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Report on Integration of different measures to reach Millennium Development Goals (MDGs) In Sub-Sahara Africa

TECHNEAU

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This report is:
PU = Public

Executive Summary

WA1 'Rethink the system' is aiming to identify future challenges of the water supply system and the outcome is used as an input in other TECHEAU activities. In WP 1.1, trends and drivers for change have been analysed for several European regions and for Southern Africa, with respect to several SEPTED dimensions (Social-cultural, Economical, Political, Technological, Ecological and Demographical). Several dimensions were studied in more detail separately: risks, organisational aspects, and sociological aspects. Combinations of drivers will pose challenges to the water supply sector that must be addressed by developing adaptive strategies and multi scale systems for different regions. These adaptive strategies were developed in WP1.2. The adaptive strategies include source-to-tap solutions to cope with future changes. The adaptive strategies are based on the principles of (1) Integration, (2) Maximum Flexibility and (3) Consideration of Local Conditions, which can be applied in different dimensions.

Case studies to test the adaptive strategies

The aim of the Work Package 3 was to test and evaluate the adaptive strategies developed in WP1.2 using case studies with end-users. The general approach involved (1) making use of the opportunities provided by one of the ten trends defined in WA1.1, to (2) exploit the implications of the other. Researchers worked with end-users to translate the adaptive strategies into interventions that are applicable to specific practical problems. The suitability of the strategies was assessed based on the results of the case studies. Dissemination of the lessons learned will be maximised by integrating the results of the case studies with other TECHNEAU activities and with the TKI (TECHNEAU Knowledge Integrator) in WA7.

The following five case studies were proposed:

1. A decision support system for flexibility enhancing instruments (KIWA WR: Brabant Water)
2. Flexibility in coping with water stress and integration of different measures: (RWTH; Cyprus)
3. Flexibility in addressing future water demand, required infrastructures and drinking water quality in the Baltic area (RTU, Riga)
4. Integration of different measures to reach MDGs in Sub-Saharan Africa (Swartz, South Africa)
5. Integration of stakeholders: consumers and utilities (Surrey, Amsterdam)

The Millenium Development Goals case study

This case study comprised an investigation of the measures that can be taken to reach the Millennium Development Goals (MDGs) in sub-Saharan Africa, and in particular how these measures can be integrated to present realistic ways of reaching the goals (it is generally accepted that single solutions will not be sufficient to meet the MDGs). The case study covered the whole sub-Sahara African region, but specific aspects were investigated at an end-user in South Africa, viz. Umgeni Water, where another TECHNEAU case study (WP2.5) is also conducted (i.e. consideration of local conditions).

The following adaptive strategies, as measures to meet the MDGs, were, among others, investigated: decentralisation, possible combination of centralised and decentralised systems, addressing the large-scale urbanisation in sub-Saharan Africa, response to climate change, improved operation and maintenance (replacing deteriorating infrastructure), rising energy costs and deteriorating quality of water sources.

As mentioned, integration is needed to cope with these problems and the proposed adaptive strategies. The case study therefore focused on how these elements can be integrated to present the best possible means of meeting the MDGs. Specific attention was also be given to flexibility of adaptive strategies in particular situations. The integrated approach comprised investigation of the integration of the whole water cycle (water resources, drinking water, and wastewater), integration of all stakeholders (water utilities, authorities/regulators, consumers, NGOs) and integrated approach of water and energy. The assessment of the above measures to be considered, and integration thereof, consisted of own experience of the project partner gained during assessment of trends (WP1.1), knowledge and information base of the Water Research Commission (WRC), and interviews with stake holders and key role players in the study area under consideration.

Techneau scenario analysis: trends in water supply in Sub-Sahara Africa

From the notes taken by the author at a Global Research Alliance (GRA) scenario-planning workshop held in March 2006 in Windhoek on water scenarios in sub-Sahara Africa (Swartz, 2006) and subsequent interviews with role players, and through a desk study of literature, the driving forces impacting on future drinking water supply in South Africa and sub-Sahara Africa were identified and further studied. The results are presented in the report by Swartz and Offringa (2006).

The following ten main trends in drinking water supply in Southern and sub-Saharan Africa were identified (Swartz and Offringa, 2006):

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

For each of the above main trends, adaptive strategies were identified to address the challenges posed by these future trends in drinking water supply. Based on these adaptive strategies (which are listed in Section 3 of the report), 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 meeting the MDGs 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 MDG's
- 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

Main strategies to test and validate for this case study

For purposes of this case study, the following three main strategies were selected for further consideration and evaluation:

a. Decentralisation

b. Development of application of appropriate water treatment technologies for rural areas (high-tech [membrane systems])

c. Improved operation and maintenance (e.g through outsourcing)

Consideration of these main strategies comprised an evaluation of the most important contributing and related aspects impacting on drinking water supply in sub-Sahara Africa, and integrating these to provide practical options for addressing the MDGs. The following three contributing aspects were also considered as integrating factors in Section 4:

- Climate change
- Increasing cost of energy
- Financing methods.

Case Study: Test and validate the integration of adaptive strategies to meet the MDGs: Ilembe, KwaZulu-Natal (Umgeni Water)

To test whether the adaptive strategies that were developed in the planning framework are realistic and whether it can also be applied in sub-Sahara Africa to reach the MDGs, the Ilembe case study was used. The Ilembe District Municipality Bulk Water Supply Scheme was selected 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. A project workshop was held with members of the planning and operational departments of Umgeni Water (one of the Techneau end-users in southern Africa).

In a Water Research Commission (WRC) project to consider strategies for positioning rural water treatment in South Africa for the future, a planning framework was developed. In the framework, a listing of of driving factors (internal and external) impacting on drinking water supply in rural South Africa led to identification of adaptive strategies to mitigate or minimize these impacts. It was decided that this framework also be used as basis to test the adaptive strategies for meeting the MDGs in sub-Sahara Africa due to the driving forces and expected impacts being the same.

Testing the planning framework for rural water supply in Sub-Sahara Africa towards reaching the MDGs

Identification of the driving factors that have an influence on the rural water supply, both now but especially in the future, led to the conclusion 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 analyze by manual methods or simple models. It was therefore necessary to apply more sophisticated software to analyze the situation.

The Think Tools decision-support system (now called Parmenides EIDOS) was used. It is supported by the Centre for Knowledge Dynamics and Decision-making of the University of Stellenbosch (US). DWA 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 methodology for the overall development of the planning framework is described below, indicating the various steps that were followed.

Methodology for development of the Planning Framework

The following steps were followed in developing the framework:

a. Evaluate the status quo in South Africa 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 consideration 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**rganizational, **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 (and to reach the MDGs in this instance).

d. Develop the planning framework, using the EIDOS software.

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, and the stake-holder of the Water Research Commission (a partner of the TECHNEAU project), 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

Results

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 DWA, 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.

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.

Contents

1 Case study background

1.1 Work Area 1: Rethink the System

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Several dimensions were studied in more detail separately: risks, organisational aspects, and sociological aspects. (Combinations of) drivers will pose challenges to the water supply sector that must be addressed by developing adaptive strategies and multi scale systems for different regions. These adaptive strategies were developed in WP1.2. The adaptive strategies include source-to-tap solutions to cope with future changes. The adaptive strategies are based on the principles of (1) Integration, (2) Maximum Flexibility and (3) Consideration of Local Conditions, which can be applied in different dimensions.

On basis of the adaptive strategies, case studies were defined in collaboration with end-users where adaptive strategies were tested and evaluated (WP 1.3). These case studies were carried out in The Netherlands (Brabant Water Flexibility and Amsterdam Water Recycling), Cyprus, Sub-Saharan Africa and in Latvia.

1.2 Case studies to test the adaptive strategies

The aim of the case study was to test and evaluate the adaptive strategies developed in WP1.2 using case studies with end-users. The general approach involved (1) making use of the opportunities provided by one of the ten trends defined in WA1.1, to (2) exploit the implications of the other. Researchers worked with end-users to translate the adaptive strategies into interventions that are applicable to specific practical problems. The suitability of the strategies was assessed based on the results of the case studies. Dissemination of the lessons learned will be maximised by integrating the results of the case studies with other TECHNEAU activities and with the TKI (TECHNEAU Knowledge Integrator) in WA7.

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1.3 The Millenium Development Goals case study

This case study comprised an investigation of the measures that can be taken to reach the Millennium Development Goals (MDGs) in sub-Saharan Africa, and in particular how these measures can be integrated to present realistic ways of reaching the goals (it is generally accepted that single solutions will not be sufficient to meet the MDGs). The case study covered the whole sub-Sahara African region, but specific aspects were investigated at an end-user in South Africa, viz. Umgeni Water, where another TECHNEAU case study is also conducted (i.e. consideration of local conditions).

The following adaptive strategies, as measures to meet the MDGs, were, among others, investigated: decentralisation, improved centralised treatment, possible combination of centralised and decentralised systems, addressing the large-scale urbanisation in sub-Saharan Africa, financing methods, water savings devices, response to climate change, improved maintenance (replacing deteriorating infrastructure), rising energy costs and deteriorating quality of water sources.

As mentioned, integration is needed to cope with these problems and the proposed adaptive strategies. The case study therefore focused on how these elements can be integrated to present the best possible means of meeting the MDGs. Specific attention was also be given to flexibility of adaptive strategies in particular situations. The integrated approach comprised investigation of the integration of the whole water cycle (water resources, drinking water, and wastewater), integration of all stakeholders (water utilities, authorities/regulators, consumers, NGOs) and integrated approach of water and energy. The assessment of the above measures to be considered, and integration thereof, consisted of own experience of the project partner gained during assessment of trends (WP1.1), knowledge and information base of the Water Research Commission (WRC), and interviews with stake holders and key role players in the study area under consideration. These included authorities, government and water utilities. The focus was especially on long term planning and strategies.

2 Challenges of water supply in Sub-Sahara Africa

2.1 The Millenium Development Goals

The Millennium Development Goals (MDGs) acknowledge the critical and multifaceted role of water in realizing a world, which aims, by 2015, at achieving the following (UN Millennium Project Task Force on Water and Sanitation, 2005; www.unmillenniumproject.org):

Goal 1: halving the prevalence of hunger (water improves food and income from crops, animals and small businesses in poor rural and peri-urban areas);

Goal 2: universal primary education (girls are liberated from domestic water chores, and boys from herding livestock to distant water points);

Goal 3: women's empowerment (women are liberated from domestic water chores and obtain equal access to water for food and income);

Goal 4: reduced child mortality;

Goal 5: improved maternal health;

Goal 6: HIV/AIDS, malaria and other diseases combated (more water of higher quality is available for drinking and hygiene, and water related diseases are prevented); and

Goal 7: enhanced environmental sustainability (water resources are used equitably, rationally and sustainably, and watershed management ensures adequate drainage and prevents pollution and land and water erosion)

Global assessments by WHO and UNICEF show that a large proportion of the World's population does not have access to improved or microbiologically safe sources of water for drinking and other essential purposes: at the beginning of 2000 one-sixth (1.1 billion people) of the world's population was without access to improved water supply. Insufficient water supply, sanitation, and hygiene contribute to 3.7% of globally quantified DALYs (indicator for overall burden of disease) (WHO 2002). One of the millennium development goals (MDG nr. 7) states that by 2015, ***the proportion of people without sustainable access to safe drinking water and sanitation should be halved in comparison to 1990*** (UN, 2006). The rapidly increasing population in Sub-Saharan countries, the enormous urbanisation ratio and the increasing number of immuno-compromised people in these regions add even more challenges in complying with these goals (Pronk, 2008).

Broad consensus has been reached amongst governments, NGOs, international development and funding agencies and donors on what key changes are necessary to meet the challenges of the MDGs. These include:

- Good governance, including people's participation and the devolution of decision making authority and the required resources to the lowest appropriate level.
- Participatory and demand-based technology choice, from a range of appropriate and affordable technologies.
- A central role for women in planning and managing water services, as expressed in the Dublin principles (1992).

Muller and Manus (2007) reports that in South Africa, current trends show that the target of halving the population without any sustainable access to safe drinking water could not be met in 2015, but more likely in 2040, and a lot of uncertainty lies in facing the growth of the population.

Good governance, decentralization and participatory technology development on their own are not enough to address the MDGs; it is also necessary to approach the challenge in a more integrated and holistic way. This approach is reflected in the concept of Integrated Water Resources Management (IWRM), which is defined as *a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems* (GWP 2000). IWRM has become a commonly accepted approach within the water community, but has also been challenged by some (Biswas 2004).

In response, the nation of South Africa has set the following water sector targets (DWAF 2003b):

- Apply the 'free basic water service' policy to all people, with access to a basic service by 2004
- Basic water services to all schools and clinics by 2005
- Education on hygiene and wise use of water at all schools by 2005
- Provision of at least basic water supply services to 8 million more people by 2008
- Provision of at least a basic sanitation service to an additional 18 million people (3 million households) by 2010
- Education to 3 million households receiving a basic sanitation service by 2010

2.2 Windhoek workshop on water scenarios for Sub-Sahara 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 (Swartz and Offringa, 2006).

The Global Research Alliance (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 and Dr Gerhard Offringa were among the participants at the workshop.

During the workshop, groups were asked to compile a list of key certainties that will bring about or inhibit change in Africa, and the main findings of this exercise are presented below.

- Climate will change and extreme conditions can be expected
- Urbanisation will challenge the water supply infrastructure
- Technological solutions are already or will be available for use and monitoring capabilities will improve
- Political instability in the region will continue
- Cleaner production technologies and incentives for rural area farming and spatial planning will bring ecological balance
- Water conflicts are a certainty
- Increased environmental tension
- Increased pollution
- Increased demand and shortage of fresh water
- Energy crisis
- Hydro-politics will come into play
- Regional integration will increase opportunity for collaborative projects
- Improved lifestyles will demand more water
- Population growth and demographics will change
- Tension in meeting greater demands for food and water from available resources

2.3 Techneau scenario analysis: trends in water supply in Sub-Sahara Africa

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

The following ten main trends in drinking water supply in Southern and sub-Saharan Africa were identified (Swartz and Offringa, 2006):

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 trends are discussed in some more detail below, providing the driving forces, implications for the water industry and the adaptive strategies.

Population Growth

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.

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, and 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 dominant role. Innovative systems will be required.

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

Urbanisation

Driving Forces

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

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 will be required in an attempt to counter the urbanisation trend.

Degradation of Source Water Quality

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.

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.

Interventions will be needed to improve the sustainability of existing treatment systems to treat the poorer raw water quality as well as to improve the operation and maintenance of these systems. Some privatisation in this market sector is expected.

Adaptive Strategies
Better source protection; major effort to reach MDG's, 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.

Climate Change: Water Resource Quantity (Water Stress)

Driving Forces
Global warming as 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.

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 metropole; Swakopmund and other areas in the southern region of Southern Africa are planning for this. 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.

Life-style Choices

(Point-of-use Systems and Bottled Water)

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. In many cases it is have become fashionable to drink bottled water.

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 of the water quality 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 to 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.

Increasing Cost of Energy

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.

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).

Better Access to Communication Technology and Information

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.

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.

Increase in Water-borne Diseases

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

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.

Degradation of Infrastructure

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.

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 te receive high priority are 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.

<u>Political Tensions over Water</u>

<u>Driving Forces</u>

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

<u>Implications for the water industry</u>

- 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.

<u>Adaptive Strategies</u>

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

3 Adaptive strategies

3.1 Listing of potential options and strategies

From the adaptive strategies discussed in Section 2, 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 meeting the MDGs 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 MDG's
- 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

3.2 Main strategies to test and validate for this case study

For purposes of this case study, the following three main strategies were selected for further consideration and evaluation:

a. Decentralisation

b. Development of application of appropriate water treatment technologies for rural areas (high-tech [membrane systems])

c. Improved operation and maintenance (e.g through outsourcing)

Consideration of these main strategies comprised an evaluation of the most important contributing and related aspects impacting on drinking water supply in sub-Sahara Africa, and integrating these to provide practical options for addressing the MDGs. The following three contributing aspects were also considered as integrating factors in Section 4:

- Climate change
- Increasing cost of energy
- Financing methods.

4 Integration of the strategies

4.1 Integration factors developed in the Techneau project

In work package 1.1 the SEPTED analysis for Sub-Sahara led to the identification of trends for this region. From this, the ten most important trends for the region were selected, and adaptive strategies were developed for each of these trends.

In combining all of the trends of the various regional analyses in Techneau, the following three general strategies were defined (Pronk, 2008):

- An integrated approach
- Maximum flexibility
- Consideration of local conditions

Because the adaptive strategies that were developed for the different regions vary widely, a number of case studies were proposed to evaluate these possible options in actual conditions.

As indicated earlier, the objectives of the case studies were to evaluate the integration and flexibility of the adaptive strategies of each of the selected regions, so that an understanding of the trends and underlying driving forces could be applied, and an investigation done on how the measures can be taken to address the challenges. This could firstly lead to developing remedial measures, but also to explore potential opportunities. The success of this will depend on how well the strategies approach the future trends and take into account the possibilities for integration and flexibility.

According to Pronk (2008), the end-users can either make gradual adjustments (*evolution*), immediate intervention (*revolution*), or no adjustment at all (*business-as-usual*). If intervention is necessary to counteract a trend, this could be done through lessening its driving force (*mitigation*), changing it to fit the new circumstances (*adjustment*), or protecting their conventional practices and technologies (*resistance*).

Pronk further points out (Pronk, 2008) that the *integrated approach* involves a holistic, comprehensive approach and a collective and united action. It aims at maximizing cooperation and harmonization. In the water cycle, this would imply inclusion of water resources, water supply and wastewater systems. All these aspects should therefore be considered in an integrated approach.

The goals of the end-users largely determine the success of a strategy. Common goals are sustainability (maintaining the integrity of the social, economic and ecological aspects) and maximizing the resilience (ability to cope with problems, adapt to change and recover from setbacks). Water supply companies traditionally choose robust strategies, implying that they minimize risk by investing in sources or technologies in most circumstances.

In assessing sustainability and resilience, *flexibility* plays a key role. Flexibility is required because the extent and effects of many of the trends are unsure. It will be required with regard to water resources, treatment technologies, and financial and organizational structures (Pronk, 2008).

4.2 Measures to integrate the adaptive strategies to ensure that the MDGs will be met

In Workarea 1, trends and their adaptive strategies were discussed for the following representative regions (Pronk, 2008):

- Southern Europe (Portugal)
- Central Europe
- Sub-Saharan Africa
- Western-Europe
- Water-Stress regions

From Pronk's report, possible solutions and strategies for addressing the Millenium Development Goals were listed and discussed. An overview of the most important aspects, relevant to the MDGs, is given below.

Climate change
Climate change has an impact on drinking water supply (either directly or indirectly), which can be manifested in a number of different ways. The most important impacts relates to changes in source water quantity (droughts as well as floods), changes in water quality and water temperature.

Water quantity: 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 (this is already evident on a large scale in some of the southern countries) and long lag periods to repair the damage and restore the water supply service to its original condition (due mainly to lack of funds).
Water quality: Climate change also results in change of water quality in water sources (*e.g.*salinisation; higher organic content; eutrophication).

Increasing cost of energy
It is widely known (and currently being researched) that to make water treatment technologies affordable and sustainable in the developing countries,

- the energy costs should be minimised
- technologies with lower energy requirements should be developed
- alternative renewable energy sources should be sought and developed (*e.g.* solar; wind; tidal).

The development of energy efficient water treatment technologies will be crucial in Africa in the future. Equally important will be the development of alternative energy technologies which will ensure affordable and sustainable treatment systems for developing countries. This 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. As an example, 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). Other examples include the use of tidal energy being for drinking water production (desalination processes) and of the generation of "blue energy" from mixing sea water and river water by the process of reverse electrodialysis (RED) (Pronk, 2008). In case of suitable geography, hydrostatic pressure can be used to drive drinking water processes (e.g. membrane filtration processes).

Decentralisation

Experience has shown that direct application of technologies developed in the West often does not function properly or are not sustainable when applied in developing countries. The main reasons for this has been found in studies to be of sue to socio/cultural or political reasons. Involvement of local companies, authorities and communities are imperative in trying to ensure successful application over the longer term. Local inputs in development of the technologies are also very important.

A lot of attention is also currently being place on solutions in which the users can directly implement the treatment systems themselves, i.e. Point-of-Use (POU) treatment systems. In many cases, these decentralised systems should be the preferred option as compared to centrally managed solutions (centralisation), which often suffer from deterioration and poor maintenance. Therefore, help from industrialized countries (e.g. European countries) should rather be focused on creating the local capacity to create solutions instead of introducing ready-to-use equipment.

Considering the large changes required to improve the situation, transition management is an important step. For example, POU treatment (Point-of-Use) could serve as temporary solutions until central systems function in a reliable manner. Also for the developing countries, solutions should not be necessarily "low-tech". Modern technology is often more efficient and more reliable and therefore actually can be more suitable. In order to decide drinking water investments, not only cost criteria should be handled, but the whole sustainability and feasibility of solutions should be considered (technical as well as economical as well as political). In order to prevent that only the rich part of the population profits from improved water supply, commonalities in interest between poorest and other part of population should be created. This could lead to justification of new concepts, e.g. the concept of free water for the poor.

In many developing and transition countries, the operation of centralized systems in some cases is less reliable than in the industrialized countries and the resources are often less well managed. Once again, this may ascribed to a number of reasons, of which lack of funding, lack of management and technical capacity, and political interferences are some of the more important factors. Monitoring of water quality parameters is therefore even more crucial, both in water sources, in the treatment process as well as in the treated water (final product). In order to enable this, cost-effective on-line monitoring technologies for a range of water parameters should become available, thereby reducing the risk associated with non-availability of plant managers and process controllers. Where funding remains a problem, attention should be given to alternative financing methods.

Financing Methods
Privatisation or PPP (Public Private Partnerships) is sometimes regarded as a threat, especially in developing countries where unemployment presents huge challenges to the authorities, and where privatisation presents a perceived threat to the workers. It is also perceived that the community could lose control over essential goods such as their drinking water when the privatisation route is opted for.

However, this problem only occurs in countries / regions where a regulatory framework is failing or where the political system is subject to bribery. In the meantime, a large range of reference projects are available where PPP has been implemented successfully (Pronk, 2008).

When privatisation is considered, full coverage of the service area can be a critical aspect. The more densely populated areas tend to be more profitable than rural areas and examples exist where only the urban areas are under contract of privatization (e.g. Bukarest).(Pronk, 2008). Numerous examples can also be cited in other developing areas, *e.g*. Africa, East Asia and south America. It is the responsibility of the regulator to prevent this situation, e.g. by creating cross-financing systems and alternatives.

The case study focused on a number of these aspects, and particularly on integration of the possible solutions applicable to developing countries, and which could result in expedition of reaching the MDGs.

In a Water Research Commission (WRC) project to consider strategies for positioning rural water treatment in South Africafor the future, a planning framework was developed. In the framework, a listing of of driving factors (internal and external) impacting on drinking water supply in rural South Africa led to identification of adaptive strategies to mitigate or minimize these impacts. It was decided that this framework also be used as basis to test the adaptive strategies for meeting the MDGs in sub-Sahara Africa due to the driving forces and expected impacts being the same.

5 Case study: Test and validate the integration of adaptive strategies to meet the MDGs: Ilembe, KwaZulu-Natal (Umgeni Water)

To test whether the adaptive strategies that were developed in the planning framework are realistic and whether it can also be applied in sub-Sahara Africa to reach the MDGs, the Ilembe case study was used. The Ilembe District Municipality Bulk Water Supply Scheme was selected 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. A project workshop was held with members of the planning and operational departments of Umgeni Water (one of the Techneau end-users in southern Africa).

5.1 Overview of Umgeni Water (Techneau end-user)

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

The district municipalities within the province of KwaZulu-Natal is shown in figure 5.1.

5.2 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 (see below for more information).

The maps in Figures 5.2 and 5.3 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.

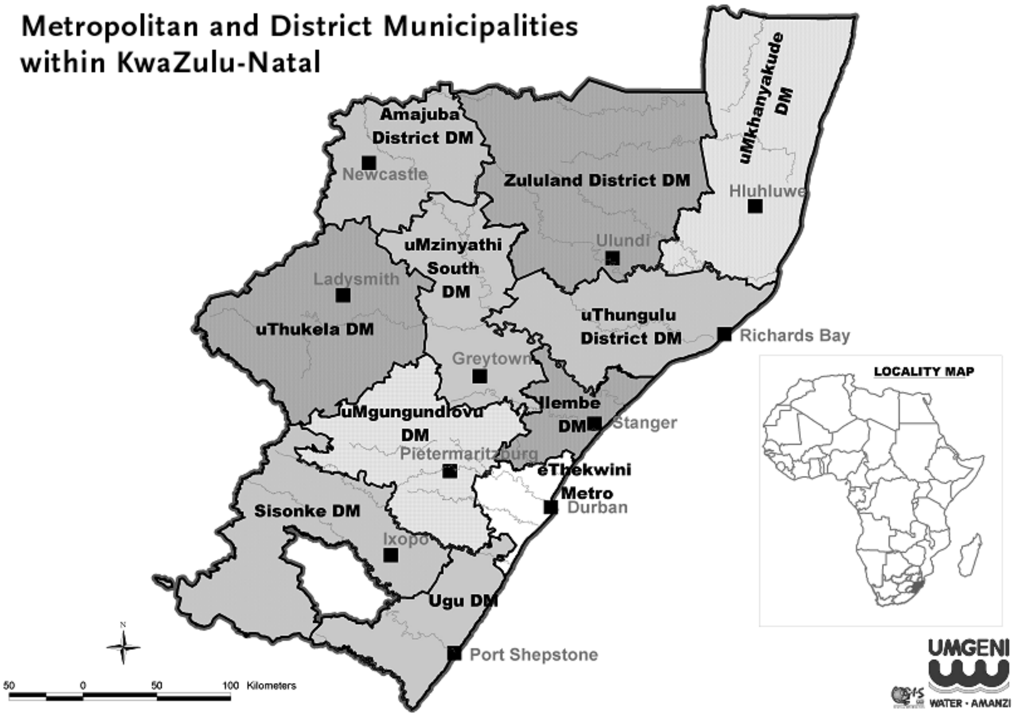


Figure 5.1 District Municipalities in the KwaZulu-Natal Province

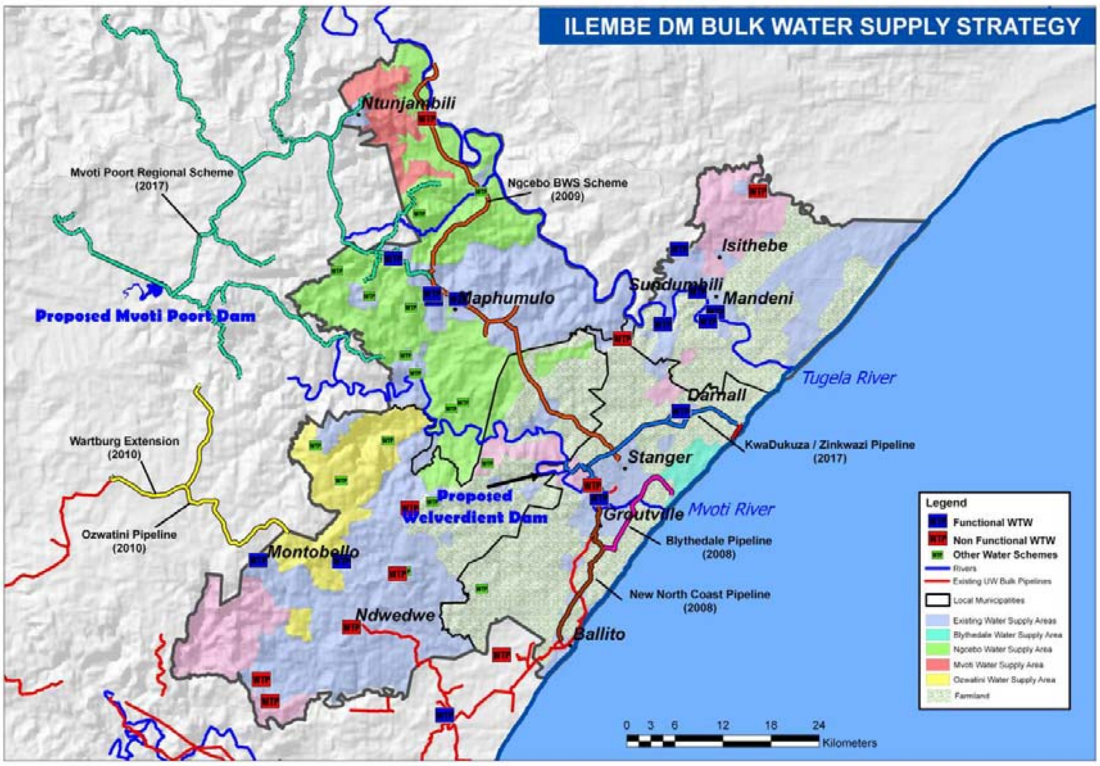


Figure 5.2: Details of Ilembe DM bulk water supply scheme

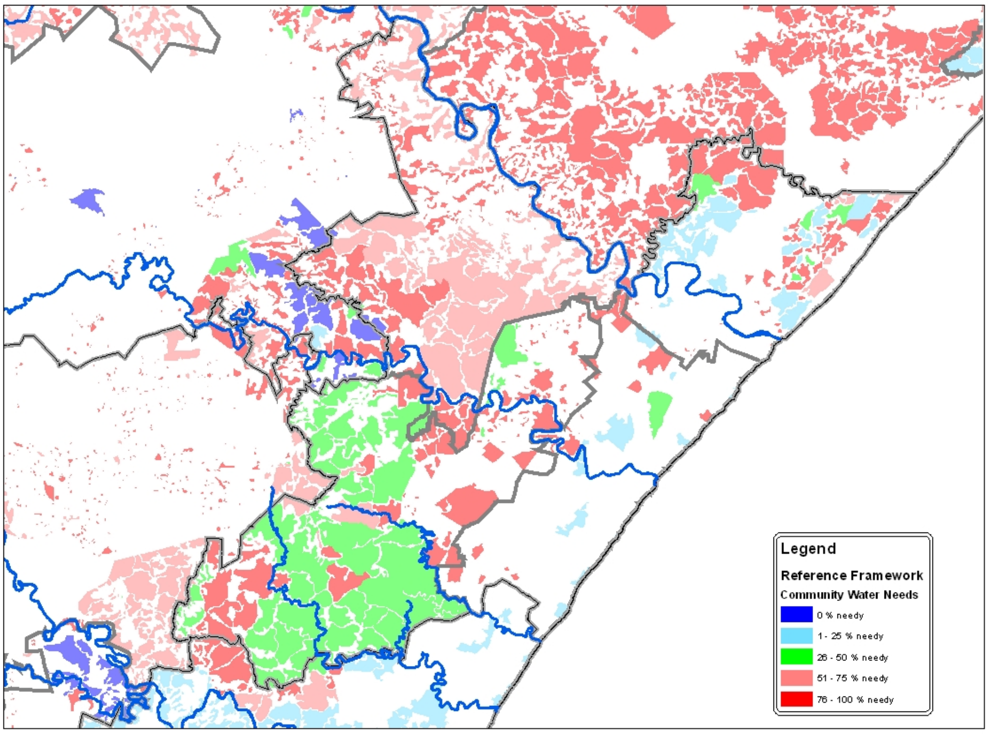


Figure 5.3: Community water needs in Ilembe DM

There are around 37 water supply schemes (points), which consist of water treatment plants, abstraction points and groundwater systems (boreholes and springs) within the 3 Local Municipalities of Ilembe District Municipality. 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.

Table 5.1 provides a list of all the water treatment plants in the Ilembe DM, with capacities, plant description and time scales for tying in with Umgeni Water's regional schemes.

Table 5.1 List of water treatment plants within the Ilembe District Municipality (Oct 2009)

	Location by area	Scheme	AADD (KL/day)	Description	Date of tying into Scheme	Name of Umgeni Regional Scheme
KwaDukuza						
1	KwaDukuza	uMvoti Water Works	12000	Conventional treatment	2020	North Coast Bulk Pipeline (link to Lower Thukela Bulk Water Scheme) & construction of Welverdient Dam
2	KwaDukuza	Bulwer Farm Waterworks	1200	Slow sand filters	2009	To tie into San Souci Scheme of Ilembe DM
3	KwaDukuza	Blythedale Water Scheme	650	Ground water system	2014	Blythedale Pipeline
4	KwaDukuza	Zinkwazi Water Scheme	800	Ground water system	2017	Zinkwazi Pipeline
5	KwaDukuza	Driefontein Water Scheme	55	Ground water system	2015	North Coast Bulk Pipeline
Ndwedwe						
1	Ndwedwe	Montebello Water Scheme	300	Package plant	2014	Ozwathini Bulk Water Supply
2	Ndwedwe	Esidumbini Water Scheme	500	Conventional treatment		Nil
3	Ndwedwe	Emayilisweni Water Scheme	100	Abstraction & disinfection	2014	Ozwathini Bulk Water Supply
4	Ndwedwe	Waterfall Water Scheme	100	Package plant		Nil
5	Ndwedwe	Ntabaskop Water Scheme	150	Slow sand filters	2014	Ozwathini Bulk Water Supply
6	Ndwedwe	Isiminya Water Scheme	150	Slow sand filters		Nil
7	Ndwedwe	Glendale Water Scheme	200	Ground water system	2013	Maphamulo Bulk Water Supply
8	Ndwedwe	Deda / Nkivane Water Scheme	100	Ground water system	2014	Ozwathini Bulk Water Supply
9	Ndwedwe	Phambela Water Scheme	40	Ground water system	2014	Ozwathini Bulk Water Supply
10	Ndwedwe	Glendale Heights Water Scheme	30	Ground water system		Nil
11	Ndwedwe	KwaSathane	30	Ground water system		Nil
12	Ndwedwe	Madundube	40	Ground water system		Nil
Maphamulo						
1	Maphamulo	Vukile	150	Package plant	2011	Maphamulo Bulk Water Supply

2	Maphamulo	Masibambisane Waterworks	350	Slow sand filters	2011	Maphamulo Bulk Water Supply
3	Maphamulo	Mbitane Waterworks	10	Pressure filters	2011	Maphamulo Bulk Water Supply
4	Maphamulo	Mushane Waterworks	50	Pressure filters	2011	Maphamulo Bulk Water Supply
5	Maphamulo	Mphumulo Waterworks	300	Package plant	2011	Maphamulo Bulk Water Supply
6	Maphamulo	Isithundu Water Scheme	100	Abstraction & disinfection	2010	Isithundu WW Upgrade
7	Maphamulo	KwaMxhosa Water Scheme	64	Ground water system	2011	Maphamulo Bulk Water Supply
8	Maphamulo	Mphise Water Scheme	50	Abstraction only	2011	Maphamulo Bulk Water Supply
9	Maphamulo	Ntumjambili Water Scheme	20	Ground water system	Nil	Nil
10	Maphamulo	Ntumjambili Phase 1&2	1000	Ground water system	Nil	Nil
11	Maphamulo	Thafamasi Water Scheme	20	Ground water system	2011	Maphamulo Bulk Water Supply
12	Maphamulo	Maqumbi / Otimati Water Scheme	153	Ground water system	2011	Maphamulo Bulk Water Supply
13	Maphamulo	Vuleka Water Scheme	20	Ground water system	2011	Maphamulo Bulk Water Supply
14	Maphamulo	Esindi Water Scheme	100	Slow sand filters	2011	Maphamulo Bulk Water Supply
15	Maphamulo	Ekwazini Water Scheme	50	Ground water system	Nil	Nil
16	Maphamulo	Balkomb Water Scheme	20	Ground water system	2013	Maphamulo Bulk Water Supply
17	Maphamulo	Ndukwende Water Scheme	10	Ground water system	2013	Maphamulo Bulk Water Supply
18	Maphamulo	Ngididi Water Scheme	30	Ground water system	2013	Maphamulo Bulk Water Supply
19	Maphamulo	Menyezwayo Tribal Court Water Scheme	50	Ground water system	Nil	Nil
20	Maphamulo	Ocheni Water Scheme	20	Slow sand filters	2014	Ozwathini Bulk Water Supply

5.3 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 process controllers and samplers 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 centralised laboratory.

5.4 Testing the planning framework for rural water supply in Sub-Sahara Africa towards reaching the MDGs

Identification of the driving factors that have an influence on the rural water supply, both now but especially in the future, led to the conclusion 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 analyze by manual methods or simple models. It was therefore necessary to apply more sophisticated software to analyze the situation.

The Think Tools decision-support system (now called Parmenides EIDOS) was used. It is supported by the Centre for Knowledge Dynamics and Decision-making of the University of Stellenbosch (US). DWA 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 methodology for the overall development of the planning framework is described below, indicating the various steps that were followed.

5.5 Methodology for development of the Planning Framework

The following steps were followed in developing the framework:

a. Evaluate the status quo in South Africa 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 consideration 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**rganizational, **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 (and to reach the MDGs in this instance).

d. Develop the planning framework, using the EIDOS software.

5.6 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, and the stake-holder of the Water Research Commission (a partner of the TECHNEAU project), 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**

5.6.1 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 vizualisation of the overall task flow for the process.

The overall process or task flow is as follows:

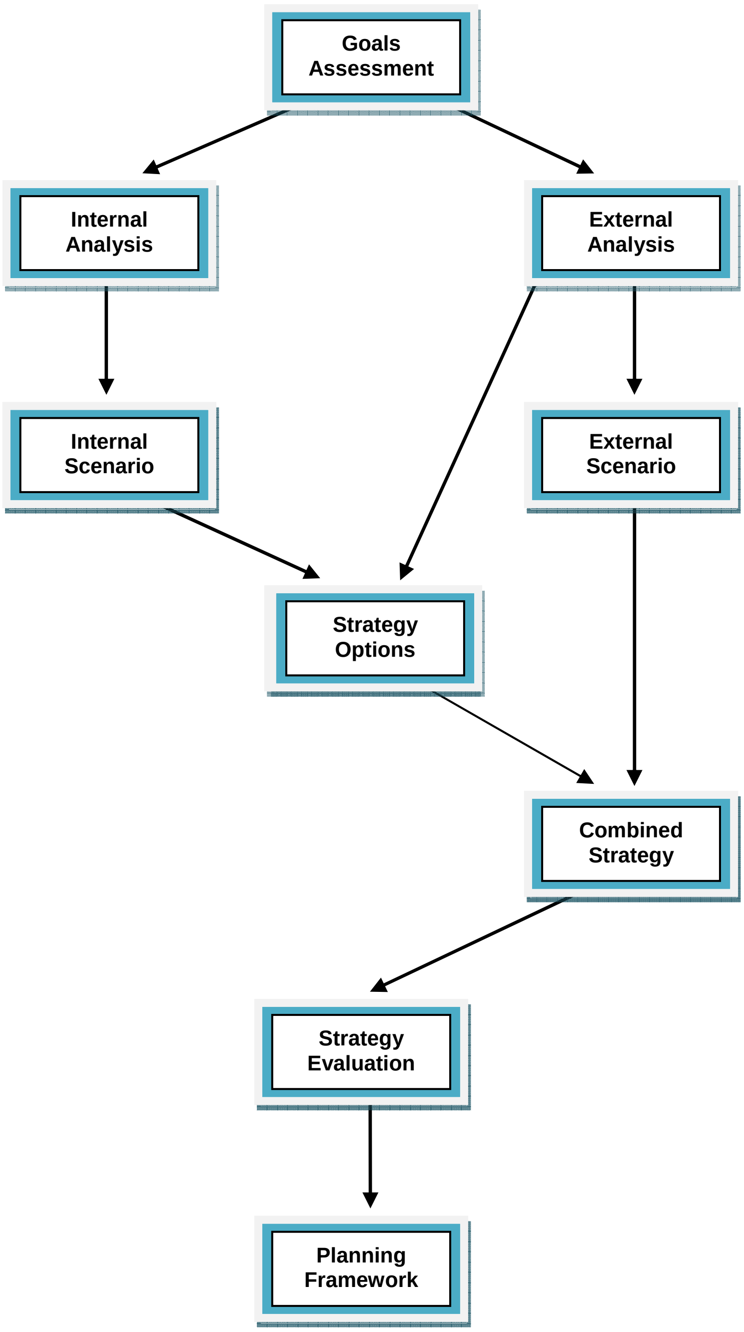


Figure 5.4 Decision architecture: overall process flow diagram

5.6.2 Goals Assessment

For this study, the process consisted firstly of assessing the MDGs. Three time frames ("views") were considered, viz. 1 year (2010), 3 years (2012) and 10 years (2019). The following goals were set for applying the rural water framework :

a. ***Safe drinking water***

b. ***Appropriate technologies***
   - energy efficient
   - easy to operate and maintain

c. ***Skilled and qualified human resources***
   - technical
   - management

d. ***Cost-effective***
   - capital cost
   - operating cost

The overall goals with respect to the Techneau project is also to the consider the following with regarding to applicability of the adaptive strategies:

Integration
Flexibility
Consideration of local conditions

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

5.6.3 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.

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).

a. ***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[O&M]
- Availability of training service providers
- Lack of proper operation and maintenance [O&M]
- Deteriorating infrastructure [O&M]
- Deterioration of raw water quality
- National and local level policies and planning [DECENTR.]
- Legislation [DECENTRALISATION]
- Management level incompetency [O&M]
- Poor image of municipal water sector
- Lack of funds / mismanagement of funds [FINANCING]
- Political interference
- Management level motivation
- Rising cost of energy [ENERGY]
- Availability of energy (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 the diagram below:

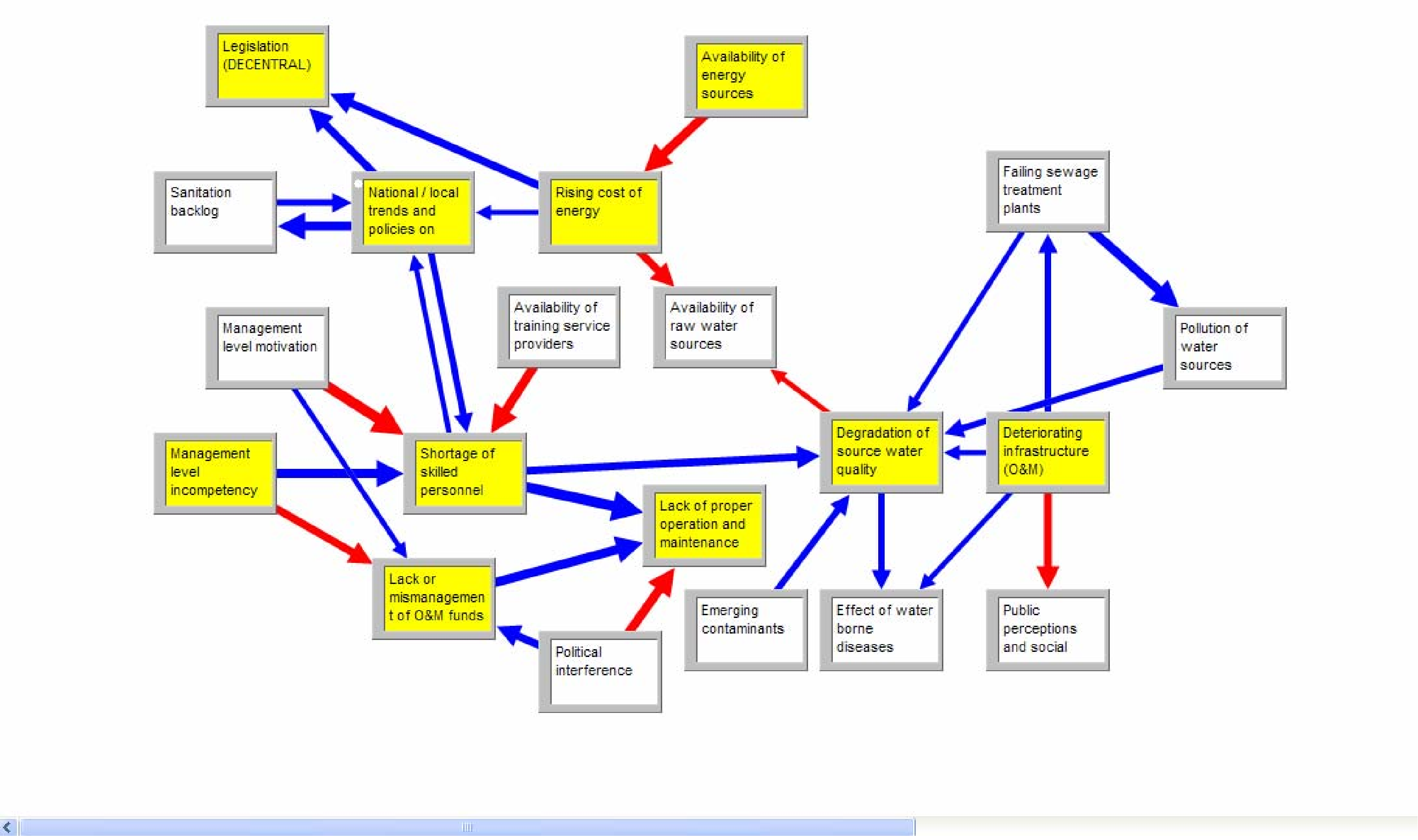


Figure 5.2 Internal factors

b. <u>Situation Analysis: External factors</u>

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

- <u>High population growth (DECENTRAL)</u>
- <u>Urbanisation (DECENTRAL)</u>
- <u>Climate change (severe droughts; floods) [CLIMATE]</u>
- Poor global economy
- Life-style changes
- Impact of HIV / AIDS
- <u>Poverty in rural areas [FINANCING]</u>
- Surface water shortages
- <u>Water stress [CLIMATE]</u>

The internal factors and their inter-relationships are shown in the diagram below:

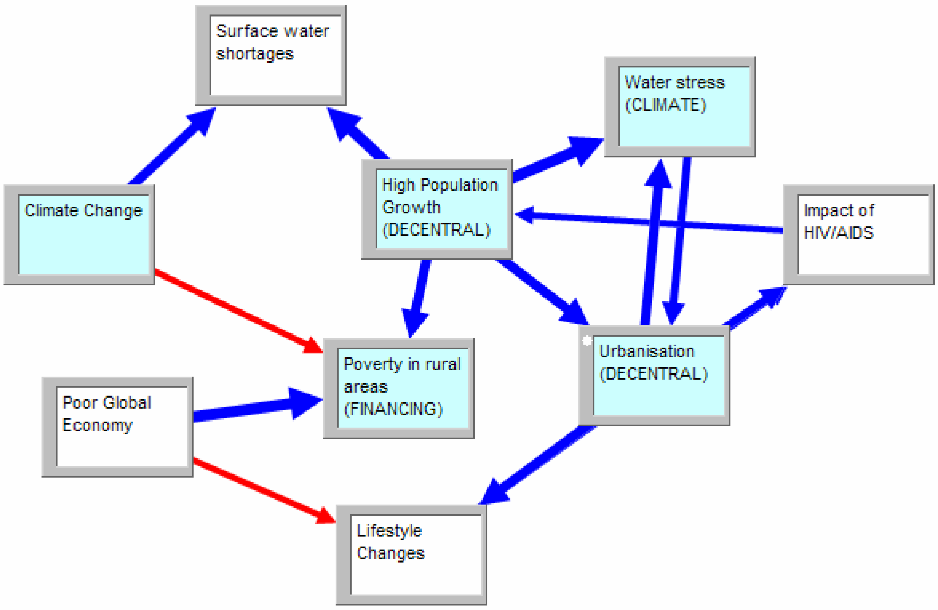


Figure 5.3 External factors

5.6.4 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.

The scenario's for the internal and external factors are provided below. From the internal and external analyses and scenario's, 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 scenario's 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.

a. <u>Options Development: Internal Scenario</u>

In considering the possible internal scenarios for the water sector over the next decade, 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.

- 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

b. Options Development: External Scenario

For the external scenarios, 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

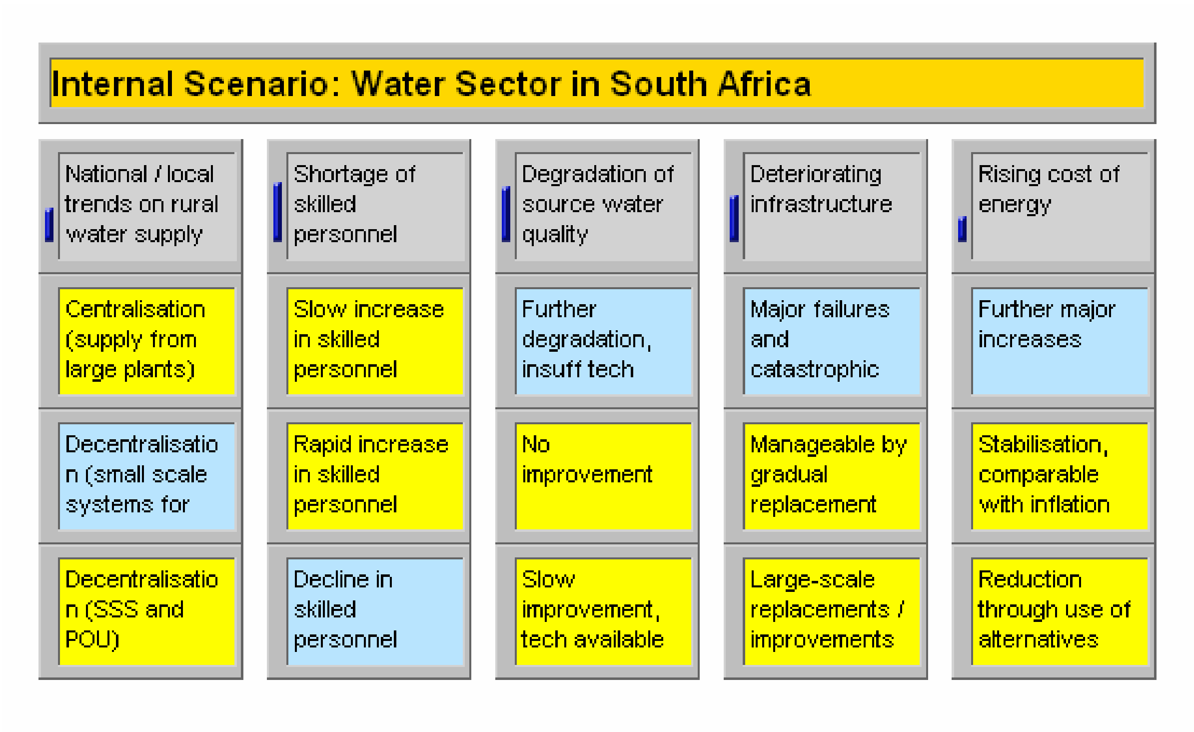


Figure 5.4 Internal scenario for the water sector in South Africa

b. Options Development: External Scenario

For the external scenarios, 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

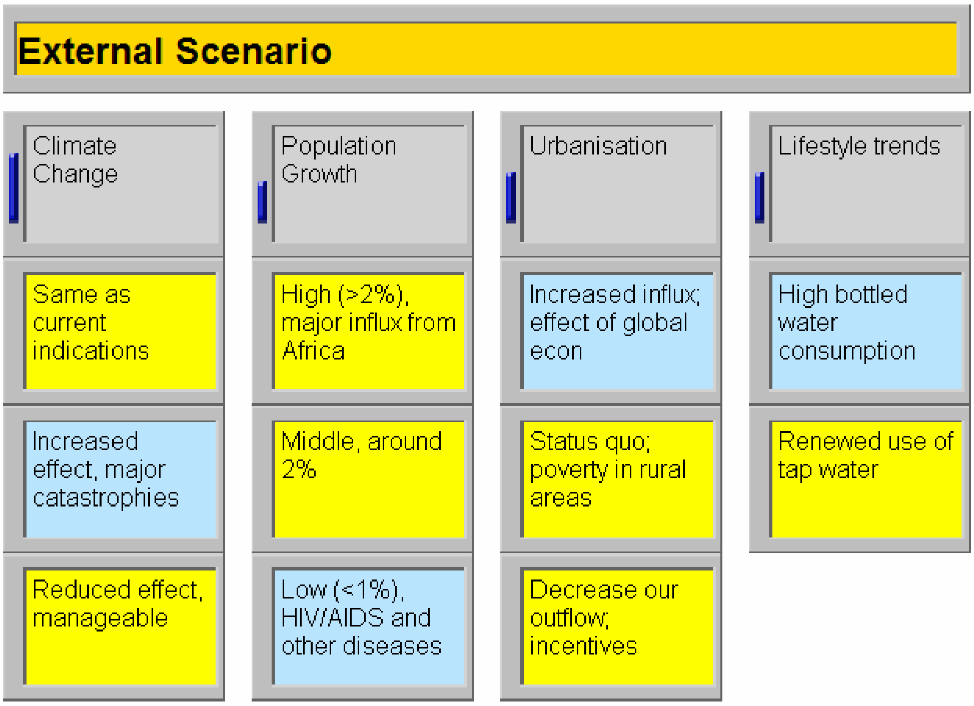


Figure 5.5 External scenario for the water sector in South Africa

c. *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 B.Tech 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.

<u>Skills Development Training through Learnerships</u>
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.

<u>Mentorship Programmes</u>
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.

d. *Options Development: Combined Strategy/Scenarios*

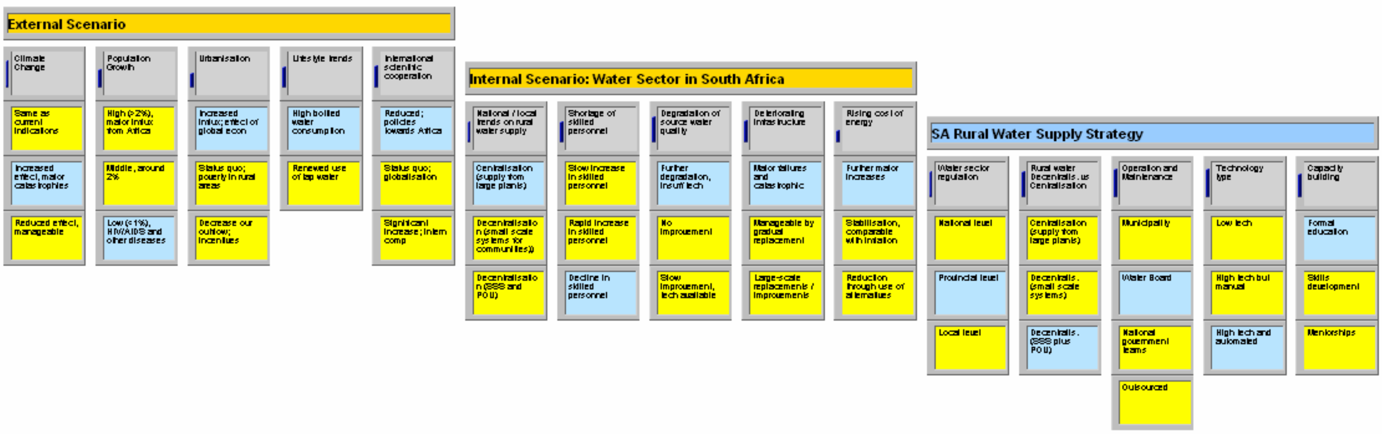


Figure 5.6 Combined strategies and scenarios

The strategy results in the right hand of the option space are enlarged below:

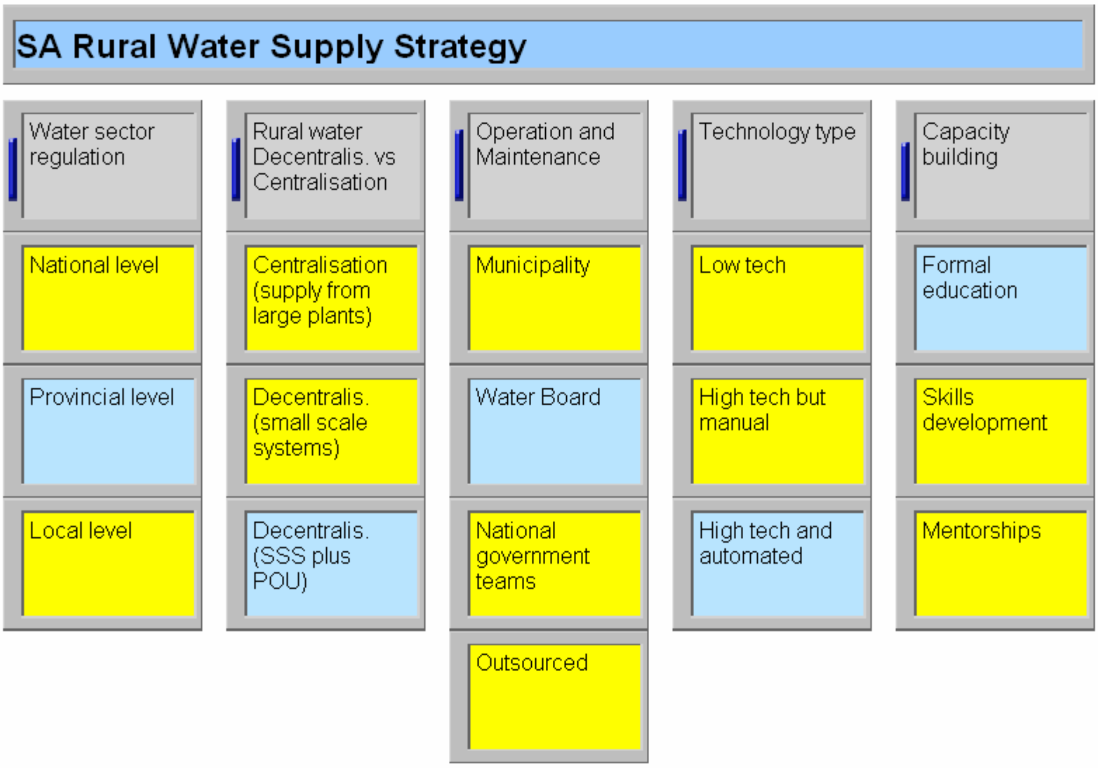


Figure 5.7 The South African rural water supply strategy

5.6.5 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:

A. 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.

B. *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.

C. *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 A to C are shown in the diagram below (Techneau, 2008).

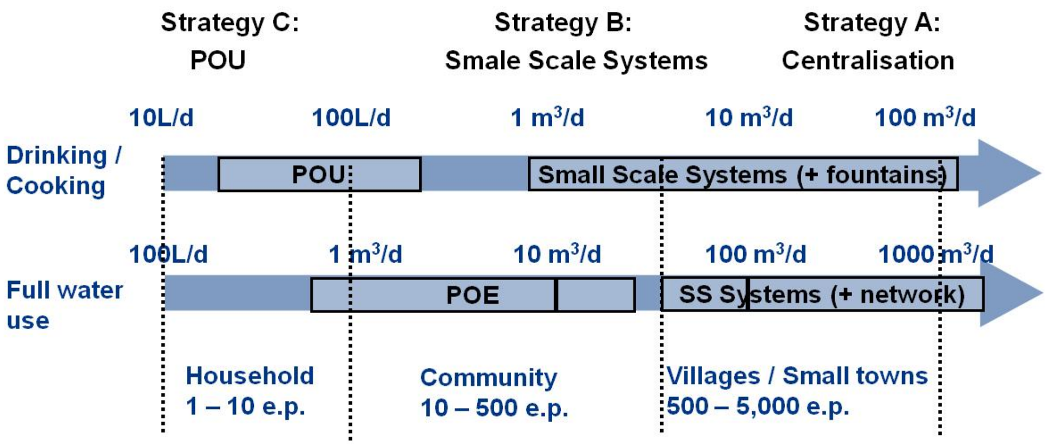


Figure 5.9 Internal scenario for the water sector in South africa

Each of the three strategies were then rated against the goals that were set for sustainable rural water supply and treatment (see 5.6.2), 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 below.

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).

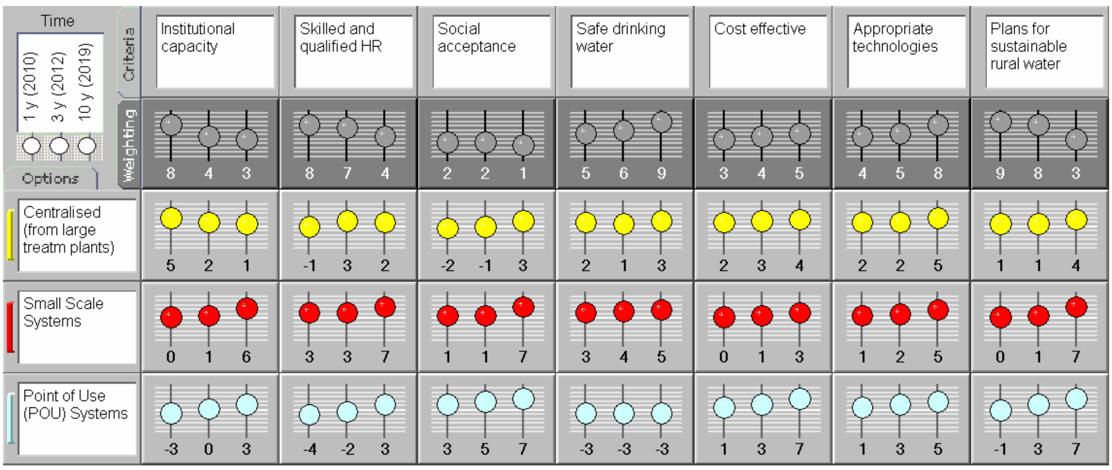


Figure 5.10 Ratings for the different scenarios and different time frames

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 below.

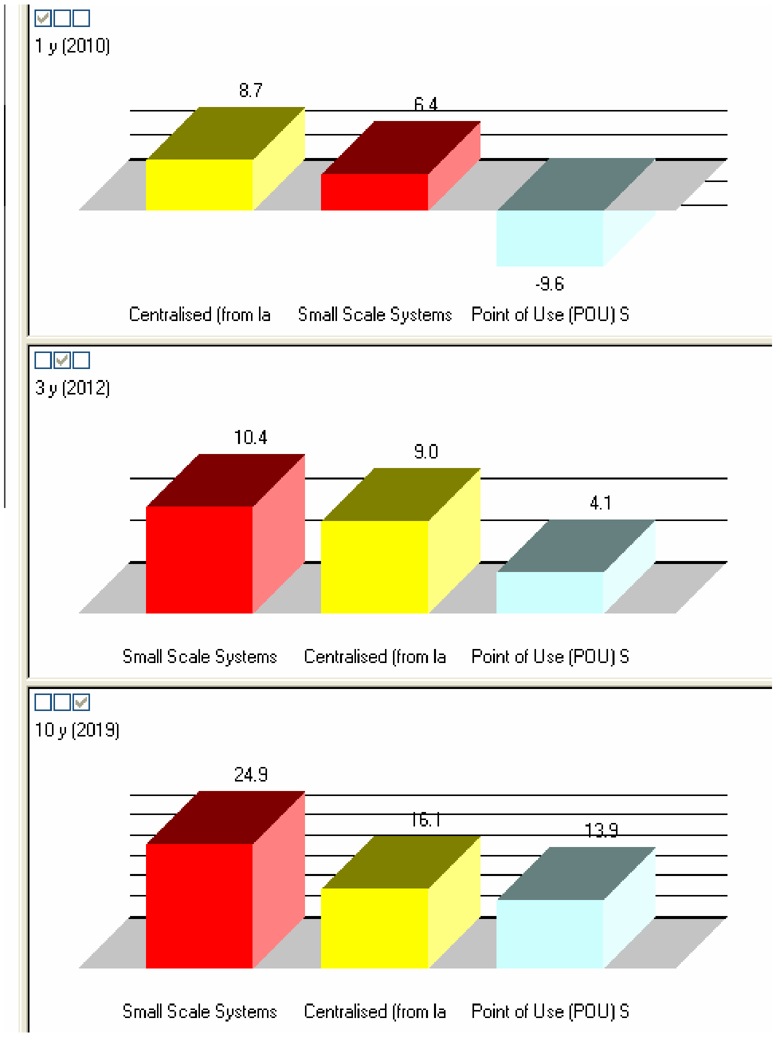


Figure 5.11 Ranking analysis results for the three scenarios

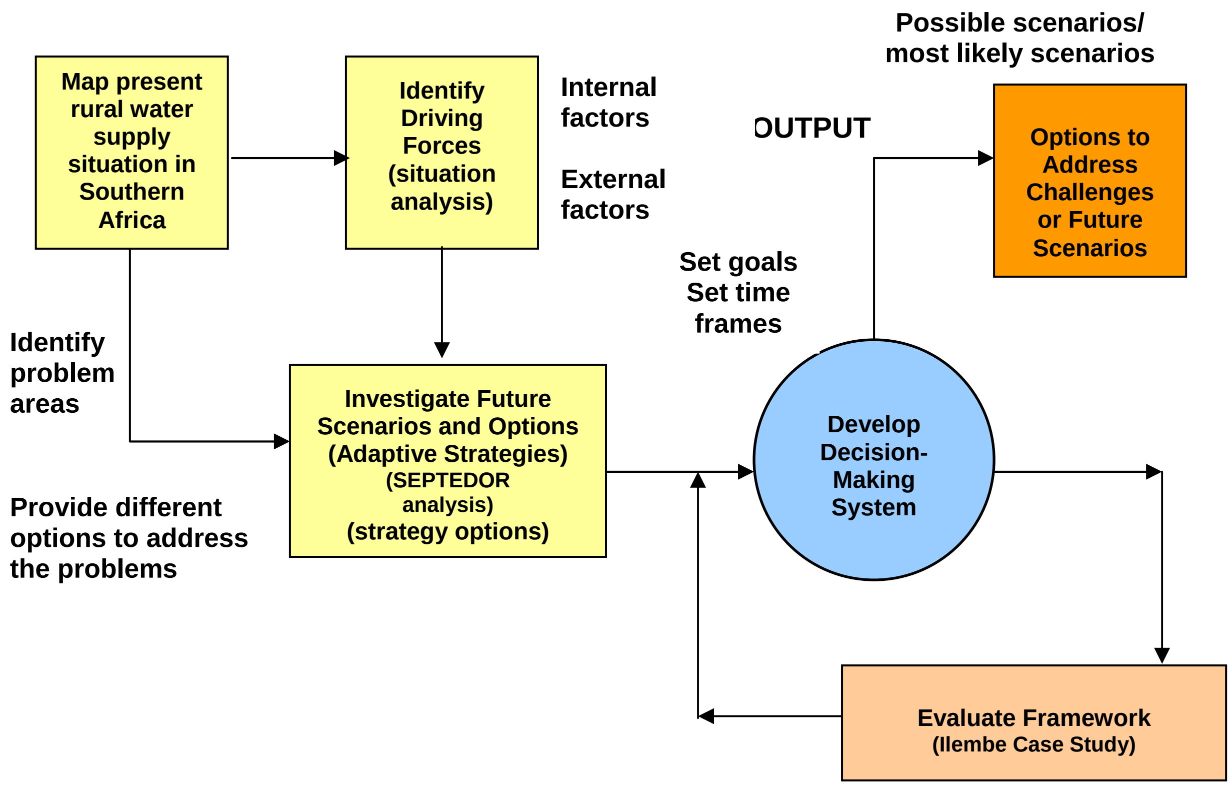
The results of analysis of the three decentralised versus centralised treatment scenarios shows that at present, centralised water supply is still being applied most and the supply system of choice. The main reason for this would be lack of capacity in local communities to operate and maintain decentralised 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.

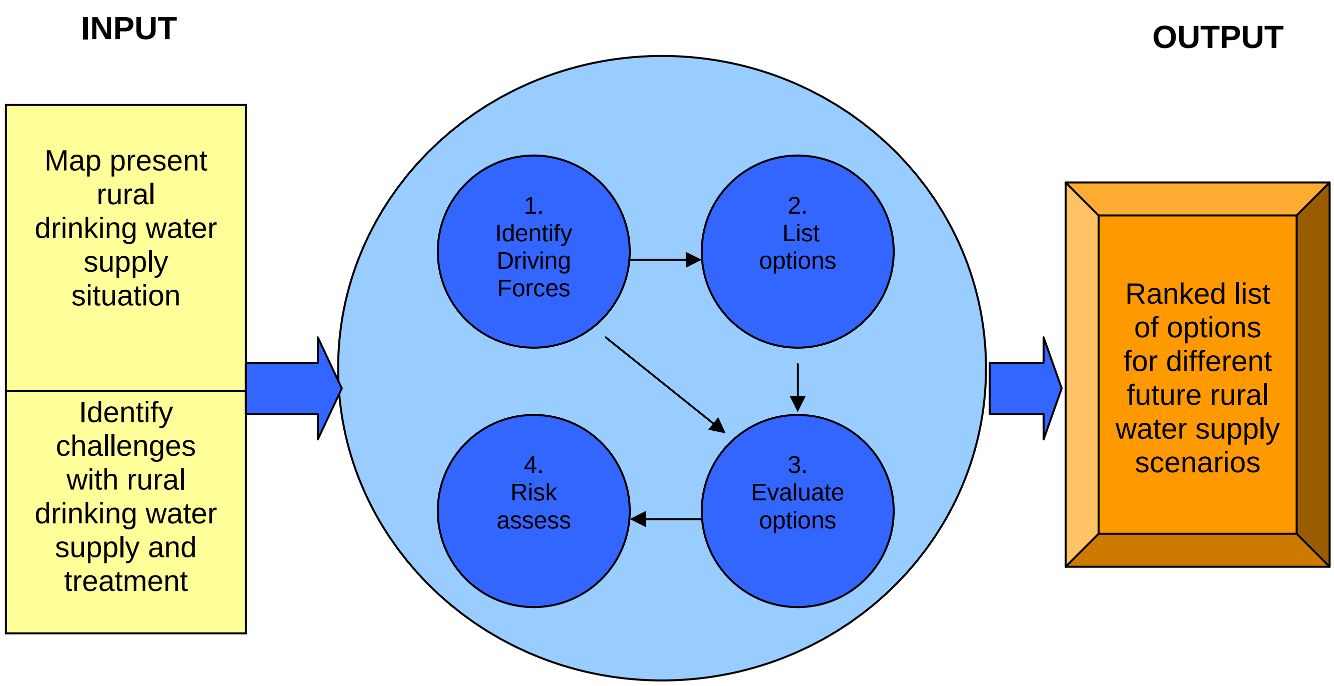
With considerable focus currently on research on and developing guidelines for decentralised systems (including wastewater treatment systems), the results show that in the three year time frame, small scale treatment systems will have gained popularity with DWA, WSAs and design engineers, and that there 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.

5.6.6 Planning Framework

Flow diagrams showing the reasoning process for the decision-making system (planning framework) for rural water supply in the future





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

As mentioned earlier, Umgeni Water's response to this challenge with respect to reducing water and sanitation backlogs in rural areas within KwaZulu-Natal focuses on:

(a) infrastructure delivery
(b) sustainable water supply at household level
(c) integration of water, sanitation, health and hygiene issues
(d) role of community management

All four of the above focus areas of Umgeni Water relates to the strategic choice of decentralisation for improved service delivery and to reach the MDG's in their area of jurisdiction. 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.

5.7.1 Decentralisation and centralisation

As an extension to 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 effective from 1 July 2009. 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.* decentralized water supply schemes) will be decommissioned. This will therefore represent a move from decentralized plants to centralization. However, strategic planning is still in process to establish which treatment schemes would be more feasible (and sustainable) as stand-alone schemes (decentralization), rather than tying in with the regional schemes (Thompson, 2007).

Some of the challenges experienced by Ilembe DM on the wide-spread decentralized 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 accessability 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 centralized supply versus decentralized schemes.

5.7.2 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 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.

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

a. Management

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).

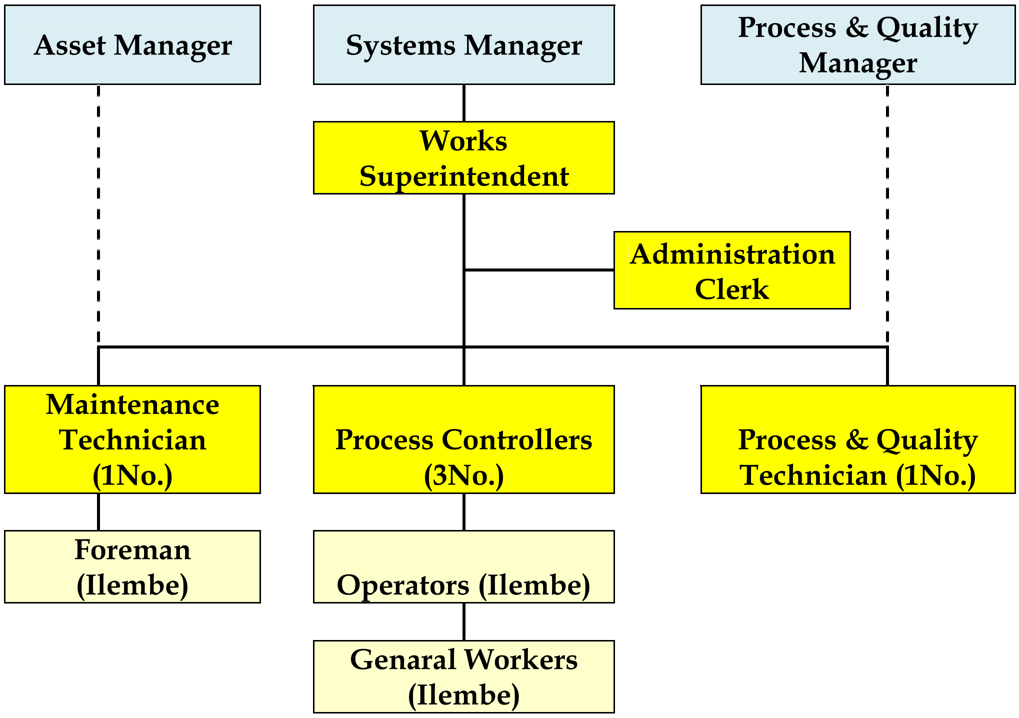


Figure 5.15 Proposed organogram for Ilembe treatment plant O&M

b. Works Operations

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.

5.7.3 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 (decentralized 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 decentralized 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.

5.8 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.

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