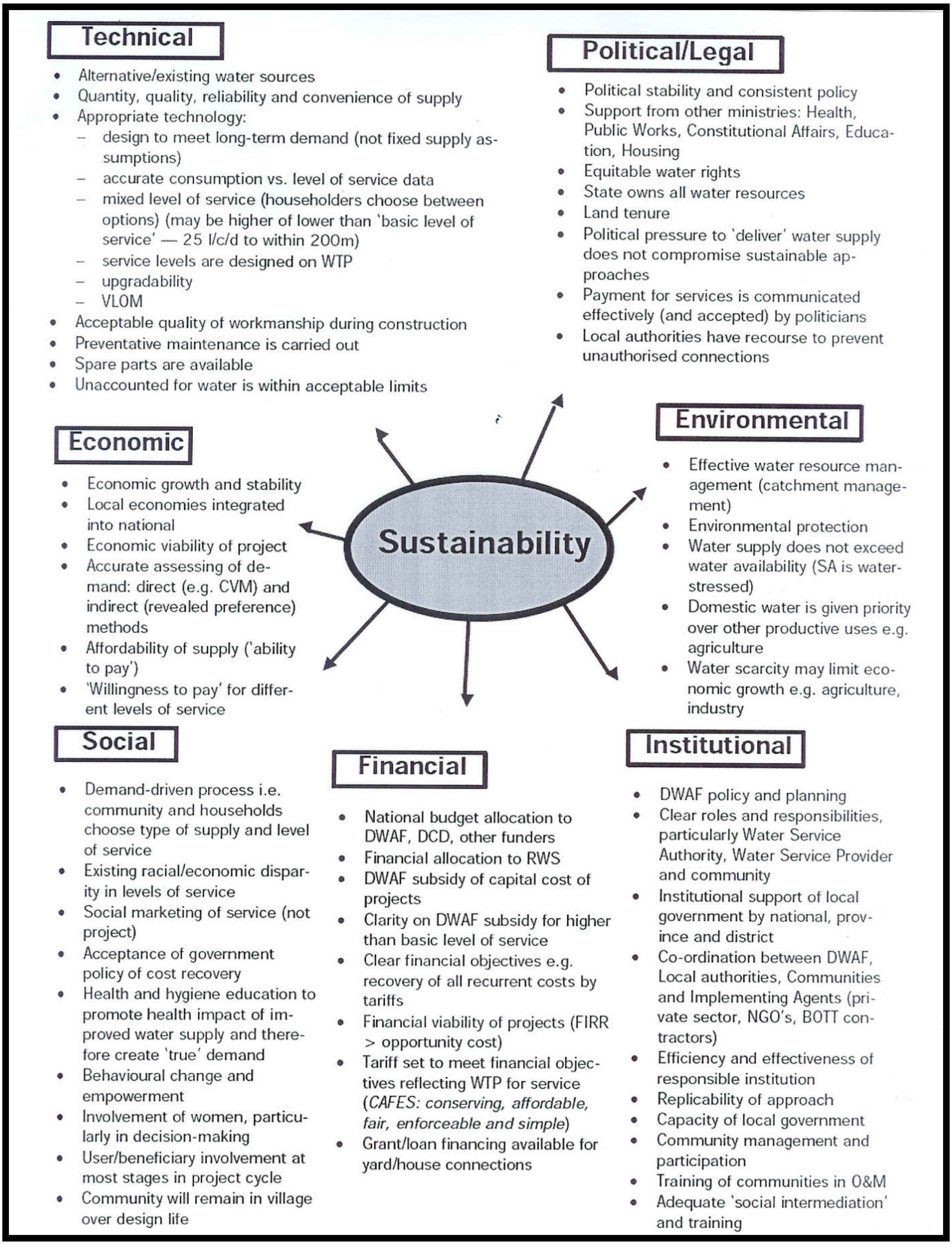


Figure 2.2: Factors affecting sustainability of rural water supply in South Africa (Webster, 1999)

2.3.5.a. Staffing and working conditions

Most of the small plants do not have a 24-hour operator presence. Such plants are only operated on a day's shift and some of them were just visited regularly without dedicated operators. Therefore remote operation and maintenance is a major problem in most plants.

The low level of operator education and training were also some of the general problems related to staffing. This resulted in communication challenges in many plants since the operators do not the capacity to convince management.
Poor working conditions were found to frustrate most operators.

2.3.5.b. Documentation

The lack of documentation both on site and at municipal offices, relating to the design, operation and maintenance of the various plant processes was one of biggest general problems encountered. This in the ends contributed to lack of process understanding in as far as operation, monitoring and maintenance was concerned.

a. Operation
Most small water treatment plants were characterised by poor operation practices. In addition to poor staffing, this general problem is attributed to challenges in the supply and availability of necessary equipment and consumables. Key aspects necessary to operate plants, such as flow measurements and water quality analysis cannot be performed in these plants.

b. Maintenance
Maintenance in most plants is more of the reactive in nature; it is done as the need arises. There is no deliberate action to perform preventative maintenance. The maintenance problems, like many other problems, are mainly directly related to poor staffing and training.

Operators were generally found to be ignorant of the consequences of poor maintenance, although some reported of poor support systems in place as the maintenance tasks were left for a lone operator to manage.

c. Monitoring
Lack of adequate in-house process monitoring is common in all the plants audited. The key aspects that require monitoring relate to water quality and operational parameters such as chemical dosing rates, filtration rates and flow rates. The lack of adequate monitoring is directly attributed to the lack of dedicated and trained personnel, as well as a lack of equipment.

d. Security, Health and Safety
Due to the size and remoteness nature of small water treatment plants, there is a general problem of providing proper security. Most plants audited are not protected and are easily accessible without any hindrance at all.

The aspects of tidiness, safety and hygiene were also found wanting in most plants. Facilities for ablutions and chemical storage are generally absent or poor in most plants. The availability of safety warning signs is non-existed in most plants.

e. Management
In most plants audited, there is overwhelming evidence of management's lack of serious attention for small water treatment plants. This aspect is attributed to the lack of well qualified management personnel who would show genuine concern for the challenges of small water treatment plants.

Generally, it was observed that as a result of the size and remoteness nature of small water treatment plants, they are generally financially not self-sustaining and could be relying on cross-subsidisation from larger plants' revenue. As result, without due regard for human life – water is life, most managing and/or owning authorities of small water treatment plants do not give small water treatment plants due attention.

2.4 Motivation and mindset of water care managers and operating personnel

In the study by Momba, Swartz and Obi (2008) to establish the underlying problems of non-compliance (with SANS 241 and generally-accepted management norms) of small water treatment plants, workshops that were held across the country also raised the issue of poor communication between water care personnel and managers, and poor motivation of personnel generally. Some of the discussion points and results emanating from the workshops are presented below.

"In Mpumalanga most plants appeared to be safe although there were some complaints about building maintenance and increased/upgraded security. Relationships between co-workers also appeared to be good, with most supervisors maintaining an open door policy as well as ongoing support. It was mentioned that in-fighting sometimes occurred but it was usually born out of frustration due to lack of response in repairing broken equipment or overlapping of duties. The DWAF often hold informal braais, which offered a chance for informal engagement, and often issues were discussed more readily under these circumstances. Most common performance indicators were the quality of the final waters. Often the standards required were not known and there were little to no bonuses or awards in place as incentives.

In KwaZulu-Natal, participants spoke somewhat negatively about the working condition in water treatment plants. There were no good ablution facilities, tea facilities, proper lightning/air conditioning system and no proper security (i.e. fences around the plants) in most cases. Participants also agreed that safety posed a huge challenge due to lack of fencing of some plants. Relationship between supervisors and subordinates was described as strained or not cordial in some cases, but not at all plants.

In the Eastern Cape, some mangers reported that workers were not satisfied with their working environment because of higher expectations and unfulfilled aspirations. Others felts that their workers were satisfied with their working environment because there were not many resignations. Relationship between supervisors and subordinates was described as tense because appointments of supervisors from the ranks of senior process controllers were reportedly tainted with favouritisms. Blaming syndrome was also mentioned to be rife. Supervisors were always blaming process controllers for any deviations around acceptable norms. In terms of safety of the working environment, this was considered moderately safe but maintenance posed a huge challenge. Some plants are not fenced and this posed a safety hazards. Performance indicators/targets were reportedly available at some plants.

In the Western Cape, the need to improve worker motivation was expressed. One of the main complaints from shift workers was on how they should keep themselves busy during shifts when plant operations only required their inputs for a part of the overall shift time. In general, the inter-relationships were good to manageable. Relationships between plant personnel did not normally present major problems; however, in certain cases the relationship between process controllers and the superintendents were not good (lack of trust; not transparent) and this led to poor motivation and tasks not done. The problems were then invariably attributed to the other party (neither party wants to accept responsibility). The workshop attendees indicated that the question refers back to human resources and the need for trained personnel and well-defined job descriptions. Most of the conflict occurred as a result of failed communication.

Safety matters were very often not given the high priority that it should. A need for safety training was expressed. Safety representatives wanted to be paid for their work. When volunteer for the position of safety representative realised that pay is not forthcoming, he/she was not interested anymore. The lack of proper safety management on water treatment plant often contributes to poor relationships between plant personnel and water care management.

Propositions to improve the situation

Proposals put forward in order to improve the situation included:

- Good and regular maintenance of plants,
- Increases in process controllers salaries,
- Making process controllers salaries commensurate with their qualifications,
- Giving process controllers more of a voice on issues concerning them,
- Improving the standard of living of process controllers (i.e. provision of better on-site housing)
- Respect for process controllers
- Career path development for process controllers
- Improving safety at plants and in-service training."

2.5 Lack of capacity

Lack of capacity remains a serious challenge also for the national government, as can be seen from the following excerpts taken from DWAF Provincial Overview for 2006/2007 (DWAF, 2007):

"Municipalities are faced with HR and capacity constraints which affect staffing and capacity issues. Most WSAs responsible for providing services to largely rural populations are faced with limitations when it comes to technical, financial and institutional capacities." (Mr Vusi Kubheka, Chief Director: DWAF Kwazulu-Natal Region)

"The capacity of local government to deliver remains a concern mainly because Limpopo is predominantly rural and it remains difficult to attract technical people." (Mr Alson Matukane, Chief Director: DWAF Limpopo Region)

"One of the most serious challenges facing the province (North West) is that of capacity constraints that hinder municipalities from delivering services to communities. It is essential to develop and strengthen technical and financial management capacity in municipalities. Some changes have been noted under the Project Consolidate programme, however more effort is still required in this regard. Improving data and information management in municipalities is still a challenge, this affects the quality and reliability of backlog data that municipalities provide." (Mr Chadwick Lobakeng, Acting Chief Director: DWAF North West Region)

Momba *et al* (2006) found in a survey of 55 treatment plants in the Eastern Cape that the worst technical problems encountered at rural water treatment plants tended to be at the newly commissioned or upgraded plants where properly trained operators had yet to be appointed or where the existing staff lack proficiency in the use of the upgraded systems or why certain modifications to the treatment process were being made. Operators were lacking in the required technical knowledge such as flow rate and chemical dosing to effectively execute their duties. Lack of communication between consultants, operators and municipal officials on technical issues relating to plant operation appeared to be a problem.

Drinking water supply operators' training, schooling and experience are inadequate as shown in Table 2.2 below from a survey from 181 rural plants in seven provinces in South Africa (Momba, 2005).

Table 2.2: Operator qualification experience (Momba *et al.,* 2005)

Province	Operator qualification			Years experience		
	Std 8 (%)	Matric (%)	Post Matric (%)	<5 (%)	5-10 (%)	11+ (%)
Limpopo	28	56	22	32	34	34
Mpumalanga	23	51	20	31	38	31
N-West	19	61	20	38	34	28
Free State	39	61	0	27	37	36
KZ-Natal	6	80	14	32	26	42
E-Cape	46	43	11	31	24	45
W-Cape	11	37	52	29	38	33

2.6 Insufficient funds

The following challenges of insufficient funding were pointed out, *inter alia*, in the DWAF Provincial Overview for 2006/2007 (DWAF, 2007):

"The issue of funding is a constraint in most municipalities and they are unable to cross-subsidise to recover costs and to undertake O&M of infrastructure. This has an impact on the ability to eradicate backlog. Besides a lack of infrastructure there is also a huge constraint when it comes to recovering costs of setting up and maintaining infrastructure, adequate cross subsidisation is not a possibility in some areas, this causes reluctance by municipalities to place themselves in a position that is not financially sustainable. Some of the problems are caused by debilitated infrastructure, since the current equitable share allocation does not sufficiently cover the cost of provision." (Mr Vusi Kubheka, Chief Director: DWAF Kwazulu-Natal Region).
"Inadequate funding for O&M of existing infrastructure is posing to be a serious challenge, as most WSAs are struggling to raise funds for this important function. The problem of dilapidated infrastructure is thwarting sincere efforts towards eradicating service backlog in the province." (Mr Chadwick Lobakeng, Acting Chief Director: DWAF North West Region).

2.7 Ownership and community participation

Stephen (2000) quotes the Minister of Water Affairs & Forestry, Mr Ronnie Kasrils, as saying in his opening speech at the 10th Congress of the Union of African Water Suppliers (UAWS) held in Durban, South Africa in February 2000: "*No project can be sustained if people have no sense of ownership or participation in that project. And no project can be sustained if the circumstances in people's lives are not addressed". He also said that: "Those who live at the heart of the problem are the people who truly understand its nature. It is this wisdom that we must draw upon in our relationships with our communities. They have much to teach us and we have much to learn".*

2.8 Comparison of different management systems in South Africa with other countries

Small water systems suffer from the same problems all over the world. In the USA, a study was recently carried out to consider the status of small water systems. It was interesting to note that, "more than 54, 000 small water plant systems provided drinking water to approximately 20% of the US population. Sixty percent of these systems served communities with 5000 or fewer. Furthermore, it was stated that many small communities lack a fee structure that is adequate to generate the necessary operating revenues, let alone funds for capital improvements". There is a strong correlation of this study and the situation in southern Africa (Swartz and Ralo, 2004).

A superficial survey of people in South African community served by small water systems showed that almost 20 % of our population relied on these systems. The issue of affordability is also very much the same (Swartz and Ralo, 2004). Recently, a number of small water systems serving rural communities in South Africa were evaluated to establish how effectively they were meeting their designed objective. Most problematic systems were not sustainable for non-technical reasons. Lack of financial management was on top of the list of reasons for system failing. Lack of funds resulted in the inability of water service provider to carry out repairs and preventative maintenance (DWAF, 2005).

2.9 Current initiatives to address these problems and challenges

2.9.1 Improving drinking water quality in non-metro South Africa

Drinking Water Quality Initiatives

The Department is in the process of introducing various innovative arrangements to address the challenges with drinking water quality in South Africa (Manus and Hodgson (2008):

- *Revising secondary legislation for the classification of treatment facilities and process controllers to allow for the continuous building of operating skills & capacity*

The current Regulation 2834 under the Water Act has been revised with significant changes as far as process controller is concerned. The one aspect of making it mandatory for Water Services Authorities to build the capacity and improve the skills level of process controllers will ensure that water treatment will be approach with greater professionalism and responsibility. The Regulation is a draft and will be submitted to obtain approval for public consultation soon.

- *Revising secondary legislation for the management of drinking water quality. Regulation 5 under Section 9 of the Water Services Act of 1998 will be revised to be less output-based*

The revision is to ensure that the responsible authorises do not merely compare results with SANS 241 but that they should comply with the national standard on drinking water quality. Greater emphasis will be placed on the importance of effective monitoring. This has resulted the revision of the SANS 241.

- *Facilitating the revision of the national standard for drinking water quality. This would allow management content of the standard to be normative*

Current appendices of the standard are all regarded as recommendations. However issues as important as a suitable sampling programme (as requested by legislation) needs to be normative for regulatory purposes. Certain maximum allowable limits are also under revision.

- *Introducing a DWQ laboratory strategy to ensure credible results (to be discussed in further detail in a workshop session)*;

The local historic situation does not allow for the usage of only accredited laboratories to be legislated, yet is it clear that there is concern regarding the credibility of results coming from some of the laboratories. While blanket accreditation would be a far-fetched objective, an intermediary solution is being developed to ensure that the levels of competence and credibility are being assessed on a regular basis.

- *Introducing the "Blue Drop" certification to allow for ordinary citizens to be more informed on the DWQ management of a specific town*

Through this initiative the Department is taking up the challenge to ensure that South Africans develop a higher level of confidence in our tap water. Within the next year various ways of communicating credible information on the status of our drinking water quality at regular frequencies will be revealed (to be discussed in further detail in a workshop session).

- *Initially introducing the roll-out of Water Safety and Security Plans to all 2010 host cities and towns, and to be extended to all municipalities prior to 2010.*

This initiative is an extension of the roll-out of the DWQ Framework for South Africa on a more localised level. It will ensure that municipal officials and politicians would become more aware of their specific responsibilities as far as the management of DWQ is concerned.

2.9.2 National Water Resources Strategy

The DWAF has developed a National Water Resource Strategy (NWRS) (DWAF, 2004) to address the management of the water resources to meet the development goals of the country. One of the key objectives of the NWRS is to identify areas of the country where water resources are limited and constrain development as well as development opportunities where water resources are available.

2.10 Performance indicators to improve water supply management

Performance indicators enable the health of a water supply scheme to be monitored and evaluated on a regular, on-going basis, and allow for corrective action to be taken, where necessary (Stephen and Still, 2000). These performance indicators will be used in evaluation of the decision-making framework developed under this project.

The Performance Indicators, classified as given above, are divided for easy reference into Categories A, B and C. The performance indicators are described below (Stephen and Still, 2000).

2.10.A. Service Performance Indicators

<u>A1. Working Supply Points</u>
Description: A simple count of the number of functioning standpipes or household connections is a direct indication of Operation and Maintenance status.
Indicator = Number of functioning supply points (communal and private)
<u>A2. Water Supply Reliability</u>
Description: A characteristic of many rural water supply systems is that the bulk supply is discontinuous, particularly in the case of stand-alone systems reliant on pumps. The cause of the failure may or may not be beyond the control of the Local Water Committee.
<u>A3. Water Consumption</u>
Description: The provision of an adequate quantity of potable water is crucial if anticipated health benefits are to be realised. Consumption is a function of tariff, reliability, distance to supply and availability of alternative sources of water.
<u>A4. Water Quality</u>
Description: A water quality monitoring programme can detect any changes in water quality, which may indicate an Operation and Maintenance problem.
<u>A5. Water Losses</u>
Description: Water losses are a useful indicator of the overall integrity of a scheme.
<u>A6. New Connections Response Time</u>
Description: The Local Water Committee needs to be responsive to the needs of consumers. The time it takes, from the time of application (and payment) to install a new connection will affect user satisfaction.
<u>A7. Stock Control</u>
Description: Effective stock control relies on: (i) whether regular stock-takes are carried out, and (ii) whether minimum stock levels of spare parts are maintained. Not having the required parts (especially critical items) in stock may seriously affect the Local Water Committee's ability to provide a reliable water supply.

2.10.B. Financial Performance Indicators

B1. Unit Cost of Water
Description: Knowledge of the real unit cost of water is essential to understanding the financial performance indicators.
B2. Profit/Loss
Description: The Profit/Loss indicator shows whether sales are exceeding expenditure.
B3. Cash Balance
Description: Cash on hand is very important in order for the Local Water Committee to meet its current expenses. Cash flow problems may be experienced depending on the amount of money tied up, for example, in arrear payments for water.
B4. Late Payments
Description: A Local Water Committee needs to be aware of trends in its debtor's book.

2.10.C. Accountability Indicators

C1. Financial Accountability
Description: Good management is not possible without financial accountability. The most basic requirement is that all income and expenditure is recorded in a generally accepted way. From these records, income and expenditure statements can be drawn up and the financial health of a system can be assessed.
C2. Accountability "Up" to Water Services Authority
Description: Section 22 of the Water Services Act makes it illegal for a Local Water Committee to function as a WSP without the written permission of the WSA. The Water Services Authority is entitled to obtain information from the Committee regarding the provision of water services to people living within the area of supply.
C3. Accountability "Down" to the Community
Description: The Local Water Committee as WSP has an obligation to provide adequate water services to the community. Regularly convened community meetings, to which representatives of the Water Services Authority are invited, are considered essential to ensure that problems are heard.

2.11 An operation and maintenance report for rural water schemes

An Operation and Maintenance Report has been developed and is being used to monitor and evaluate a number of rural water schemes in KwaZulu-Natal, South Africa (Stephen, 2001). It is anticipated that it will form part of the reporting requirements of Section 23 of the Water Services Act (No. 108 of 1997) (DWAF, 1997) which makes it compulsory for Water Services Providers to give information to a wide range of interested parties, including the Water Services Authorities, Provincial Authorities, the Minister of Water Affairs and Forestry and consumers (both existing and potential).

The O&M Report serves as a valuable management tool for WSPs by providing a record, on a regular monthly basis, of both the technical and financial aspects of water schemes, and by providing a means for sound business planning.

It also serves as a management information system for the WSAs by providing the information necessary for appropriate and timely interventions to assist in the long-term functional and financial sustainability of schemes.

According to Stephen (2000), Support Services Agents (SSAs), who may be contracted to provide support to either the WSP or the WSA (or both), could assist in the report's preparation, its interpretation (to both WSA and WSP), or use it as a teaching tool. Improvements in the managerial, technical, financial or administrative aspects of schemes are some of the desired outcomes arising from the use of the report.

The O&M Report provides information relating to schemes at both Local Water Committee (LWC) and overall project level (i.e. including external support and mentoring costs), in both tabular and graphical forms.

It is intended to complement the graphed Performance Indicators which have been developed specifically for LWCs (Stephen, 2000).

2.12 Summary of challenges and needs to be addressed

Based on the identification and study of the challenges facing rural water treatment in South Africa at present, and predicted for the future as well unless serious intervention is implemented, the following are the main needs for future improvement in this important water supply sector in South Africa:

- Effect of water-borne diseases
- Shortage of skilled personnel
- Availability of training service providers
- Lack of proper operation and maintenance
- Deteriorating infrastructure
- Deterioration of raw water quality
- National and local level policies and planning
- Legislation
- Management level incompetency
- Poor image of municipal water sector
- Lack of funds / mismanagement of funds
- Political interference
- Management level motivation
- Rising cost of energy
- Availability of energy
- Pollution of water sources
- Failing wastewater treatment plants
- Sanitation backlog
- Availability of raw water sources
- Public perceptions and social acceptance

The above needs and challenges comprise the ***internal factors*** that impacts on rural water supply in South Africa. The ***external factors*** impacting on rural water supply are considered and discussed in Chapter 3.

CHAPTER 3
DRIVING FORCES IMPACTING ON RURAL WATER TREATMENT IN SOUTH AFRICA

3.1 Introduction

The main source for identifying and prioritising the driving forces was the results of a workshop that was held in Windhoek (Namibia) during March 2006 on *Science and Technology-based Scenarios for sub-Saharan Africa* (Swartz, 2006). From the trends, the ten most important ones impacting on drinking water supply in South Africa and Sub-Saharan Africa were identified and are listed below:

- Population Growth
- Urbanisation
- Degradation of Source Water Quality
- Climate Change: Water Resource Quantity (Water Stress)
- Life-style Choices: Point-of-use Systems and Bottled Water
- Increasing Cost of Energy
- Better Access to Communication Technology and Information
- Increase in Water-borne Diseases
- Degradation of Infrastructure
- Political Tensions over Water

3.2 Workshop on Scenarios for Water Supply in Sub-Saharan Africa

The United Nations World Water Development Report No 2 of March 2006 states that environmental degradation, poor management and a burgeoning population have produced some of the worst water shortages in the world in sub-Saharan Africa, exacerbating poverty and disease. The associated challenge is illustrated by the fact that the population of sub-Saharan Africa, despite the impact of HIV/AIDS, is projected to grow to 1.1 billion in 2050 from 532 million in 1995.

The GRA, in association with various international agencies and stakeholders, has embarked on a journey to generate baseline stories for creating plausible science and technology-based water scenarios which can illuminate worthy actions. With this in mind a workshop was held from 26 – 29 March 2006 in Windhoek, Namibia, at which more than 30 water scientists from 15 countries made inputs to identify the underlying drivers and outcomes and produce the baseline storylines for the scenarios, and which was printed towards the middle of the year. Chris Swartz, Dr Gerhard Offringa and Dr Rivka Kfir were among the participants at the workshop.

The workshop was made possible through the generous support of the World Association of Industrial and Technological Research Organisations (WAITRO) with its Secretariat in Kuala Lumpur, the British High Commission in Namibia, the German Federal Ministry for Education and Research, the Fraunhofer-Gesellschaft in Germany, the Finnish Embassy in Pretoria and the South African Water Research Commission.

3.3 Trends impacting on drinking water supply in Sub-Saharan Africa

From the notes taken by Swartz (2006) at the workshop and subsequent interviews with role players, and through a detailed desk study of literature, the driving forces impacting on future drinking water supply in South Africa and sub-Saharan Africa were identified and further studied, and the results are presented in this report.

The ten main trends in drinking water supply in Southern and sub-Saharan Africa that were identified, are listed below:

- Population Growth
- Urbanisation
- Degradation of Source Water Quality
- Climate Change: Water Resource Quantity (Water Stress)
- Life-style Choices: Point-of-use Systems and Bottled Water
- Increasing Cost of Energy
- Better Access to Communication Technology and Information
- Increase in Water-borne Diseases
- Degradation of Infrastructure
- Political Tensions over Water

The driving forces (trends) are discussed in more detail under the following headings:

- Introduction
- Definitions
- Driving Forces
- General Implications
- Implications for the Water Industry
- Adaptive Strategies
- Conclusion

The study of driving factors was based on a matrix of factors that were developed for this purpose by the **EU FP7 project entitled TECHNEAU: *technology enabled universal access to safe drinking water*.** The matrix of factors contained the elements of the so-called **SEPTEDOR** dimensional analysis, of which the components are shown below:

S **Socio-cultural factors**
Willingness to pay
Whether consumers are informed
Appreciation of water
Ecological awareness
Land reform issues
Gender mainstreaming
Marginalised communities
E **Economical factors**
Financing models
Maintenance/renovation of infrastructure
Energy costs and energy consumption
Role of decentralised systems
P **Political factors**
Decision making process of innovations/investments
Role of NGOs
Administrative procedures
Role of political parties
T **Technical factors**
Breakthrough technologies
Emerging technologies
Point-of-use systems
Water recycling systems
Water saving technologies
E **Ecological factors**
Emerging pollutants
Accumulation of pollutants
Pollution control

Water resources

D **Demographical factors**

Population distribution (Urban vs. rural)

Population growth

Life expectancy

Educational level

O **Organisational factors**

Privatisation

Centralisation / regionalisation

R **Risk-related factors**

Terror attacks

Technical failure

Water quality

3.4 Discussion of Top Ten Key Factors

3.4.1 Population Growth

Introduction

Type of factor: Demographic.

Population growth in sub-Saharan Africa has historically always been high, and is expected to continue to be high, even with high prevalence of HIV/AIDS in this region.

Definitions

Population in sub-Saharan Africa is estimated to increase from 432 million in 1995 to 910 million in 2025.

Driving Forces

The extent of population growth will be determined by the economies of the respective countries in sub-Saharan Africa, and the region as a whole (i.e. poverty levels); the effect of water-borne diseases on mortality rates (especially amongst infants); the impact of HIV/AIDS on certain countries (especially in the south); health programmes.

General Implications

The high population growth in the area will place enormous pressure on the existing water sources, especially in those countries already experiencing water stress. There will also be a greater demand on food from available sources.

Implications for the water industry

As a result of the substantial increase in water demand, alternative water resources will have to be exploited, such as groundwater exploitation, water reclamation and reuse, rainwater harvesting, desalination of seawater and brackish water. It is expected that central government will need to start intervening on a large scale to assist local authorities and communities to supply water for drinking purposes.

There will be increasing tensions regarding the allocation of water, from community level through to international level where water resources are shared (which is the case in the majority of countries in sub-Saharan Africa).

The high population increase will also result in sanitation backlogs and pollution of water sources, requiring in many cases additional water treatment technologies to produce water complying with health requirements (WHO). The international community is expected to play a major role in supplying these technologies, of which Europe and China will play a major role. Innovative systems will be required.

In the more affluent societies in the cities there will be increasing use of household water treatment systems (point-of-use and point-of-entry) and there will be very active competition in the marketing and supply of these systems.

Adaptive Strategies

Effective water demand management will be critical. Better regional cooperation will be necessary (political cooperation between countries sharing water sources). Innovative solutions for exploitation of alternative water resources and treatment technologies (to enhance existing systems) will be required.

Conclusion

The high population growth in sub-Saharan Africa will place enormous pressure on the existing water sources, especially in those countries already experiencing water stress. There will also be a greater demand on food from available sources, for which more water is required. The high population increase will also result in sanitation backlogs and pollution of water sources.

Additional water treatment technologies to produce water complying with health requirements, and alternative water resources will have to be exploited, such as groundwater exploitation, water reclamation and reuse, rainwater harvesting, desalination of seawater and brackish water.

The international community will play a major role in supplying these technologies, of which Europe and China is expected to play leading roles. Innovative systems will be required.

The trend in sub-Saharan Africa will be more towards centralised water treatment rather than decentralised treatment in the rural and peri-urban areas.

3.4.2 Urbanisation

Introduction

Type of factor: Demographic.

Urbanisation in South Africa (and other African countries) has been steadily increasing during the last two decades, but has been increasing dramatically during the past five years or so. It is expected to increase even more rapidly in the immediate future (at least for the time window of this study), but in the long term there may be some return to rural areas as the stresses of over-population in urban areas takes its toll.

Definitions

A major migration from rural areas where unemployment is extremely high and resources are few, to the large cities in an attempt to find jobs and have more access to amenities. Examples (in South Africa) are the Cape Town metropolis, Durban and Johannesburg.

Driving Forces

Economic prosperity will dictate poverty and unemployment levels, which in its turn will determine to what levels urbanisation in African countries, and in South Africa in particular, will increase or stabilise.

General Implications

The current trend results in major challenges for planners and authorities to provide satisfactory urban water supply and sanitation facilities that can meet all the needs. It will have a major effect on pollution levels and on crime.

Implications for the water industry

There will be a strain on existing infrastructure, and requirements for new services and infrastructure will be more than what can be supplied. With concomitant degradation of existing infrastructure, it will place huge burdens on the local authorities (financial and capacity) to meet the requirements. International funding will undoubtedly be necessary to try to alleviate the backlogs.

Extensions to large water treatment plants and distribution systems will be required, and in many cases more advanced technologies (*e.g.* membranes and advanced oxidation) will also be required to treat the poorer raw water quality, new contaminants and micropollutants. However, bear in mind that the bottleneck is almost always in the distribution system.

More emphasis will be placed on urban water supply in research and development programmes (*cf.* GWRC initiatives). Research on how to improve urban water demand management will receive high priority.

Adaptive Strategies
Use of alternative water resources, such as water reclamation and reuse; seawater desalination in coastal cities; reducing water losses by better water demand management; upliftment programmes and development in rural areas in an attempt to counter the urbanisation trend. Meet the MDGs in rural areas.

Conclusion
A major migration from rural areas where unemployment is extremely high and resources are few, to the large cities in an attempt to find jobs and have more access to amenities is taking place in sub-Saharan Africa, and will continue to do so.

There will be a strain on existing infrastructure, and international funding will be necessary to try to alleviate the backlogs. More advanced technologies (*e.g.* membranes and advanced oxidation) will also be required to treat the poorer raw water quality. There will be more emphasis on urban water supply in research and development programmes in Africa.

3.4.3 Degradation of Source Water Quality

Introduction
Type of factor: Ecological; Technological.
Increasing pollution and wider dispersal of pollutants is taking place. The trend is expected to continue in African countries and in South Africa in particular where there is large scale migration from the north to South Africa.

Definitions
This trend comprises the increasing decline in water quality of raw water sources in African and developing countries. It is mostly contamination of surface water sources as a result of poor sanitation, wastewater treatment plants not function satisfactorily, and discharge. Groundwater sources are also contaminated by improper sanitation facilities. Examples are the Vaal River in South Africa and Lake Victoria.

Driving Forces
Increasing population; urbanisation; industrialisation; change in life-style resulting in higher waste loads. The trend is expected to continue and even increase in the urban areas.

General Implications
The poorer source water quality will lead to increasingly difficulties to produce drinking water that complies with basic health standards, resulting in potentially more incidences of outbreak of water-borne diseases. More emerging pollutants will land in raw water sources, requiring new strategies to manage this situation.

Implications for the water industry

Improved technologies will be required to treat the poorer raw water quality, as the conventional treatment systems of coagulation/flocculation, sedimentation, filtration and chlorination will in many cases not be adequate to ensure safe water. The occurrence of emerging contaminants and increase in water-borne diseases such as malaria, cholera and typhoid (and also diseases that had previously been eradicated or suppressed such as smallpox, dengue fever, Ebola fever and tuberculosis that are likely to re-emerge) will require more advanced treatment technologies, such as membrane treatment and advanced oxidation (UV; ozonation).

The poorer quality drinking water supplied to households in the cities (not only from inadequate treatment but also from quality deterioration in the distribution systems) will lead to more consumers in the affluent societies using point-of-use treatment systems, which will be marketed on large scale in these areas. This will be especially the case in the highly populated areas such as Johannesburg/Pretoria and Cape Town in South Africa.

The gradual increase in organic content (NOM) of surface waters will lead to expedited research in treatment technologies that can reduce these compounds cost-effectively, and that will be sustainable over the long term.

To improve the sustainability of existing treatment systems to treat the poorer raw water quality will need interventions to improve the operation and maintenance of these systems. Some privatisation in this market sector is expected to realise.

Adaptive Strategies

Better source protection; major effort to reach MDGs, thereby improving sanitation services and reducing pollution of water resources; development of cost-effective sustainable treatment systems and technologies applicable to Africa conditions and that of developing countries. Major programmes to improve operation and maintenance of both new and existing technologies. Assessment of steps and processes needed to improve measurement processes, monitoring, database development and data analysis.

Conclusion

There is an increasing decline in water quality of raw water sources in African and developing countries. It will lead to increasingly difficulties to produce drinking water that complies with basic health standards, resulting in potentially more incidences of outbreak of water-borne diseases.

The poorer quality drinking water supplied to households in the cities will lead to more consumers in the affluent societies using point-of-use treatment systems, which will be marketed on large scale in these areas. This will be especially the case in the highly populated areas such as Johannesburg/Pretoria and Cape Town in South Africa.

The gradual increase in organic content (NOM) of surface waters will lead to expedited research in treatment technologies that can reduce these compounds cost-effectively, and that will be sustainable over the long term.

3.4.4 Climate Change: Water Resource Quantity (Water Stress)

Introduction

Type of factor: Ecological.

Increasing incidence of extreme weather conditions, evident in South Africa where major floods were experienced recently after spells of severe droughts in certain areas (in some instances in the same regions, *e.g.* the Western Cape province in South Africa. There is general consensus that the impact of global climate change will continue for the foreseeable future (at least until 2050), and that it will have definite impact on sub-Saharan Africa.

Definitions
Due to global warming, weather patterns and meteorological systems are resulting in rainfall becoming increasingly unpredictable and leading to major catastrophes. Examples in South Africa are droughts in the western parts of the country, and unprecedented flooding in the Southern and Eastern Cape provinces during August and September of this year. Also changes in vegetation and land-use.

Driving Forces
Global warming is a result of CO_2 emissions. The problem is being addressed in programmes across the globe, but the effects of eradication will take at least fifty years to become evident.

General Implications
The climate change will have a great impact on the availability of water, resulting in water stress and unsustainable development in many regions in Africa, especially in the south-western parts. Flooding results in damage to infrastructure and long lag periods to repair the damage and restore the water supply service to its original condition. Also results in change of water quality in water sources (*e.g.* salinisation).

Implications for the water industry
For drought periods, strict water demand management measures will be required (allocation of water; water restrictions). Water restrictions have already been implemented in a number of towns in the western parts of South Africa. There will also be an increased focus on alternative water supply options and technologies, such as seawater desalination (Cape Town metropolis; Swakopmund planning for this; also areas in the southern parts of the continent). Also increasing R&D of rainwater harvesting and water reclamation and reuse as alternative water supply options.

There has been a significant increase in marketing of desalination technologies in the sub-continent, notably in South Africa. New competitors are entering the market.

Institutionally, the central government will work towards implementing improved water demand managements programmes, particularly in the urban areas.

Increasing migration – particularly to southern Africa and South Africa – is placing further stress on this region's scarce water supplies.

Adaptive Strategies
More emphasis will be required on the use of alternative water sources such as desalination, water reclamation and reuse, rainwater harvesting. Also flood protection to protect water treatment plants against possible damage during flooding, thereby ensuring uninterrupted water supply and acceptable drinking water quality.

Conclusion
There is an increasing incidence of extreme weather conditions in southern Africa where major floods were experienced recently after spells of severe droughts in certain areas (in some instances in the same regions, *e.g.* the Western Cape province in South Africa). There is general consensus that the impact of global climate change will continue for the foreseeable future (at least until 2050), and that it will have definite impact on sub-Saharan Africa.

There has been a significant increase in marketing of desalination technologies in the sub-continent, notably in South Africa. New competitors are entering the market.

3.4.5 Life-style Choices

(Point-of-use Systems and Bottled Water)
Introduction
Type of factor: Socio-cultural.

The use of point-of-use water treatment devices and bottled water only started to be on any significant scale during the past five years in South Africa, but since then it has grown dramatically, especially bottled water. The trend is expected to continue in urban areas; in rural areas and developing countries the use of POU systems and bottled water will not generally be affordable.

Definitions
The trend comprises the use of household water treatment devices to further improve the quality of piped water supply, mainly due to remove chlorine taste and other taste and odours. Bottled water is consumed rather than tap water due to a number of reasons.

Driving Forces
Deteriorating quality of piped water at the point of use, due to inadequate treatment (which may be the result of poor raw water quality, or poor O&M), and/or water quality deterioration in the distribution system. Another driving force is lack of confidence in drinking water supplied by the water service provider, often the result of marketing efforts of device suppliers, or negative media reports. It many cases it is have become fashionable to drink bottled water.

General Implications
The trend signifies a greater demand for better quality drinking water, which will require the water suppliers to improve their service delivery and quality of the end product if they want to retain consumer confidence.

Implications for the water industry
A wide variety of point-of-use water treatment devices have appeared on the market in South Africa (and some other African countries), and there are very strong marketing drives. Often misleading statements are made regarding the quality of tap water, or what the treatment device can achieve. This has generally resulted in decline in consumer confidence in many areas in South Africa.

More effective communication with consumers will be required to restore the confidence in water supply authorities; however, the water suppliers will need to ensure that water of high quality is not only produced at the treatment plant, but actually delivered at the tap at households (*i.e.* much more focus should be placed on eradicating the deterioration of water quality that takes place in the distribution systems).

Adaptive Strategies
Improve communication with consumers. Improve quality control through effective operation and monitoring, especially in the rural areas where this is generally lacking.

Conclusion
The use of point-of-use water treatment devices and bottled water is expected to continue in urban areas; but in rural areas and developing countries the use of POU systems and bottled water will not generally be affordable. A wide variety of point-of-use water treatment devices have appeared on the market in South Africa (and some other African countries), and there are very strong marketing drives. The water suppliers will need to ensure that water of high quality is not only produced at the treatment plant, but actually delivered at the tap at households (*i.e.* much more focus should be placed on eradicating the deterioration of water quality that takes place in the distribution systems).

3.4.6 Increasing Cost of Energy

Introduction
<u>Type of factor:</u> Economical.
The cost of energy has been increasing only gradually, but is expected to increase much more significantly in future. Energy costs have been relatively low in South Africa compared to other countries.

Definitions
The increasing cost of energy which impacts on the treatment and conveyance of drinking water.

Driving Forces
The cost of energy is driven by the availability and cost of producing the energy; the demand (expected to increase significantly in urban areas in South Africa); and on political cooperation between countries sharing hydro-electric power sources.

General Implications
To make water treatment technologies affordable and sustainable in the developing countries, the energy costs should be minimised, or technologies with lower energy requirements should be developed and/or alternative renewable energy sources should be sought and developed (*e.g.* solar; wind; tidal).
Implications for the water industry
Emphasis will need to be placed on energy efficient water treatment technologies, or on development of alternative energy technologies which will ensure affordable and sustainable treatment systems for developing countries with limited sources.

Research on renewable energy sources will therefore have to be fast-tracked.

For rural and remote areas, research on treatment systems that requires no electricity will be a high priority. The proposed application of membrane technologies in rural areas will need to strive towards using low or no energy, such as gravity fed systems (low-pressure systems).

Adaptive Strategies
Develop water treatment technologies that are energy efficient.
Develop renewable energy resources that could be used in combination with small-scale water treatment technologies for rural and remote areas (decentralisation).

Conclusion
The cost of energy has been increasing only gradually, but is expected to increase much more significantly in future. Energy costs have been relatively low in South Africa compared to other countries. Emphasis will need to be placed on energy efficient water treatment technologies, or on development of alternative energy technologies which will ensure affordable and sustainable treatment systems for developing countries with limited sources.

3.4.7 Better Access to Communication Technology and Information

Introduction
Type of factor: Technological.
IT technology has impacted on all technological spheres, including water treatment. It has ensured improved process control and remote monitoring.

Definitions
Improvement in communication and information technologies is resulting in improved process and quality control.

Driving Forces
Affordability of improved communication technologies is a main driving force. Access to internet in rural areas and developing countries will ensure more appropriate technologies and better monitoring and control systems.

General Implications
In African countries, the access to information through better communication and IT facilities will result in empowerment of the population, access to knowledge, training and skills development,

communication of science results, development of on-line systems, use of satellite data, GIS, and remote sensing and control.

Implications for the water industry
More sophisticated treatment technologies and accompanying control systems will be within reach of the rural and remote communities (as evidenced by the widespread use of cellular telephones world-wide).

Adaptive Strategies
It will be possible to supply treatment technologies to rural and remote areas in Africa that can be controlled remotely via telemetry and communication technology, which should ensure improved sustainability of these systems through rapid corrective action during plant upsets.
Conclusion
More sophisticated treatment technologies and accompanying control systems will be within reach of the rural and remote communities (as evidenced by the widespread use of cellular telephones world-wide). It will be possible to supply treatment technologies to rural and remote areas in sub-Saharan Africa that can be controlled remotely via telemetry and communication technology, which should ensure improved sustainability of these systems through rapid corrective action during plant upsets.

3.4.8 Increase in Water-borne Diseases

Introduction
Type of factor: Socio-cultural; ecological; demographical.

Definitions
Due to deterioration of service delivery and infrastructure, poor sanitation conditions and pollution of water sources, there is an increase in the number of incidences of water-borne diseases.

Driving Forces
The provision of water supply and sanitation services (meeting the MDGs).
Pollution of water sources (ability to prevent pollution and/or source protection).

General Implications
Poorer quality of life (generally) due to illness and deaths associated with/caused by the water-borne diseases is a result of deterioration of quality of water sources. It furthermore leads to increased mortality, especially amongst infants.

Implications for the water industry
There is a need for technologies that can effectively prevent any pathogens, viruses, parasites, emerging micropollutants from occurring in the treated water consumed by communities.

Re-contamination in the distribution network should be prevented by implementing effective monitoring systems.

General health improvement drive needed by governments to ensure adequate sanitation provision and water supply.

Adaptive Strategies
There should be increased environmental awareness.
Water source protection should be high priority.
Development/application of technologies that can prevent pathogens, parasites, etc. occurring in the treated water, *i.e.* the use of barrier treatment systems such as membranes.

Conclusion
In sub-Saharan Africa, there is an increase in poorer quality of life (generally) due to illness and deaths associated with/caused by the water-borne diseases. This includes increased mortality, especially amongst infants. There is a need for the development and application of technologies that can prevent pathogens, parasites, etc. occurring in the treated water, *e.g.* the use of barrier treatment systems such as membranes.

3.4.9 Degradation of Infrastructure

Introduction
Type of factor: Technological.
This has been an increasing trend in Africa, and is expected to continue in future.
Definitions
Poor condition of all systems in the water supply chain is found, *i.e. in* raw water abstraction, treatment facilities, storage facilities, distribution network.

Driving Forces
Poor maintenance, caused by political issues, mismanagement of funds, or by no funds being available in certain instances, are the main driving forces here.
Also a lack of capacity to properly maintain the assets.

General Implications
Poor service delivery, and shortage of water in extreme cases is a result of deteriorating infrastructure. In South Africa, studies have shown that a large percentage of rural water treatment plants do not comply with the required drinking water quality standards.

Implications for the water industry
Water supply authorities will not be able to ensure continued provision of acceptable quality water.

The consumers will have less confidence in the water supply authorities, and increased use of point-of-use systems and bottled water will prevail. This is currently the situation in South Africa. The problem is being addressed on a national scale.

Donors may become tired of continually having to fund solutions for Africa's many problems and shift from the donation of funds to market (investment and commercial) opportunity funding.

Adaptive Strategies
Asset management programs should be improved.
Also to receive high priority is capacity building in preventative maintenance programs and management thereof by the authorities, funding allocation on a priority basis, and providing capacity to improved project and financial management.

Conclusion
There is an increasing deterioration of water supply and sanitation infrastructure in sub-Saharan Africa, and it is expected to continue in future. The consumers have less confidence in the water supply authorities, and increased use of point-of-use systems and bottled water will prevail (mostly in urban areas).

3.4.10 Political Tensions over Water

Introduction
Type of factor: Political.
A culture of non-payment has resulted in poorer service delivery, which has become highly politicised in certain communities in southern Africa. Poor management of resources by the water service

providers has also resulted in poorer service delivery and dissatisfaction of consumers. The trend is expected to continue throughout Africa.

Definitions

Inherit tensions over equitable and adequate water provision for human, economic and ecosystem needs. In South Africa, free basic water (first 6000 L per household per month) and increased regulation of agricultural use of water.

Driving Forces

- Economic status of the country (poverty levels).
- Availability of raw water sources.
- Perceptions of consumers.

General Implications

- Poor service delivery (due to a number of reasons) is leading to loss of confidence in the authorities and the ruling party.
- Creation of polarisation between affluent and marginalised communities.

Implications for the water industry

- Increased perception of the value of water. Affluent consumers are generally prepared to pay more for better quality water.
- Improved water demand management methods needed.
- Intervention by central government to ensure better service delivery and regain the confidence of consumers in (especially) problems areas.
- Partisan political interests prevent regional collaboration between countries, while party politics within many countries use access to water to force political support.

Adaptive Strategies

- Increasing need for science and technology to provide relevant technical input to help inform decision-making.

Conclusion

A culture of non-payment has resulted in poorer service delivery, which has become highly politicised in certain communities in South Africa. Poor management of resources by the water service providers has also resulted in poorer service delivery and dissatisfaction of consumers. The trend is expected to continue throughout southern Africa.

3.5. Conclusions

The main conclusions from the matrix of factors, strategic sessions and desk study on future drinking water supply in sub-Saharan Africa are summarised below.

3.5.1 Social

There will be an increased drive to supply remaining people without water, including an increased drive to provide remaining Free Basic Water (no charge). In general there will be a greater accent on affordability, where the people and their needs will become more important.

3.5.2 Economical

Sub-Saharan Africa remains very poor and there will be greater pressure to produce and supply more affordable water. The high population growth and urbanisation trend will put increased pressure on improved water demand management – also on household level. Greater emphasis will be on low running cost technology (people pay the running costs), and integrated with this will be pressure to produce and utilise renewable energy sources at a lower cost.

3.5.3 Political

More political pressure will be exerted to develop and exploit alternative water and energy sources. The impact of global warming will be substantial, leading to water shortages in certain areas and flooding in other areas. The quality of the drinking water for the immune deficient and vulnerable will become important. The skills shortage on the sub-continent will continue.

3.5.4 Technological

Membranes are becoming increasingly important in light of increased pollution, and renewable energy technologies will be required. Improved and economical water harvesting methods will also be required.
There will be higher demands on treatment plants for removal of increased levels and variety of chemicals and microbiological contaminants (including the increasing NOM levels in surface waters). Consequently, newer bio-technologies will play an increasing role in the water sector.

Nanotechnology will take off on large scale and this will present enormous opportunities in the water field. High development costs will further force adaptation of international technologies to South African conditions.

Continued skills shortage will increase automation and telemetric-control of plants.

3.5.5 Environmental

Droughts are becoming more of a problem as water resources become overused and global warming starts to have an effect. Pollution of water resources will become worse as resources become overused. Anthropogenic chemicals in the environment will become more of an issue (EDCs, drugs, beauty care products, industrial chemicals). Management of water-related wastes will become a bigger issue.

The most important key factors (driving forces) that will affect South Africa and sub-Saharan Africa are:

- High population growth
- Urbanisation
- Climate change (severe droughts; floods)
- Poor global economy
- Life-style changes
- Impact of HIV / AIDS
- International scientific cooperation
- Influence of Eastern Asia
- Poverty in rural areas
- Surface water shortages
- Water stress

These factors comprise the ***external factors*** impacting on rural water supply that will be considered in the development of the planning framework.

CHAPTER 4
DEVELOPMENT OF ADAPTIVE STRATEGIES TO ADDRESS THE CHALLENGES OF FUTURE RURAL WATER TREATMENT IN SOUTH AFRICA

In this chapter, possible adaptive strategies are considered for each of the key factors (internal and external) that were identified in Chapter 3.

4.1 Development of adaptive strategies

The adaptive strategies that were developed for the main driving forces (key factors) are provided below:

4.1.1. Population Growth

The high population growth in sub-Saharan Africa will place enormous pressure on the existing water sources, especially in those countries already experiencing water stress. There will also be a greater demand on food from available sources, for which more water is required. The high population increase will also result in sanitation backlogs and pollution of water sources.

The international community will play a major role in supplying these technologies, of which Europe and China is expected to play leading roles. Innovative systems will be required.

Adaptive strategies:

Effective water demand management will be critical. Innovative solutions for exploitation of alternative water resources and treatment technologies (to enhance existing systems) will be required. Additional water treatment technologies to produce water complying with health requirements, and alternative water resources will have to be exploited, such as groundwater exploitation, water reclamation and reuse, rainwater harvesting, desalination of seawater and brackish water.

4.1.2. Urbanisation

A major migration from rural areas where unemployment is extremely high and resources are few, to the large cities in an attempt to find jobs and have more access to amenities is taking place in South Africa, and will continue to do so.

There will be a strain on existing infrastructure, and international funding will be necessary to try to alleviate the backlogs. More advanced technologies (*e.g.* membranes and advanced oxidation) will also be required to treat the poorer raw water quality. There will be more emphasis on urban water supply in research and development programmes in Africa.

Adaptive strategies:

Use of alternative water resources, such as water reclamation and reuse; seawater desalination in coastal cities; reducing water losses by better water demand management; upliftment programmes and development in rural areas in an attempt to counter the urbanisation trend.

4.1.3. Degradation of Source Water Quality

There is an increasing decline in water quality of raw water sources in African and developing countries. It will lead to increasingly difficulties to produce drinking water that complies with basic health standards, resulting in potentially more incidences of outbreak of water-borne diseases.

The gradual increase in organic content (NOM) of surface waters will lead to expedited research in treatment technologies that can reduce these compounds cost-effectively, and that will be sustainable over the long term.

Adaptive strategies:

Better source protection; major effort to reach MDGs, thereby improving sanitation services and reducing pollution of water resources; development of cost-effective sustainable treatment systems and technologies applicable to Africa conditions and that of developing countries. Major programmes to improve operation and maintenance of both new and existing technologies. Assessment of steps and processes needed to improve measurement processes, monitoring, database development and data analysis.

4.1.4. Climate Change: Water Resource Quantity (Water Stress)

There is an increasing incidence of extreme weather conditions in southern Africa where major floods were experienced recently after spells of severe droughts in certain areas (in some instances in the same regions, *e.g.* the Western Cape province in South Africa). There is general consensus that the impact of global climate change will continue for the foreseeable future (at least until 2050), and that it will have definite impact on sub-Saharan Africa (Midgley *et al.,* 2005).

There has been a significant increase in marketing of desalination technologies in the sub-continent, notably in South Africa. New competitors are entering the market.

Adaptive strategies:

More emphasis will be required on the use of alternative water sources such as desalination, water reclamation and reuse, rainwater harvesting. Also flood protection to protect water treatment plants against possible damage during flooding, thereby ensuring uninterrupted water supply and acceptable drinking water quality.

4.1.5. Life-style Choices (Point-of-use Systems and Bottled Water)

The use of point-of-use water treatment devices and bottled water is expected to continue in urban areas; but in rural areas and developing countries the use of POU systems and bottled water will not generally be affordable. A wide variety of point-of-use water treatment devices have appeared on the market in South Africa (and some other African countries), and there are very strong marketing drives. The water suppliers will need to ensure that water of high quality is not only produced at the treatment plant, but actually delivered at the tap at households (*i.e.* much more focus should be placed on eradicating the deterioration of water quality that takes place in the distribution systems).

Adaptive strategies:

Improve communication with consumers. Improve quality control through effective operation and monitoring, especially in the rural areas where this is generally lacking.

4.1.6. Increasing Cost of Energy

The cost of energy has been increasing only gradually, but is expected to increase much more significantly in future. Energy costs have been relatively low in South Africa compared to other countries. Emphasis will need to be placed on energy efficient water treatment technologies, or on development of alternative (renewable) energy technologies which will ensure affordable and sustainable treatment systems for developing countries with limited sources.

Adaptive strategies:

Develop water treatment technologies that are energy efficient. Develop renewable energy resources that could be used in combination with small-scale water treatment technologies for rural and remote areas (decentralisation).

4.1.7. Better Access to Communication Technology and Information

More sophisticated treatment technologies and accompanying control systems will be within reach of the rural and remote communities (as evidenced by the widespread use of cellular telephones world-wide).

Adaptive strategies:
Supply treatment technologies to rural and remote areas in Africa that can be controlled remotely via telemetry and communication technology, which should ensure improved sustainability of these systems through rapid corrective action during plant upsets.

4.1.8. Increase in Water-borne Diseases

In sub-Saharan Africa, there is an increase in poorer quality of life (generally) due to illness and deaths associated with/caused by the water-borne diseases. This includes increased mortality, especially amongst infants.

Adaptive strategies:
There should be increased environmental awareness. Water source protection should be high priority. Development/application of technologies that can prevent pathogens, parasites, etc. occurring in the treated water, i.e. the use of barrier treatment systems such as membranes.

4.1.9. Degradation of Infrastructure

There is an increasing deterioration of water supply and sanitation infrastructure in sub-Saharan Africa, and it is expected to continue in future. The consumers have less confidence in the water supply authorities, and increased use of point-of-use systems and bottled water will prevail (mostly in urban areas).

Adaptive strategies:
Asset management programs should be improved. Also to receive high priority is capacity building in preventative maintenance programs and management thereof by the authorities, funding allocation on a priority basis, and providing capacity to improved project and financial management.

4.1.10. Political Tensions over Water

A culture of non-payment has resulted in poorer service delivery, which has become highly politicised in certain communities in South Africa. Poor management of resources by the water service providers has also resulted in poorer service delivery and dissatisfaction of consumers. The trend is expected to continue throughout southern Africa.

Adaptive strategies:
Increasing need for science and technology to provide relevant technical input to help inform decision-making.

4.2 Listing of potential options and strategies

From the adaptive strategies discussed above, as well as a consideration of possible remedial and intervention options, a list of possible options and strategies that may be considered in the strive towards sustainable rural water treatment, were compiled, and are listed below:

- Decentralised water sector regulation
- More effective water demand management
- Exploration of alternative water resources
- Improved operation and maintenance (training)
- Improved maintenance systems
- Enhanced and accelerated capacity building
- Develop new purpose-built water treatment technologies
- Groundwater exploitation
- Water reclamation and reuse
- Harvesting of rainwater
- Desalination (seawater and/or brackish water)

- Upliftment programmes in rural areas
- Better source protection
- Major effort to reach MDGs
- Development of appropriate water technologies for rural areas
- Development and application of operational management tools
- Flood protection to protect water treatment plants
- Improve quality management in rural areas
- Improved communication with consumers
- Develop more energy efficient water treatment technologies
- Decentralised treatment systems
- Automation and remote control via telemetry
- Use of membrane systems to provide barrier treatment
- Application of asset management programmes in rural areas
- Improved maintenance programs applicable for rural areas
- Improved funding systems and financial management
- Improved project management
- Strategic planning for rural water projects

4.3 Main strategies to test and validate for this project

The following five main strategies were selected for further investigation and testing in this project. These strategies contain a number of the above listed options which are integrated into the strategies below:

- Decentralised water sector regulation
- Decentralised rural water supply and treatment systems (small scale systems and point-of-use (POU) systems)
- Improved operation and maintenance (e.g. through outsourcing)
- Development of application of appropriate water treatment technologies for rural areas (high-tech [membrane systems])
- Enhanced and accelerated capacity building

CHAPTER 5
DEVELOPMENT OF A KNOWLEDGE-BASED PLANNING FRAMEWORK

5.1 Introduction

In mapping the current rural water treatment situation in South Africa and identifying the driving factors that have an influence on the rural water supply, both now but especially in the future, it soon became apparent that these factors and their impacts or potential impacts form a complex situation. This is compounded by the inter-relationships between these factors. Adding to this the adaptive strategies that were identified and considered for possible application to provide solutions for eradicating or minimising the negative impacts, it creates a multi-factor situation that is difficult to analyze by manual methods or simple models. It is therefore necessary to apply more sophisticated software to analyze the situation and present the iterations and outputs visually, to facilitate the drawing of conclusions, and to use it as a tool for presentations to key stakeholders (the Department of Water Affairs and Forestry (DWAF), Development Bank of Southern Africa (DBSA) and the Water Research Commission (WRC) in this instance). This confirms the perceived need for such software during the planning stages of this project.

In the project proposal, it was indicated that the Think Tools decision support system would be used, as this was the software that would fulfil such requirements and was used and supported by the Centre for Knowledge Dynamics and Decision-making of the University of Stellenbosch (US). However, since then the software program has changed ownership and also its name, and is now called Parmenides EIDOS, or just EIDOS for short. The DWAF and the DBSA are license-holders of the software, and the US Centre of Knowledge Dynamics and Decision-making still supports the software and its use by students, researchers and clients.

The EIDOS program was thus used in developing the planning framework for rural water treatment as product of this consultancy research project.

The methodology for the overall development of the planning framework is described in section 5.2 below, indicating the various steps that were followed.

5.2 Methodology for development of the Planning Framework

The following steps were followed in developing the framework:

a. Map the current situation in South with regard to rural water supply in general and rural water treatment in particular. This consisted of an assessment of the problems and challenges with respect to rural water supply options, resources and water treatment technologies.

b. Based on the mapping of the present situation, identify all the driving forces that will have an impact on future drinking water supply in rural South Africa.

c. With the driving factors known, a so-called SEPTEDOR analysis (*i.e.* ***S***ocio-cultural, **E**conomic, **P**olitical, **T**echnological, **E**cological, **D**emographic, **O**rganisational, **R**isk factors) was undertaken to predict possible future water supply scenarios and drinking water supply problems in South Africa. This led to the identification of possible adaptive strategies that could be used to minimise the negative impact of the driving forces in future.

d. Develop the Knowledge-based Planning Framework, using the EIDOS software.

5.3 Applying the EIDOS Decision Support Software

The Parmenides EIDOS decision support software was used in developing the framework. The software is used by the Centre for Knowledge Dynamics and Decision-making of the University of Stellenbosch, mainly in their post-graduate and research programmes, but they also provide training and support for the use of the software by clients. As DWAF is a license holder of the software, it was possible to arrange for this training and support for application of the software for this project.

The steps in applying the EIDOS program consist of:

- **Decision architecture: mapping the reasoning process**
- **Goals Assessment**
- ***Situation Analysis***
  - Internal factors
  - External factors
- **Option Development**
  - Internal Scenario
  - External Scenario
  - Strategy Options
  - Combined Strategy with Scenarios
- **Option Evaluation**
  - Strategy Evaluation
- **Planning Framework**

5.3.1 Decision architecture: mapping the reasoning process

Developing the decision architecture consists of a mapping of the reasoning process to be followed when using the program. It allows visualisation of the overall task flow for the process.

The overall process or task flow is as follows:

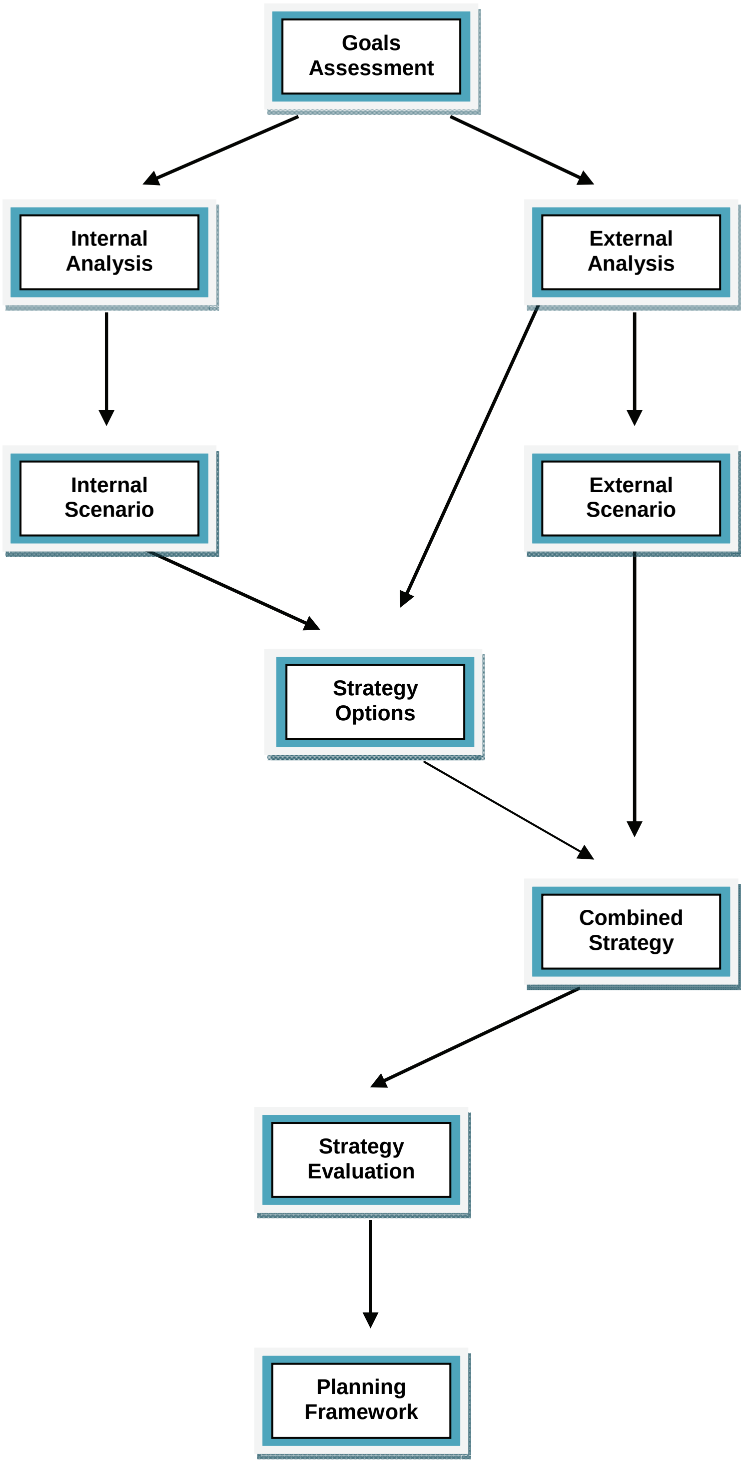


Figure 5.1: Decision architecture: overall process flow diagram

5.3.2 Goals Assessment

The process consists firstly of assessing the goals for rural water treatment in South Africa. In settling these goals, three time frames ("views") were considered, viz. 1 year (2010), 3 years (2012) and 10 years (2019). The following goals and sub-goals were set for developing the rural water framework:

a. Institutional capacity

- national level
- local level

b. Skilled and qualified human resources

- technical
- management

c. Social acceptance

- affordable
- community participation

d. Safe drinking water

e. Cost-effective

- capital cost
- operating cost

f. Appropriate technologies

- energy efficient
- easy to operate and maintain

g. National plans for sustainable rural water supply

For each of the goals and sub-goals, relevance values were then allocated for each of the three time frames. These relevance values weigh the importance of each of the goals with each other.

The goals (also referred to as criteria) are then used later in the program to evaluate the chosen strategies and establishing how they will fulfil each of the goals that were set.

5.3.3 Situation Analysis

The situation analysis helps to identify all the problems in the situation (in this case rural water supply), all the factors that make up and contribute to the problem, hence understand the nature of the problems and the relationships between the factors. This allows grouping of the factors into important factors and less important factors.

For rural water supply in general, a magnitude of factors have been identified that could affect the sustainability of the supply. Webster (1999) drew up a diagram showing some of the factors applicable in South Africa (see Figure 2.1).

The situation analysis makes a distinction between internal factors (those over which the local water sector have some measure of control, albeit indirectly in certain instances), and external factors (those determined by forces over which the policy makers have little or no control over, and which are mostly on a global scale).

5.3.3.1. Situation Analysis: Internal factors

In this project, an investigation of current rural water treatment (supply) practices identified the following aspects as having the most influence on efficiency and sustainability of rural water supply:

- Effect of water-borne diseases
- Shortage of skilled personnel
- Availability of training service providers
- Lack of proper operation and maintenance
- Deteriorating infrastructure
- Deterioration of raw water quality
- National and local level policies and planning
- Legislation
- Management level incompetency
- Poor image of municipal water sector
- Lack of funds / mismanagement of funds
- Political interference
- Management level motivation
- Rising cost of energy
- Availability of energy
- Pollution of water sources
- Failing wastewater treatment plants
- Sanitation backlog
- Availability of raw water sources
- Public perceptions and social acceptance

The relationships between these factors were subsequently considered and indicated by linking arrows, the thickness of the line indicating the strength of the relationship, and the colour of the arrow indicating whether it is a positive relationship (blue) or a negative relationship (red).

The internal factors and their inter-relationships are shown in Figure 5.2.

5.3.3.2. Situation Analysis: External factors

The external factors that were considered as having a significant impact on rural water supply in South Africa are the following:

- High population growth
- Urbanisation
- Climate change (severe droughts; floods)
- Poor global economy
- Life-style changes
- Impact of HIV / AIDS
- International scientific cooperation
- Influence of Eastern Asia
- Poverty in rural areas
- Surface water shortages
- Water stress

The internal factors and their inter-relationships are shown in Figure 5.3.

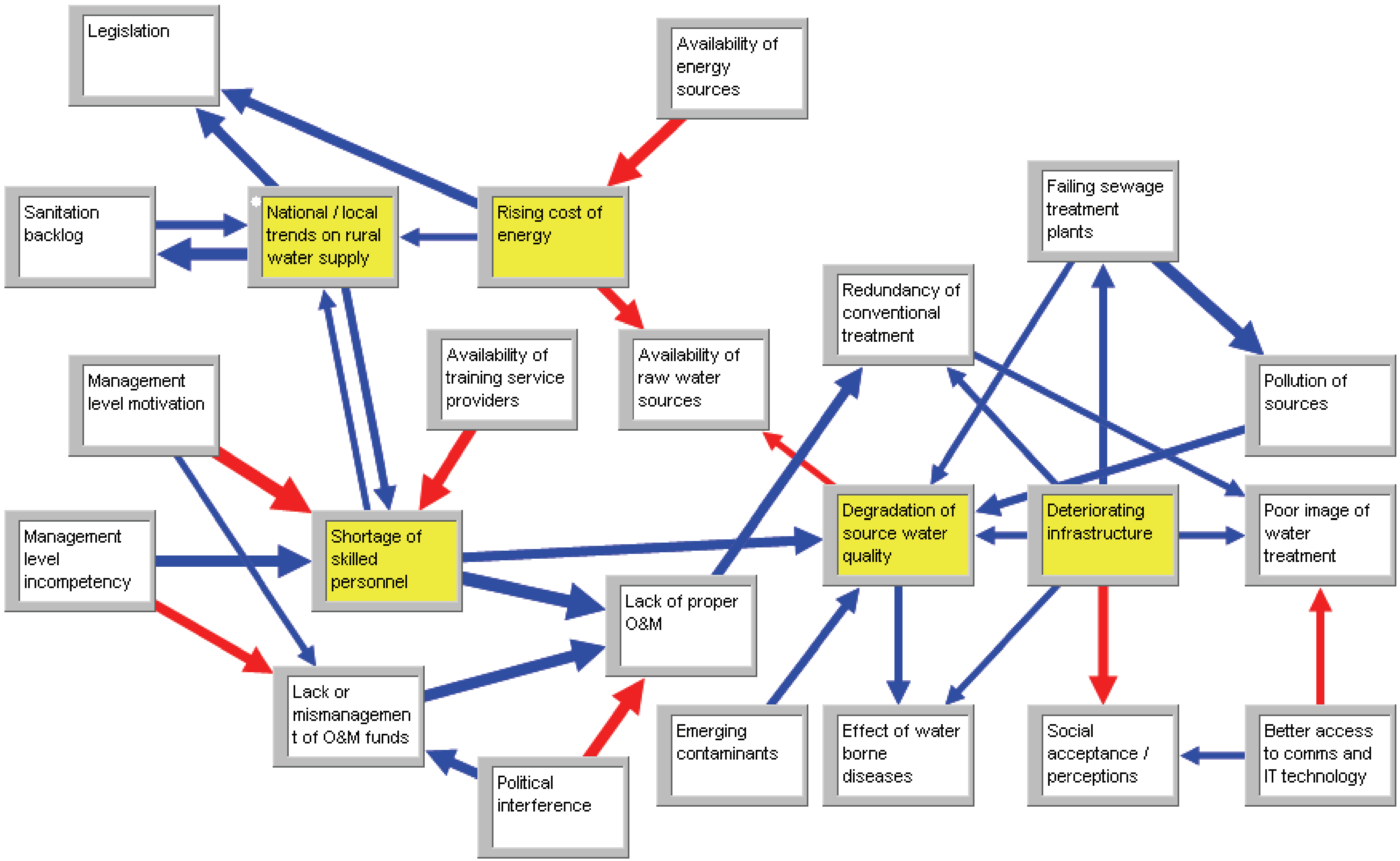


Figure 5.2: Internal factors

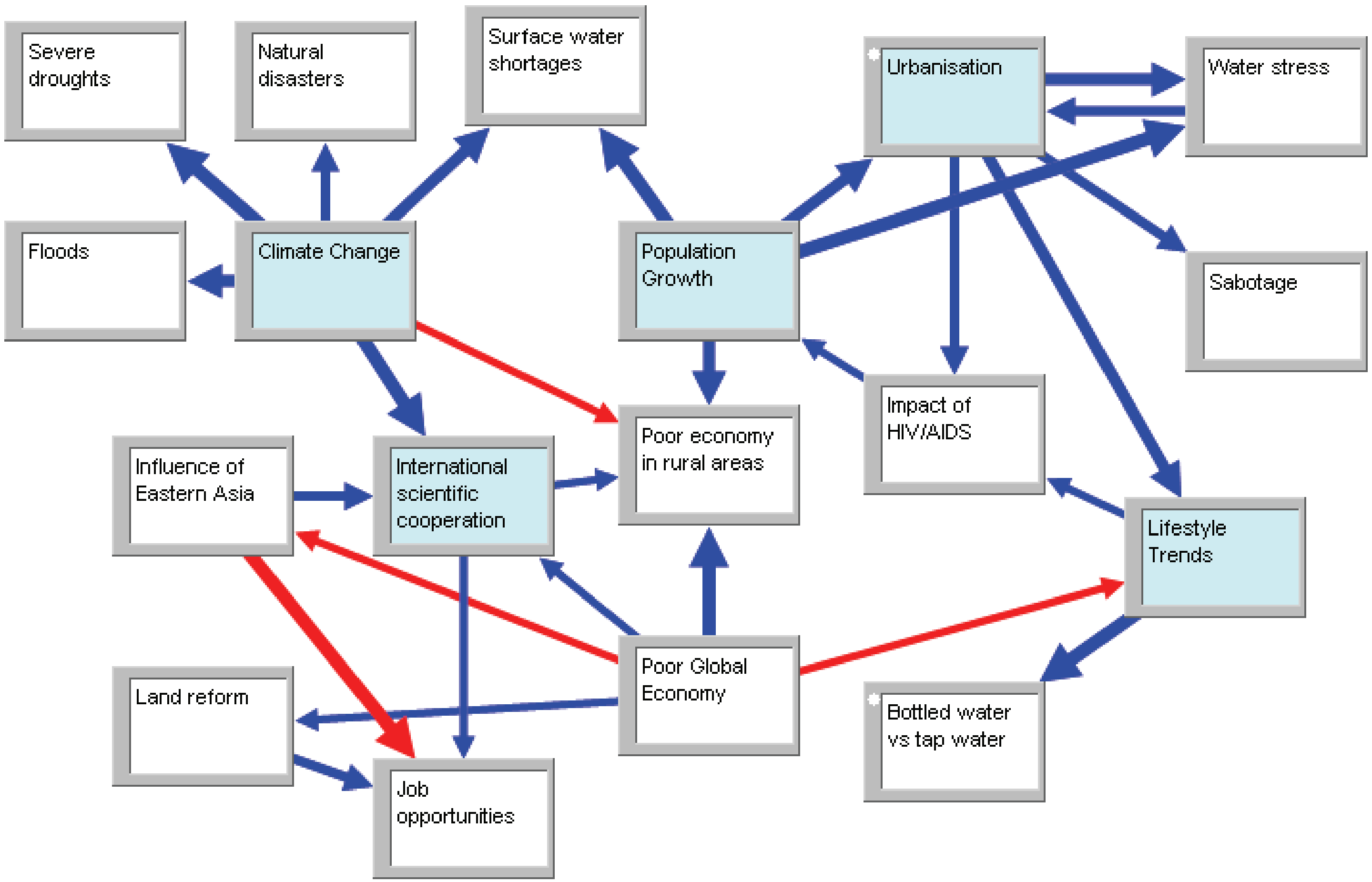


Figure 5.3: External factors

5.3.4 Option Development

From the analysis of relationships between the internal and external factors, the five most important factors in each case were identified. These are the factors indicated by yellow in the internal factor situation analysis diagram, and in blue in the external factor situation analysis diagram.

These most important factors (or key factors) in each case were then used to develop alternative options that could be possible, both now and in the future. It therefore constituted a scenario analysis, which was done separately for the internal factors (the internal scenario) and for the external factors (the external scenario). The key factors formed the dimensions of the options space, and possible alternatives (options) were identified for each of these (two to four alternatives in each case). To rate consistency of alternatives in the option space, a Consistency Matrix was used. Consistency measures the logical fit of two alternatives. A higher consistency level indicates better coexistence of the two alternatives. A lower consistency rating indicates a greater degree of friction between the alternatives.

After completing the consistency ratings, the option space is then calculated to generate strategies or scenarios. Option Development computes all possible strategies and lists the top 100 strategies or scenarios, sorted by the consistency value.

The scenarios for the internal and external factors are provided below. From the internal and external analyses and scenarios, strategies were then compiled for rural water treatment in South Africa, and mapped as strategy options. Consistency ratings are once again done, followed by a calculation. In this case three different scenarios were considered (see strategy evaluation).

The last step in the option development was then to test the robustness of the chosen strategy with the scenario's that were considered, to what would be the best strategies overall, within the constraints of the scenario's. The results of this combined strategy/scenario option development are also provided below under Options Development: Combined Strategy/Scenarios.

5.3.4.1. Options Development: Internal Scenario

In considering the possible internal scenarios for the water sector over the next decade (Figure 5.4), the following main challenges were evaluated:

- Choice of water supply arrangement (centralised versus decentralised)

The different options considered were:

- Centralised water supply, *i.e.* bulk water supply where the water is supplied via long pipelines from a large water treatment plant to all the rural water communities and villages in the bulk supply scheme
- Decentralised water supply, where every rural community or village have their own water treatment system (small-scale system, SSS)
- Decentralised treatment, including extensive use of home treatment devices (point-of-use systems, POU)

- Shortage of skilled personnel

Possible scenarios considered were:

- A slow increase in the number of skilled personnel at rural water treatment plants (*i.e.* skills development produces lower than expected results)
- Rapid increase in numbers of skilled personnel, *i.e.* sufficient numbers of skilled personnel are produced to meet the demand in the short term (2 – 3 years)
- Decline in numbers of skilled personnel. Although considerable resources are invested in improving skills levels in the rural water sector, there is a decline in the number of skilled personnel

at rural treatment plants due to already skilled staff leaving for better salaries, benefits and working conditions in the large towns, cities and metropoles.

- Degradation of source water quality
- There is further degradation in the quality of water sources, and technology is not available or affordable to remove new pollutants in the water
- The status quo is maintained, *i.e.* there is no improvement in the quality of water sources
- There is gradual improvement in the quality of the sources, and there are also sufficient technologies available to treat the water to potable standard

- Deteriorating infrastructure

In these possible scenarios:

- There are major failures of infrastructure, with catastrophic results
- The existing infrastructure is kept in a functioning condition, but there is no improvement in the overall condition
- Large-scale programs are undertaken to improve the infrastructure

- Rising cost of energy
- Energy costs continue to increase substantially
- Cost increase stabilises, and it is more or less fixed to inflation rates
- Through fast-tracking the development of alternative energy sources (largely renewable energy), it has been possible to reduce the cost of energy

5.3.4.2. Options Development: External Scenario

For the external scenarios (Figure 5.5), the following main scenarios and options were considered:

- Climate change
- The impact of climate change on water supply over the next decade will largely follow the patterns as currently predicted, indicating occurrence of droughts and floods in certain affected areas
- The effect of climate change will be significantly more severe than predicted, and leads to major catastrophes
- The impact of climate change is reducing, and it can largely be managed by applying adaptive strategies

- Population growth
- A very high population growth of more than 2% takes place, largely the result of influx of refugees from other African countries to South Africa
- Moderate population growth (around 2%)
- Low population growth (< 1%), caused by HIV/Aids and other diseases

- Urbanisation
- There is an increased influx of people to the metropoles, caused by the economic downturn and recession
- The current rate of urbanisation is maintained, with poverty in rural areas being the main driving factor
- There is a decrease in the rate of urbanisation or even an outflow of people from the cities back to the rural areas. Government incentives for developmental projects and economic growth in rural areas are the main driving factors

- Lifestyle trends
- High bottled water consumption. It is becoming increasingly fashionable to drink bottled water, while media publicity on the quality of municipal water in rural areas result in more use of bottled water in preference to tap water

- Renewed use of tap water as a result of public image programmes by DWAF, municipalities and WSPs in general

- International scientific cooperation
- International scientific cooperation is reducing as a result of European Union, American and other policies toward cooperation with Africa
- International scientific cooperation maintains the status quo, with globalisation offering many new cooperation agreements
- Due to strong international competition, there is a significant increase in international scientific cooperation, and this impacts positively on the rural water supply sector

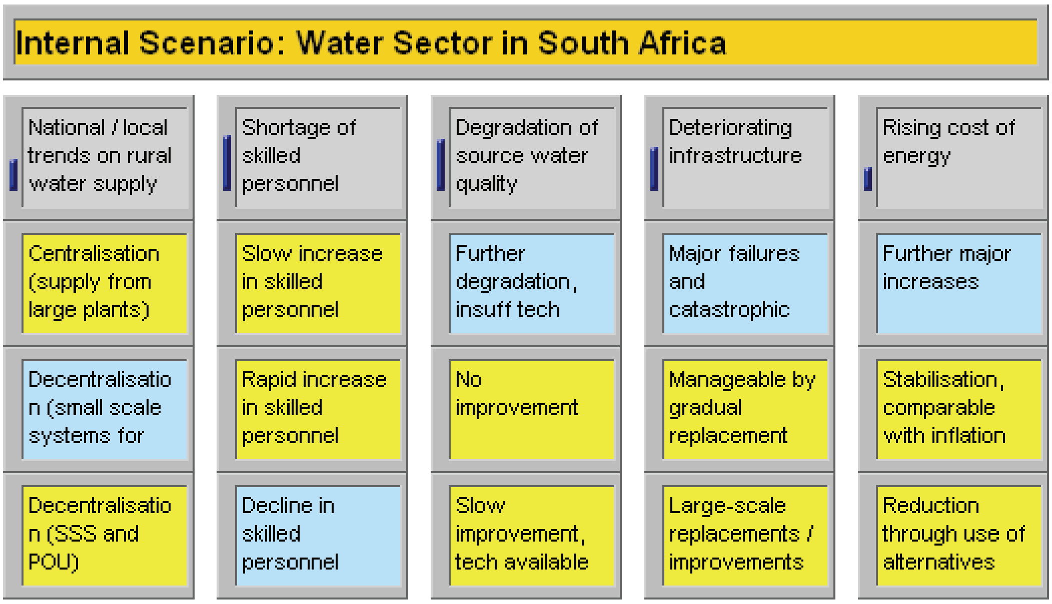


Figure 5.4: Internal scenario for the water sector in South Africa

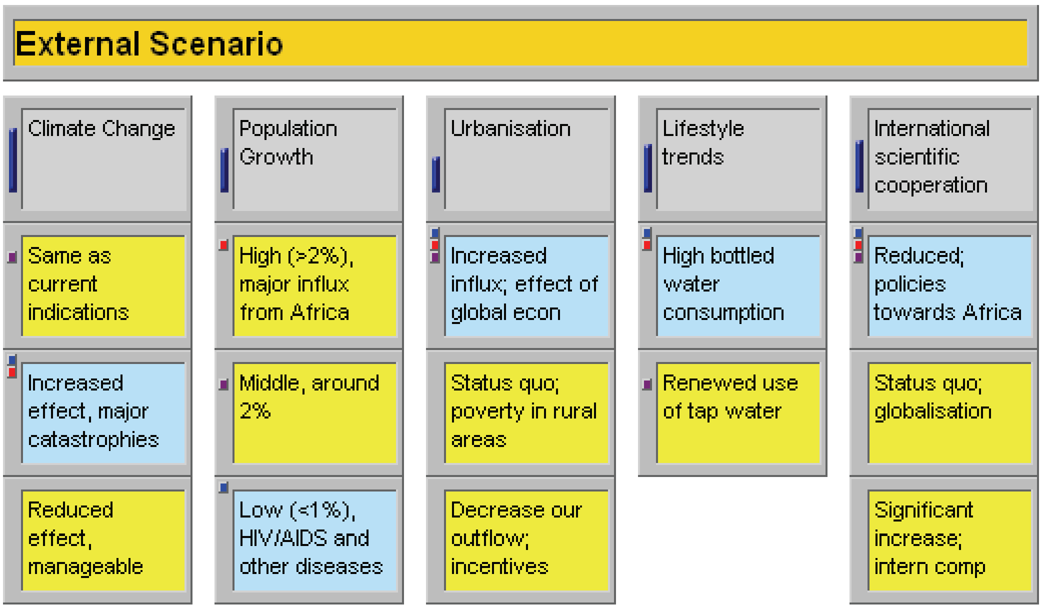


Figure 5.5: External scenario for the water sector in South Africa

5.3.4.3. Options Development: Strategy Options

The main consideration, apart from decentralisation versus centralisation, is capacity building, as part of the strategic option development. For this reason, the dire needs regarding training and capacity building in rural water supply are discussed below.

Capacity Building

Formal training
There is a need for qualified process controllers, on both NQF2 and NQF4 level. More specifically, there is a need to re-introduce technical qualifications at Technical Colleges (the previous N1 and N2 Certificates in Water Care). TechniSA is not offering these courses anymore (correspondence courses).

On NQF5 level, Tshwane University of Technology (TUT) is the only institution in the country presenting diploma and BTech qualifications in Water Care. This presents logistical problems for potential learners (travelling and accommodation costs). There is a need to address this on two levels, *viz.*

- block week system
- full-time (6 months theoretical classes; 6 months practical training)

The latter is the preferred option.

Skills Development Training through Learnerships
This new training concept was introduced in an attempt to allow workers at water care plants to have the opportunity to gain recognition for their skills obtained through years of experience performing certain tasks without having had any form of formal (or even in-house) training. The Learnership Training was aimed at allowing these workers to do the practical training at their own treatment plants and at their own pace. However, feedback on the success of this training has not always been all that positive, with complaints relating to slow progress, learners still not understanding many of the important underlying principles of water treatment processes, operational staffing problems with planning shift work schedules, and inadequate training skills of some of the training personnel.

Mentorship Programmes
Because of the lack of formal training programmes for process controllers and the inadequacies of learnership training, a number of the larger water utilities (WSAs or WSPs), such as water boards (*e.g.* Umgeni Water, Overberg Water, Amatola Water) and metropolitan municipalities (*e.g.* Cape Town), have started to do their own in-house mentorship training. This is done as 9-month training programmes where mentors are appointed for identified operators or recruited personnel (showing potential for appointment as process controllers). These mentors then provide theoretical training in the basics of water treatment processes, operational procedures and safety aspects, which is then followed by practical training on the treatment plant and in the laboratory. The identified learners on these mentorship programmes (mentees) are also rotated to other treatment plants of the WSP to gain as wide as possible experience on different treatment systems. This type of training has provided an improvement in skills levels and also the filling of vacant posts; however, the shortcoming is that no credits are obtained by the mentees which could be used towards obtaining formal qualifications.

It appears (from feedback by municipalities and water boards) that a combination of formal training and mentorship training are likely to produce the best strategic results both in the short and long term, for producing sufficient numbers of well-qualified and competent process controllers for the water sector in the country.

In rural water treatment plants, capacity building presents more challenges than at the larger treatment plants. At smaller plants there may be only one or two operators, and taking them away from their daily operational tasks at the treatment plant may result in serious problems for the municipality. In some instances, the operators at small water treatment plants do not have the learning potential to be trained as process controllers. A further problem is that small municipalities may invest substantial resources to train process controllers or supervisors, only to see them leave for larger municipalities with more attractive salaries and benefits (including better working conditions) soon after they have qualified.

During recent studies into problems experienced at small water treatment plants, it became evident that the lack of capacity not only lies at plant level (process controllers and operators), but also, and to a larger extent, at management level (plant managers and supervisors). Providing training for managers and supervisors on management of water treatment plants and water supply is equally important as process controller training.

There is hence a need for training for supervisors/managers at NQF5 level, and the best way to enable this is through a series of relevant accredited short courses.

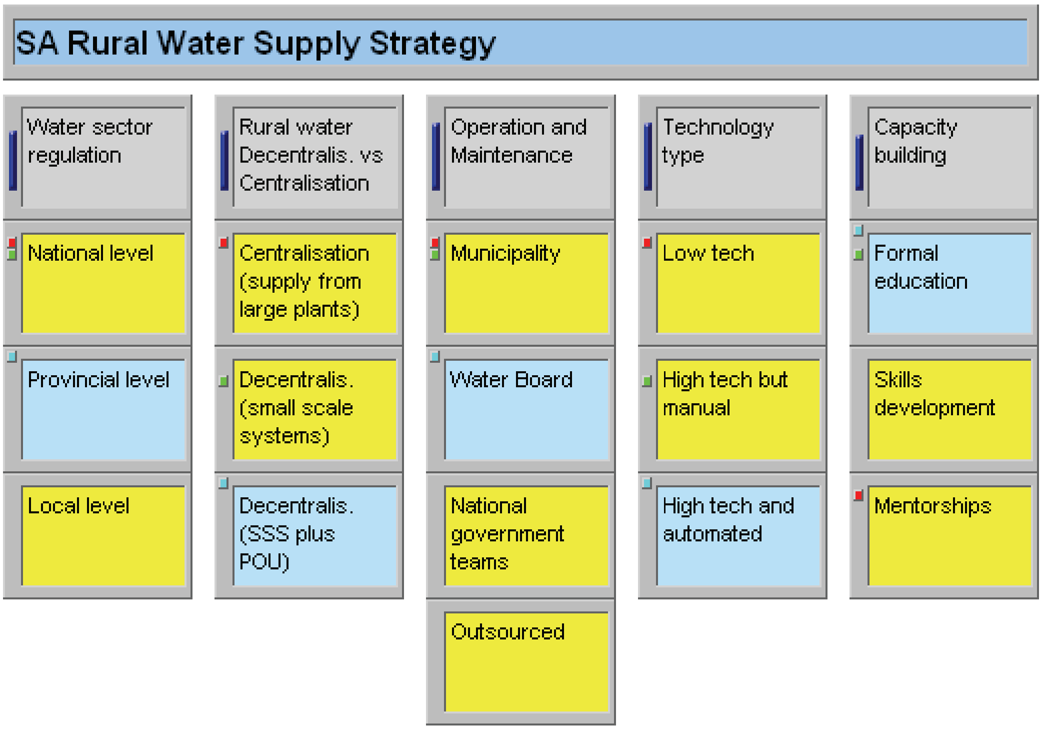


Figure 5.6: South African rural water supply strategy

<u>5.3.4.4. Options Development: Combined Strategy/Scenarios</u>

Scenarios are displayed in Figures 5.7 to 5.8 below.

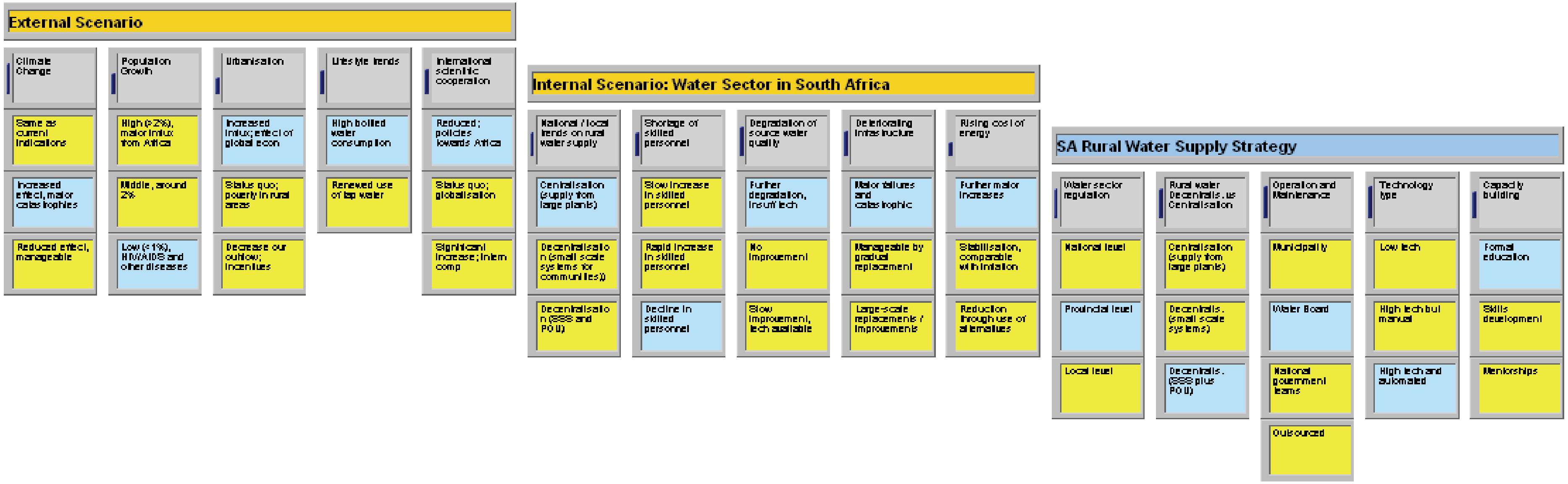


Figure 5.7: Combined strategies and scenarios

The strategy results in the right hand of the option space are enlarged in Figure 5.8.

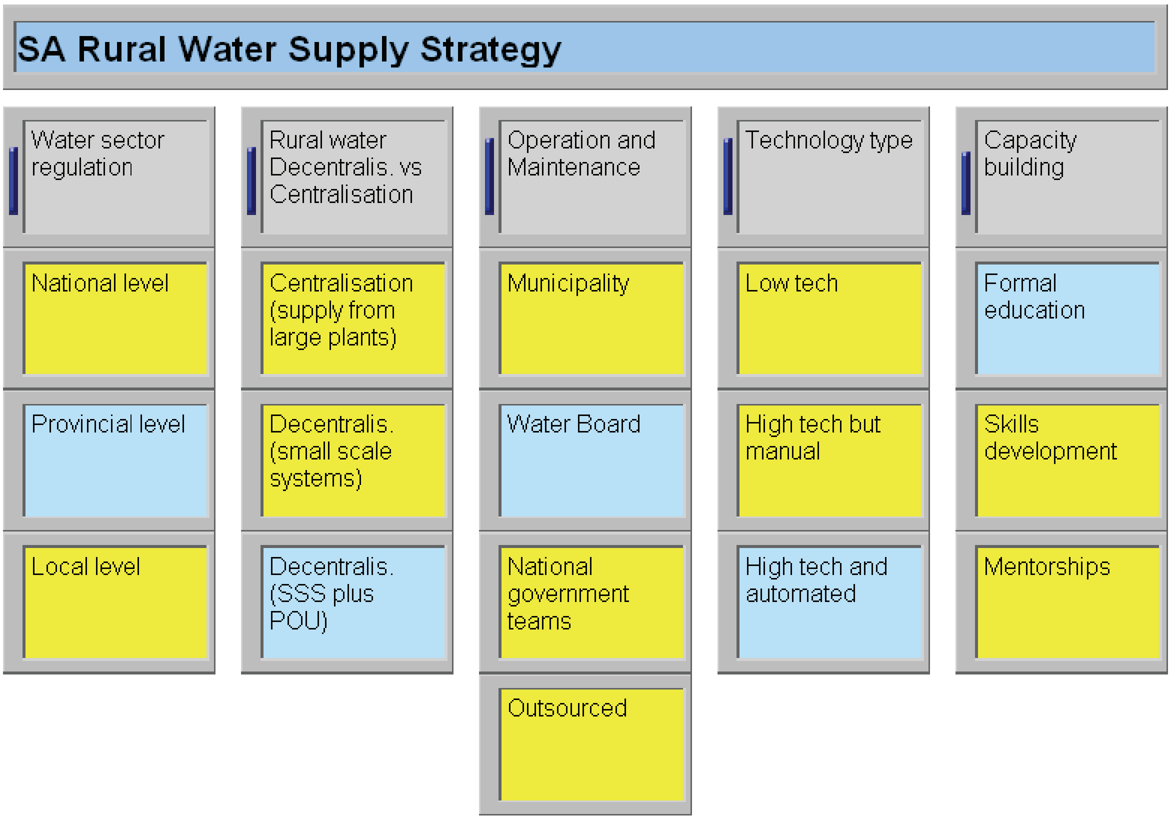


Figure 5.8: The South African rural water supply strategy

5.3.5 Option Evaluation: Strategy Evaluation

The Option Evaluation step uses weighted criteria to evaluate strategy options in multiple views. The step generates rankings and represents them visually, leading to a more thorough comparison and improved decision-making.

The weighted criteria that are used are the goals that were set in the beginning of the process. The relative importance between the seven goals that were set, and over the different time scales considered in development of the framework (*i.e*. 1 year, 3 years and 10 years), is now set as weights in this tool, which is then used in the calculation of the performance of each of the strategies that were considered.

Three strategies were evaluated as an example in this project (in using the planning framework for planning purposes in the water sector many other strategies can also be evaluated) are the following:

<u>5.3.5.1. Centralised Water Supply</u>

In this strategy, the population is supplied with drinking water from large, centralised water treatment plants. The treated water is piped to all the communities in the geographical area served by the treatment plant, thus requiring an extensive pipe network, so as to reach even the most remote communities. The treatment plants could be managed and operated by the larger municipalities or, more likely, by the Water Boards in that region. Generally, these plants should be well managed and operated effectively due to availability of sufficient O&M funds and qualified human resources.

5.3.5.2. Decentralised Water Supply, using Small Scale Systems

Here the rural communities will each have their own small scale water treatment that will supply that community with drinking water. The plants will generally be small scale plants and can be managed and operated by the local authority in that area (municipality) or, again, the Water Board, or it can be outsourced to a private company. The treatment plant personnel should ideally come from within the community, which will ensure community participation and ownership. This could be under supervision or mentorship from the municipality or Water Board, who will provide thorough training to the plant process controllers. The treatment systems could be either high-tech (e.g. membranes) or low-tech (e.g. slow sand filtration), and could be package plants or systems built by the communities themselves.

5.3.5.3. Decentralised Water Supply, using mainly household-scale systems (Point-of-Use or POU systems)

In this strategy, communities are capacitated to make large scale use of household-scale water treatment systems or devices. These devices are also referred to as point-of-use water treatment systems (POU). It comprises technologies or devices that can supply enough safe drinking water for a single or up to three households. Examples of POU systems are boiling water systems, solar water disinfection, chemical disinfection systems, UV disinfection, media filtration (slow sand, gravity rapid sand), which sometimes includes activated carbon filtration), and a range of household membrane filtration systems (microfiltration, ultrafiltration and reverse osmosis).

The relative extent of water supply and sizes of applicable treatment systems for each of the three strategies are shown in the diagram below (Techneau, 2008).

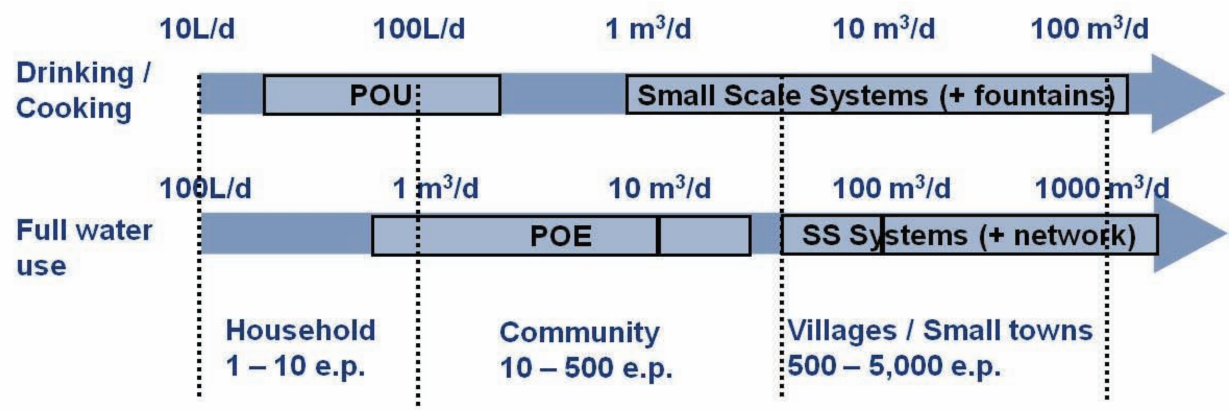


Figure 5.9: Internal scenario for the water sector in South Africa

Each of the three strategies were then rated against the goals that were set for sustainable rural water supply and treatment (see 5.3.2), for each of the three time frames, and a point allocated from -10 to +10. For example, how well does the "Centralised Water Supply" strategy perform in the "Three Year (2012)" time frame with respect to the goal "Safe Drinking Water"? The ratings are shown in Figure 5.10.

In performing the ratings, the experience of the author gained in performing WRC funded research projects on small water treatments systems (Swartz, 2000; Swartz and Ralo, 2004; Swartz *et al.,* 2007), attendance and inputs at the Windhoek Workshop (Swartz, 2006) as well as the Techneau project (Swartz and Offringa, 2006; Techneau, 2007) provided the main input, together with the policies of DWAF and personal discussions with members of the project team (Habib, 2007; Thompson, 2007).

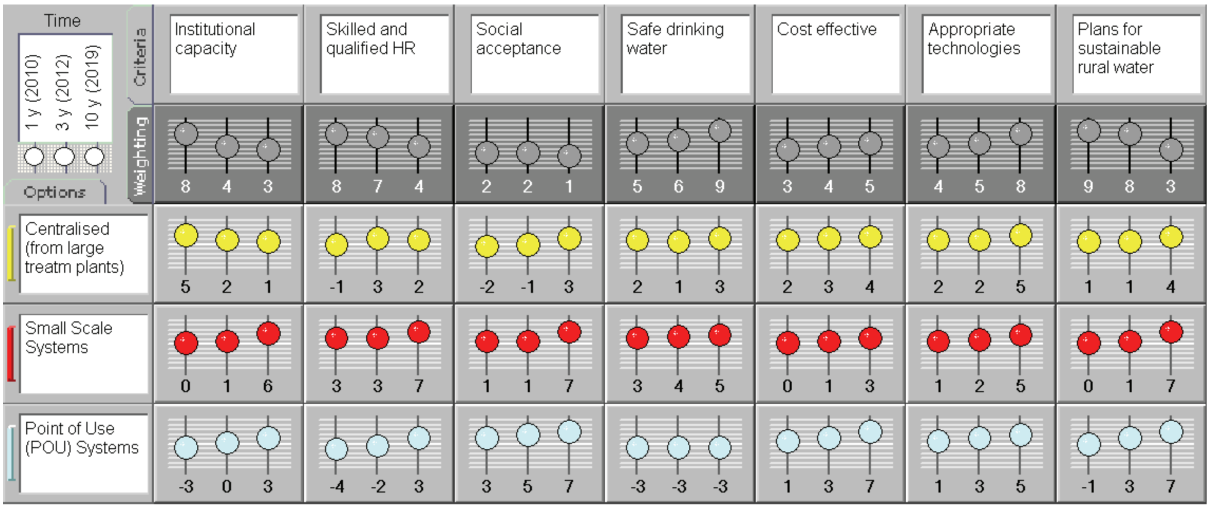


Figure 5.10: Ratings for the different scenarios and different time frames

Based on the ratings of the each of the three strategies against the goals that were set, a total score is then calculated by the tool for each of the strategies, in each of the three time frames. These total scores are then represented in a ranking analysis bar chart which provides a visual representation of the comparison between the strategies that were evaluated. For this example, the analysis results are shown in Figure 5.11.

The results of analysis of the three decentralised versus centralised treatment scenarios shows that at present, centralised water supply is still being applied most and the supply system of choice. The main reason for this would be lack of capacity in local communities to operate and maintain decentralised treatment plants effectively so as to ensure good performance and sustainability of the plants. There are also not any clear guidelines in existence for selection, implementation and management (including on institutional level) of decentralised water treatment systems, resulting in larger centralised treatment plants rather be used, in which the WSAs have more confidence in.

With considerable focus currently on research on and developing guidelines for decentralised systems (including wastewater treatment systems), the results show that in the three year time frame, small scale treatment systems will have gained popularity with DWAF, WSAs and design engineers, and that there will be more or less the same number of people supplied with water from centralised plants as from decentralised plants. Treatment systems for individual households (the home treatment devices or POUs) will also be used more, but not to the same extent as the small scale systems.

After 10 years, small scale systems will have become even more popular as the water supply route of choice in preference to centralised treatment plants, with home treatment devices also increasing its share in the rural treatment market, albeit substantially less than the community-sized small-scale systems.

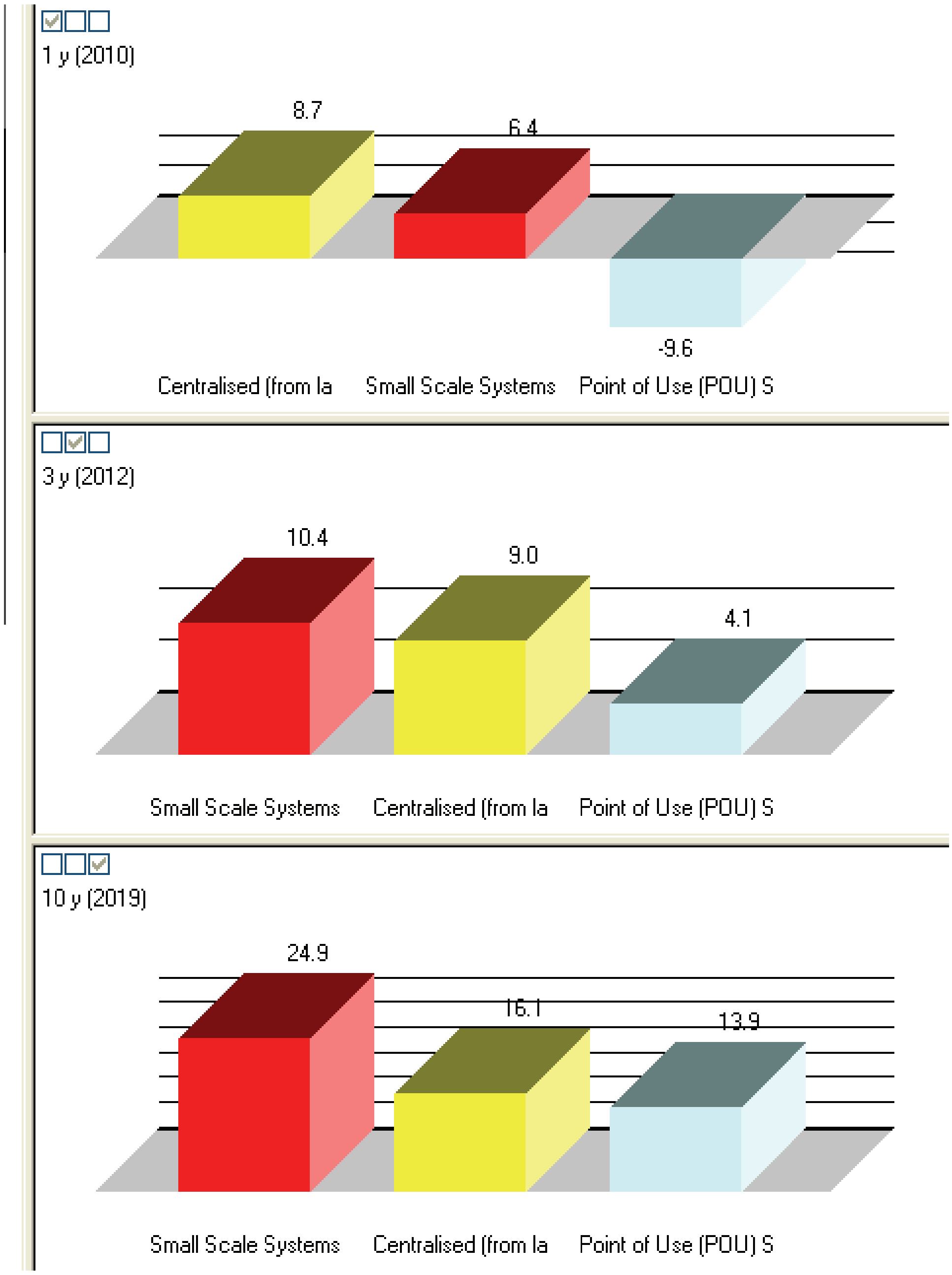
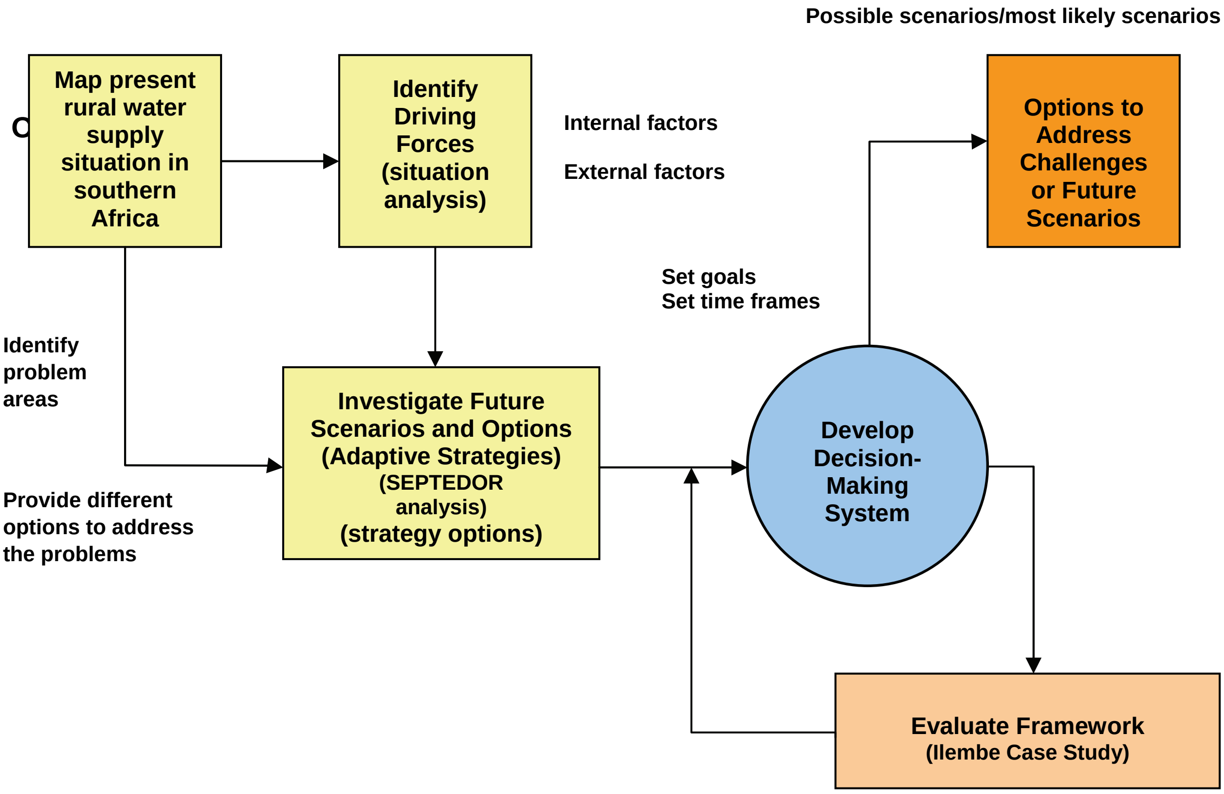
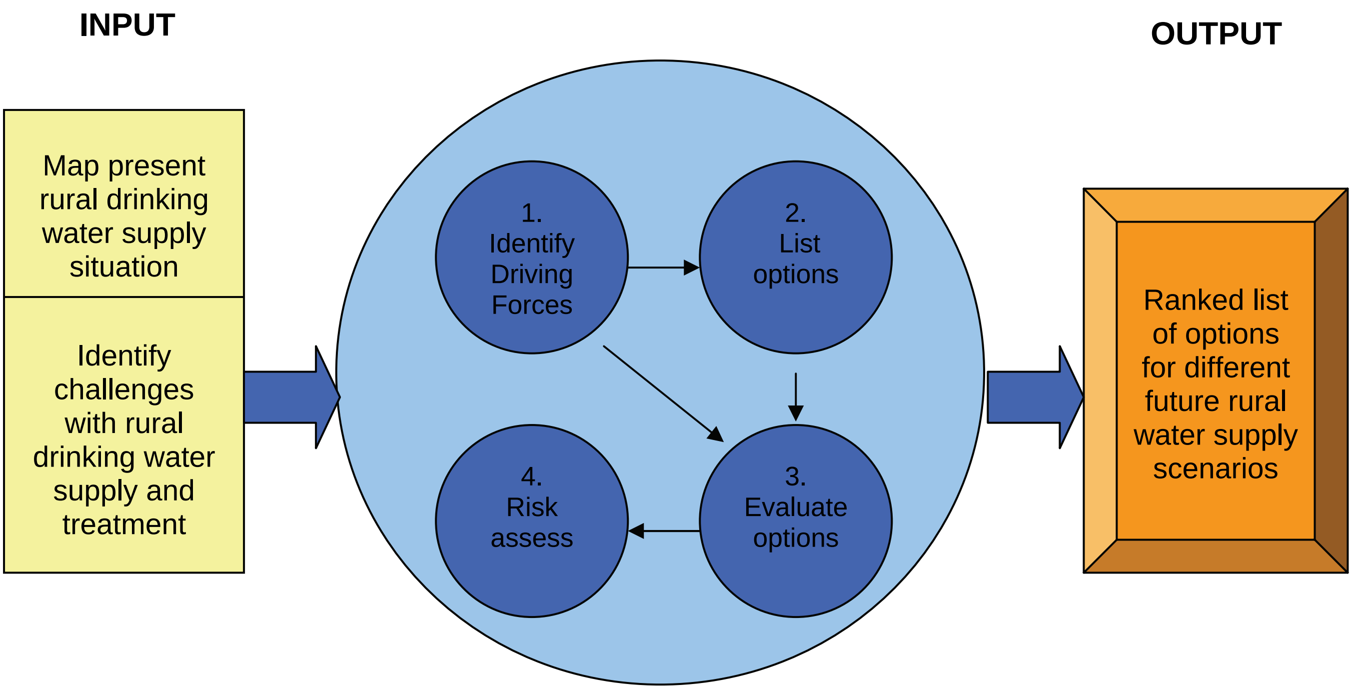


Figure 5.11: Ranking analysis results for the three scenarios

5.3.6 Planning Framework

The planning framework is displayed as flow diagrams showing the reasoning process for the decision-making system (planning framework) for rural water supply in the future.





INTERNAL FACTORS

- Effect of water-borne diseases
- Shortage of skilled personnel
- Availability of training providers
- Lack of proper O&M
- Deteriorating infrastructure
- Deteriorating raw water quality
- National and local level policies
- Legislation
- Management incompetency
- Poor image of water sector
- Lack/mismanagement of funds
- Political interference
- Management level motivation
- Rising cost of energy
- Availability of energy
- Pollution of water sources
- Failing wastewater plants
- Sanitation backlog
- Availability of raw water sources
- Public perceptions
- Social acceptance

Goals:

a. Institutional capacity
b. Skilled and qualified human resour
c. Social acceptance
d. Safe drinking water
e. Cost-effective treatment
f. Appropriate technologies
g. National plans for sustainable rural water supply

EXTERNAL FACTORS

- High population growth
- Urbanisation
- Climate change
- Poor global economy
- Lifestyle changes
- Impact of HIV/AIDS
- International tech cooperation
- Influence of Eastern Asia
- Poverty in rural area
- Surface water shortages
- Water stress

INTERNAL SCENARIOS

ADAPTIVE STRATEGY OPTIONS

- Decentralised water regulation
- More effective water demand management
- Exploration of alternative water resources
- Improved operation and maintenance (training)
- Improved maintenance systems
- Enhanced and accelerated capacity building
- Develop new purpose-built water treatment technologies
- Groundwater exploration
- Water reclamation and reuse
- Harvesting of rainwater
- Desalination (seawater and/or brackish water)
- Upliftment programmes in rural areas
- Better source protection
- Major effort to reach MDGs
- Development of appropriate technologies for rural areas
- Development and application of operational management tools
- Flood protection to protect water treatment plants
- Improved water quality management in rural areas
- Improved communication with consumers
- Development of more energy efficient water treatment technologies
- Decentralised treatment systems
- Automation and remote control via telemetry
- Use of membrane systems to provide barrier treatment
- Application of asset management programmes
- Improved maintenance programmes
- Improved funding systems
- Strategic planning of rural projects

EXTERNAL SCENARIOS

SA Rural Water Supply Strategy Pointers

- Regulation and support functions for rural water treatment plants can best be performed on a regional (provincial) basis rather than from national or local perspective
- Decentralised small-scale treatment systems (for a number of households or a whole community) will in the medium to long term present a better drinking water supply option to rural areas. Home treatment systems will be used in very remote areas, but to a lesser extent in other rural areas where small-scale systems are applied
- Water Boards have an important role to play in the operation and maintenance function of rural water treatment plants. They can provide this service on a contractual agreement basis. Current institutional arrangements prevents municipalities to provide service delivery to the required standards
- Automated high-tech treatment technologies for rural plants present a more efficient and sustainable solution where this is done under contract by a PSP or Water Board, or with technological support by reputable water treatment companies. Membrane systems in particular offer an attractive treatment option because of efficiency of these systems and the barriers that they present against pathogens and pollutants
- To ensure process controllers of high-standard, qualified and competent are employed in the water sector (for municipalities, water boards or PSPs), formal technical training institutions and courses should be re-introduced for the water care discipline. These formal training courses will produce best results when performed in conjunction with a mentorship programme, so that the learner can receive guidance for performing his duties, as well as for career planning. At the end of the training and mentorship programme, the mentee should be suitably qualified and competent to take over from the mentor.

Figure 5.12: Planning Framework for rural water treatment

5.4 Evaluating the Planning Framework: Ilembe District Municipality Bulk Water supply Case Study

To test whether the adaptive strategies that were developed in this Planning Framework are realistic and whether it can be applied in rural South Africa, a case study was selected in consultation with Umgeni Water, one of the end-users in the Techneau project. During a project workshop with members of Umgeni Water's planning and operational departments, it was proposed that the Ilembe District Municipality Bulk Water Supply Scheme be used for the case study, as this was a current rural water supply project where many of the issues and driving factors identified in the project were also matters of concern for the Ilembe Scheme.

5.4.1 Umgeni Water rural water supply

Umgeni Water, the largest catchment-based water utility in southern Africa, have responded to the challenges of the Millennium Development Goals (MDGs) by addressing the water and sanitation backlogs in rural areas in KwaZulu-Natal, through a focus on four main issues (Umgeni Water, 2002):

- infrastructure delivery
- sustainable water supply at household level
- integration of water, sanitation, health and hygiene issues
- role of community management

These focus areas also constitute important considerations in evaluating the advantages and disadvantages of decentralisation versus centralisation as "best" water supply options in the rural areas under jurisdiction of Umgeni Water.

5.4.2 Description of Ilembe District Municipality

Umgeni Water has concluded negotiations with the Ilembe District Municipality (DM) to extend the bulk water supply to 3 out of 4 Local Municipalities in the Ilembe District Municipality. These local municipalities are KwaDukuza, Ndwedwe and Maphamulo Municipalities excluding Mandeni Municipality. This involves the operation and maintenance of 37 water schemes, consisting of 18 water treatment plants and 19 borehole schemes.

The maps in Figures 5.13 and 5.14 show the Bulk Water Supply Strategy of the Ilembe DM, as well as the community water needs within the DM. It can be clearly seen that the communities in the DM is widely scattered across the DM, warranting consideration of decentralisation as drinking water supply strategy for Umgeni Water.

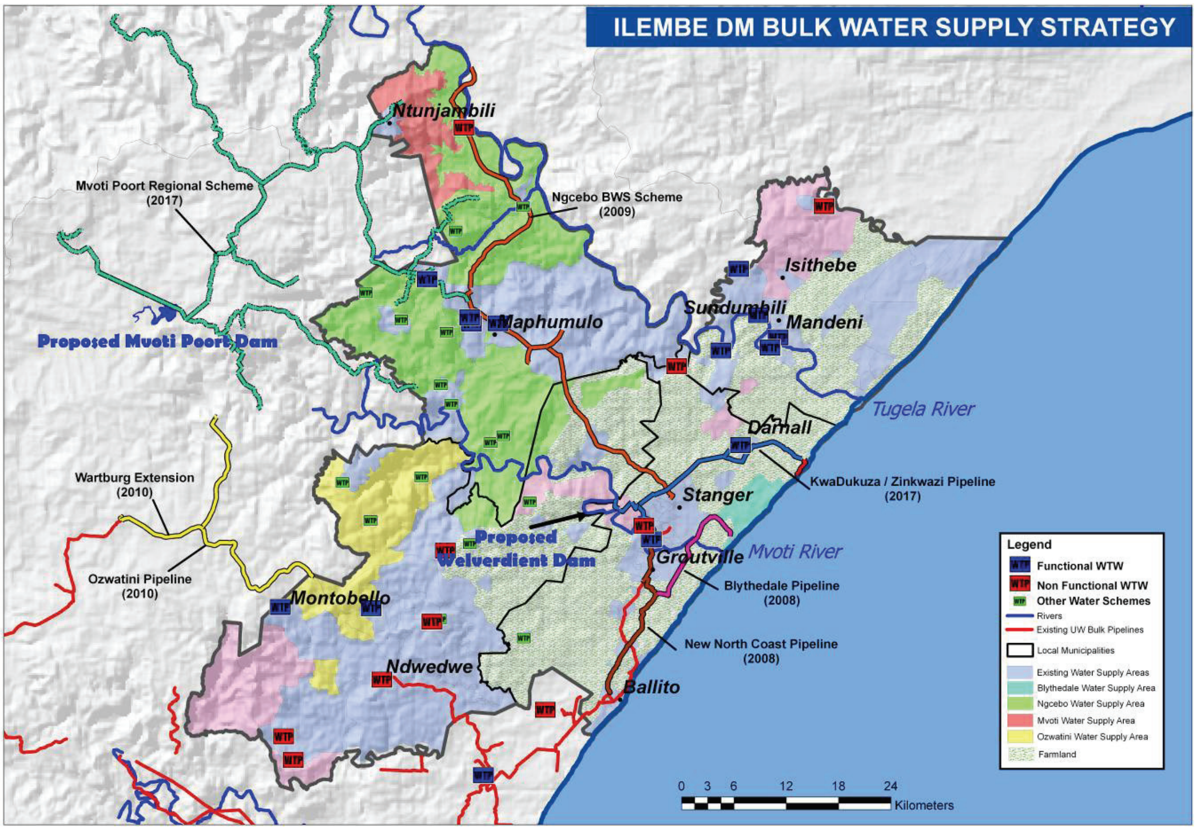


Figure 5.13: Details of Ilembe DM bulk water supply scheme

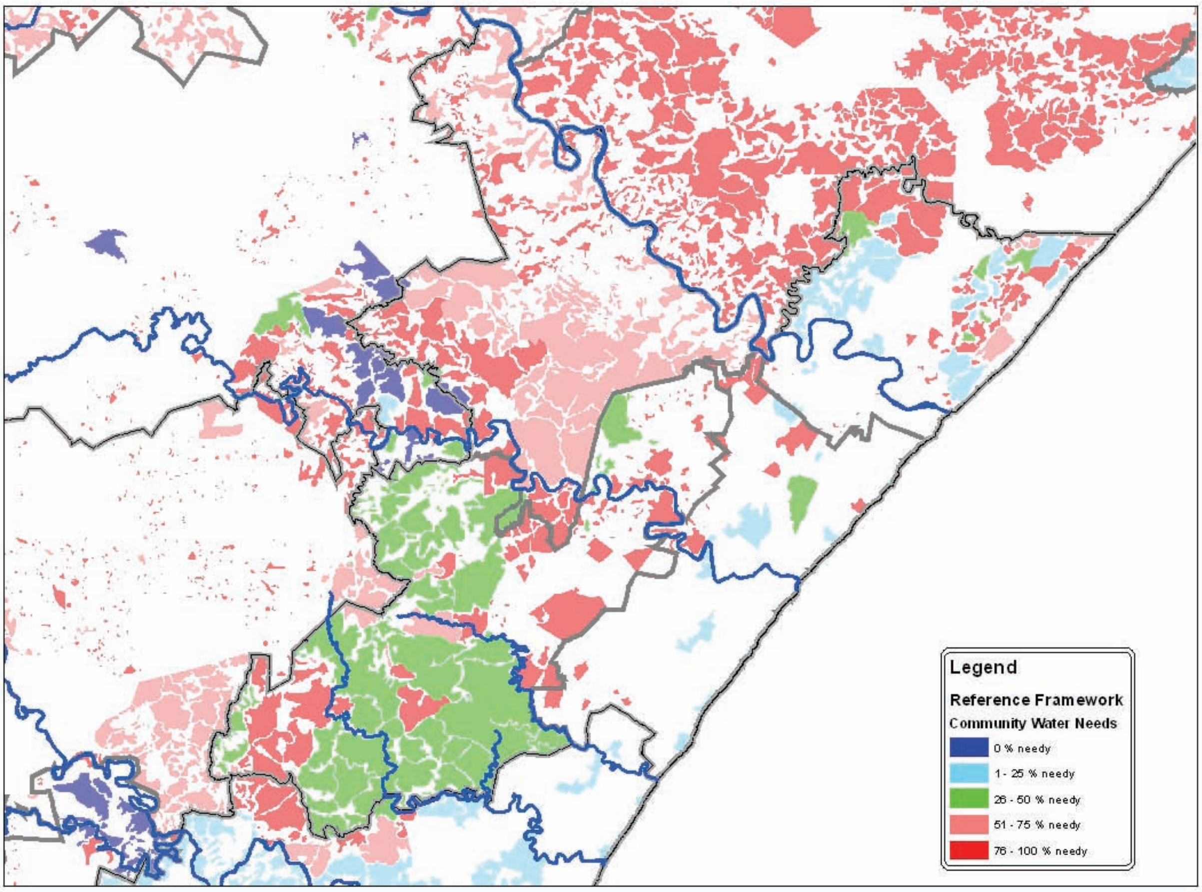


Figure 5.14: Community water needs in Ilembe DM

The DM currently has around 37 water supply schemes (points), which consist of water treatment plants, abstraction points and groundwater systems (boreholes and springs). Of the treatment plants, 12 are manned with a total staff of 31 employees The current estimation is that there are some 23 Operators, 7 General Workers and 1 Foreman (Superintendent) working on the plants to be handed over to Umgeni Water. It has been agreed that the Ilembe operational staff on the plants remain with Ilembe DM and be supervised by Umgeni Water.

5.4.3 Water supply regulation in Ilembe DM

Both water support and monitoring of the rural water supply schemes in Ilembe are undertaken by Umgeni Water. Regulating actions are also done on a regional basis by the DWAF regional office, rather than on a national basis by DWAF national office. The rural plants are visited by Umgeni Water technologists or engineers on a regular basis and samples taken at the plants. Basic measurements are done on-site (e.g. pH, chlorine residuals), while other measurements are done at the utility's laboratories at the larger water treatment plants.

5.4.4 Decentralisation and centralisation

As part of the 20 year Bulk Water Supply Agreement that was signed with Ilembe DM in February 2006, the operations of the treatment plants will be undertaken by Umgeni Water. The intention is to operate and maintain the treatment plants until the regional pipelines planned for these areas are constructed and connected to the respective reticulation schemes (see Figure 5.1). When these regional pipelines are commissioned after the construction phase, some of the stand alone water supply schemes (*i.e.* decentralised water supply schemes) will be decommissioned. This will therefore represent a move from decentralised plants to centralisation. However, strategic planning is still in process to establish which treatment schemes would be more feasible (and sustainable) as stand-alone schemes (decentralisation), rather than tying in with the regional schemes (Thompson, 2007).

Some of the challenges experienced by Ilembe DM on the wide-spread decentralised plants are as follows:

- Insufficient water supply to meet the demand in certain areas
- Poor control of treatment processes
- Poorly trained operators
- Insufficient / inadequate process control instruments
- Poor supervision of operators
- Lack of planned maintenance
- Poor response to breakdowns

The challenges have resulted in complaints from the public because of prolonged periods of water shortages (quantity) as well as the acceptability of the water (quality). Safety aspects are also a major issue.

The single large challenge remains the size of the operational area (3 035 km^2) and the remoteness and accessibility of the communities in the DM. This presents major logistical problems in certain areas, and plays an important role in the strategic planning process, especially with regard to the decision of centralised supply versus decentralised schemes.

5.4.5 Operation and maintenance

As mentioned above, Umgeni Water will be responsible for the operation and maintenance of the treatment plants in Ilembe DM. The O&M function will thus be transferred from the DM and local municipalities in the DM, to Umgeni Water, which is the largest water utility in KwaZulu-Natal. This represents a shift from municipality to Water Board for performing the operations and maintenance of the treatment plants. It also constitutes a huge improvement on the previous O&M situation, where a lack of both technical and management capacity in the municipal water care function resulted in serious challenges for the WSAs in the DM (these challenges are not localised but occur country-wide). Other contributing factors to poor service delivery by municipalities are, amongst other, lack of funds, poor planning, lack of skilled personnel and ageing infrastructure.

In taking over the operations functions of these plants from the municipal sector, Umgeni Water has given specific attention to the above shortcomings, and has, as a first step, decided to adopt a new organogram for their water treatment and distribution function in Ilembe. The organogram is part of a new O&M management model that will provide the required planning, management, operations and maintenance to the existing water treatment plants to ensure efficient and sustainable drinking water production (Habib, 2007).

The organogram of the proposed model is shown in Figure 5.15.

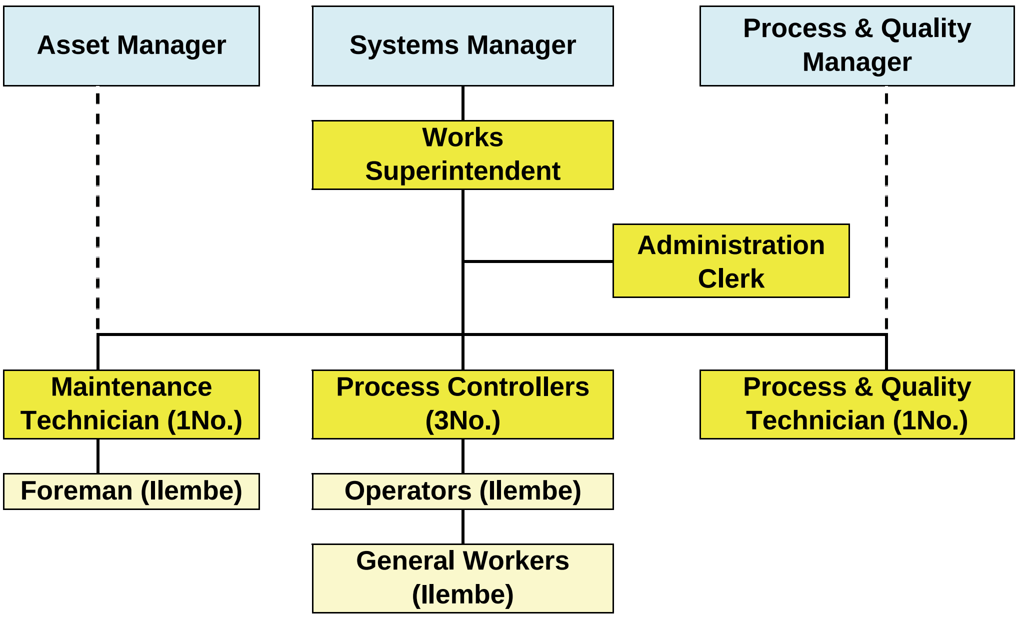


Figure 5.15: Proposed organogram for Ilembe treatment plant O&M

The proposed model is summarised below (Habib, 2007):

a. <u>Management</u>

The water treatment plants will be managed by a Works Superintendent, who will supervise the Process Controllers, Process and Quality Technician, Maintenance Technician and Administration Clerk. He will be accountable and report to the Systems Manager, who manages the overall water treatment function in the region. The Works Superintendent's responsibility will include financial management (as a cost centre).

b. <u>Works Operations</u>

Three Process Controllers will be deployed and will be responsible for the day to day operations of the plants. There will also be Operators and General Workers who will be supervised by the Process Controllers. The Process Controllers will, inter alia, be responsible for performing the following tasks:

- maintain the performance of the plant with respect to water quantity and quality
- assess the functionality of the electrical/mechanical equipment
- assess the performance of the plants

- for remote, unmanned plants, visit the plants on a regular basis to assess plant functionality and replenish chemicals
- perform water process control tests
- implement interventions
- take meter readings
- compile reports

Three Process Controllers are considered necessary to ensure adequate coverage of the vast geographical area.

c. Asset Management

It was decided that routine breakdown maintenance and repairs be contracted out to specialist equipment contractors. As part of the contractual arrangement the Maintenance Technician (of Umgeni Water) will do preliminary trouble-shooting, investigate equipment malfunctioning, determine scope of repairs required and call out the contractor (as and when required) to do repairs. Afterwards, the Maintenance Technician performs quality assurance on the work done and authorise payment to the contractor.

d. Process control and quality control

The Process & Quality Technician will monitor on site test results and laboratory results and recommend process interventions. He will also undertake chemical treatment optimisation on all the plants in addition to regular process audits. He will optimise the treatment processes, produce operating manuals and train Operators on best operating practises.

e. Administration

The Administration Clerk will provide all site administration support in terms of purchase requisitions, chemical call-offs, purchase orders, invoices, payments and time sheets for the Operators.

5.4.6 Technology type

For bulk water supply schemes, the centralised treatment plants are normally designed to allow best available technologies to be used to produce drinking water of a quality complying with the SANS 241 specifications. These plants are usually well-equipped and with a sufficient number of well-trained and competent personnel. Being well-trained (both through external training and in-service training), the process control and quality control personnel are skilled and qualified to operate and maintain the treatment plants, so as to ensure good performance and well-maintained equipment and infrastructure. The treatment plants can therefore consist of either low-tech or higher-tech technologies, although conventional chemical treatment systems are used at most of the treatment plants.

For the rural stand-alone treatment plants (decentralised plants), however, the type of technology employed has a marked effect on the sustainability of the treatment scheme. The tendency is more towards low-tech technologies requiring minimal operation and maintenance inputs. The reason, again, is the lack of skilled and trained personnel to operate and maintain the plant, poor access roads in the deep rural areas hampering delivery of chemicals and equipment, and management challenges resulting from the remoteness of these rural plants.

As such, slow sand filters are often used in the rural areas, but even these plants present challenges with operation and maintenance, and the treatment is often compromised by these challenges. The concept of using automated high-tech technologies has gained popularity because it can be operated with minimal input from the local operator, be services and maintained by a roving technician under contract, and can also be operated remotely with the aid of telemetry. Some of these technologies are also packaged in such a way that it largely eliminates the use of chemicals, contain one or more treatment barriers, have automated cleaning regimes, can operate by gravity alone and therefore obviated the need for electricity, and can be pre-manufactured and packaged on a skid-mount or in a container.

For decentralised treatment systems, the use of automated more sophisticated systems operated and maintained under contract by reputable water treatment companies are therefore likely to present a "best" treatment option in terms of performance, compliance and sustainability.

5.5 Conclusions and Recommendations

5.5.1 Conclusions

a. Regulation and support functions for rural water treatment plants can best be performed on a regional (provincial) basis rather than from national or local perspective.

b. Decentralised small-scale treatment systems (for a number of households or a whole community) will in the medium to long term present a better drinking water supply option to rural areas. Home treatment systems will be used in very remote areas, but to a lesser extent in other rural areas where small-scale systems are applied.

c. Water Boards have an important role to play in the operation and maintenance function of rural water treatment plants. They can provide this service on a contractual agreement basis. Current institutional arrangements prevents municipalities to provide service delivery to the required standards.

d. Automated high-tech treatment technologies for rural plants present a more efficient and sustainable solution where this is done under contract by a PSP or Water Board, or with technological support by reputable water treatment companies. Membrane systems in particular offer an attractive treatment option because of efficiency of these systems and the barriers that they present against pathogens and pollutants.

5.5.2 Recommendations

a. Extend the Planning Framework to a decision-making model, allowing inputs by strategic planning departments for specific regions or development projects, and obtaining as output a list of best options with details for implementation and sustainable operation and maintenance.

b. Coordinate and fast-track all capacity building initiatives in the water sector, and make clear distinction between the needs of rural water treatment plants and larger plants (in the metropoles and large towns).

c. To ensure process controllers of high-standard, qualified and competent are employed in the water sector (for municipalities, water boards or PSPs), formal technical training institutions and courses should be re-introduced for the water care discipline. These formal training courses will produce best results when performed in conjunction with a mentorship programme, so that the learner can receive guidance for performing his duties, as well as for career planning. At the end of the training and mentorship programme, the mentee should be suitably qualified and competent to take over from the mentor.

d. Draw up guidelines for WSAs for selection, evaluation, implementation and management of decentralised treatment systems on institutional level.

e. Explore the establishment of franchising systems for management, operation and maintenance of decentralised water treatment systems in rural areas.

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