Qualitative assessment of municipal water resource management strategies under climate impacts:
the case of the Northern Cape, South Africa

[to be published in *Water SA*, Vol.33 No 4, July 2007]

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Abstract

This paper considers existing coping strategies in times of climate variability and proposes long term strategies for dealing with future projected climate change and variability. A qualitative strategy assessment methodology is proposed and tested for climate conditions in the Northern Cape.

The analysis of the results suggests that dry sanitation, education projects and tariff structures are identified as being the most useful strategies.

Key factors which were perceived to inhibit the implementation of appropriate drought adaptation strategies are the lack of local capacity and the low financial resource base to cover the capital and running costs of most of the strategies.

With the likelihood of increased future rainfall variability, it is important that planners and decision-makers take into account the effects of climate change and variability on water resources. In so doing, they need to adopt sustainable water supply and demand solutions for the longer term.

Keywords: climate change, climate variability, water resource management, Northern Cape

Introduction

South Africa is classified as a water-stressed country, with an average annual rainfall of around 500mm, which is less than 60% of the world average (DWAF, 1994). In addition, South Africa's growing water demand is rapidly outstripping its natural availability. In 2004, 11 of the 19 Water Management Areas (WMAs) in the country were facing water deficits (Otieno FAO & Ochieng GMM, 2004). In the Northern Cape for example, many local municipalities resorted to providing water by road tanker water to communities whose groundwater supplies had been reduced due to drought conditions.

Increased climate variability is expected to alter the present hydrological resources in southern Africa and add pressure on the availability of future water resources. Scientific evidence confirms that climate change is already taking place and that most of the warming observed during the past 50 years is due to human activities. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), global surface temperature is estimated to have increased by 0.74°C over the past 100 years, with the last 50 years being twice that of the past 100 years. Superimposed on these changes are seasonal, annual and inter-annual variabilities, producing a complex climate variability and change signal.

To a large extent, the implications of climate change in South Africa have not yet been fully and explicitly considered in current water policy and decision-making frameworks. The financial, human and ecological impacts of climate change are potentially very high, particularly where water resources are already highly stressed in many areas, while the capacity to cope and adapt is not consistently high (Schulze, 2005). Based on the climate projections for South Africa, the most severe drought impacts are likely to occur in the western part, where small towns and subsistence farmers will be most vulnerable (Hewitson et al., 2005).

This paper is based on a recent study (Mukheibir & Sparks, 2006) and investigates the potential water resource management strategies in response to climate variability and change by drawing on the analysis of coping strategies adopted by small local municipalities in the Northern Cape province of South Africa in times of drought. To establish which strategies enable long-term resilience to climate change impacts they are measured qualitatively against various development criteria.

Specifically the paper:

- Proposes a methodology for qualitatively assessing water supply strategies under climate variability and change
- Documents existing coping strategies in times of climate variability (drought) in small towns in the Northern Cape
- Identifies long-term strategies for dealing with the impacts of predicted climate change in small towns in the Northern Cape
- Discusses the barriers to implementing these strategies.

Background

In 2000, the Northern Cape Province supply vs. demand ratio illustrated that water vulnerability exists in the province by effectively recording an undersupply of 8 million m^3 (DWAF, 2004b). Demand issues such as increased water use, peak use, seasonal variability, poor demand side management, poor water use planning, poor conservation and water losses have in the past contributed to water shortages in the Northern Cape (Van Dyk, 2004). Poor planning for emergencies and the lack of structured contingency plans have resulted in water shortages during times of rainfall variability.

This resulted in approximately 25% of the towns in the Northern Cape over-utilising their sustainable groundwater resources in 2000. Strydenburg, Van Wyksvlei and Kammieskroon were particularly vulnerable, using up to 180% of the recommended yield (Van Dyk, 2004). Van Dyk recommends using 80% of the available sustainable yield to ensure that there are sufficient resources for future growth in demand as well as providing a buffer to drought periods.

In addition, a predominant problem that occurs in most water scarce towns is that very little co-operation is received from residents with regards to water saving and change of water use patterns, since a large majority understand there to be no limit on their demand for water. Further, the supply of water has become a political issue and elected councillors are reluctant to impose punitive measures on residents to curb the water demand.

It is not clear to some local authorities whose responsibility it is to plan for drought conditions – local or national government, water services authorities or providers, or the water catchment management authorities. Water resource planning is generally not a priority until water supplies are strained due to drought conditions. The lack of capacity at local government level results in a dependency on consultants for the planning skills.

Climate variability and change for the Northern Cape

Climate variability can be thought of as the way climatic variables (such as temperature and precipitation) depart from some average state, either above or below the average value. Although daily weather data depart from the climatic mean, the climate is considered to be stable if the long-term average does not significantly change. On the other hand, climate change can be defined as a trend in one or more climatic variables characterized by a fairly smooth continuous increase or decrease of the average value during the period of record (IPCC, 2001).

The Northern Cape is characterized by a harsh climate with minimal rainfall and prolonged droughts. The area's arid climate is accompanied by high evaporation due to the intense heat of the summer months. The mean annual precipitation ranges between 20mm on the west coast to approximately 300mm on the eastern side (V3 Consulting & WRP, 2002).

Rainfall variability is particularly pronounced over the dry western parts of South Africa, where a dry year can have significant repercussions. Furthermore, extreme dry years tend to be more frequent in the driest regions of the country. The variability in rainfall is pronounced over the Northern Cape (Tyson, 1986).

As can be seen by the examples of Calvinia (Namakwa - winter rainfall region) and Kenhardt (Siyanda - summer rainfall), as illustrated in Figure 1 precipitation displays a high degree of inter-annual variability, with periods of more plentiful rainfall followed by periods of drought. The intermittent single extreme events skew simple analyses, and hence precipitation is difficult to analyse in terms of trends. This makes planning for times of drought difficult yet essential, since with large inter-annual variabilities there are no rainfall guarantees in any year.

Further climate variability is expected to increase under future climate change scenarios. By the year 2050, higher temperatures of between 1-3 °C are predicted over the whole of South Africa, with greatest increases in the arid zones towards the west and central regions, and least increases in the coastal regions. Precipitation projections for southern Africa, as provided by empirical and regional climate model-based downscaling tools, indicate a wetter escarpment in the east, a shorter winter season in the southwest, a slight increase in intensity of precipitation, and drying in the far west (Hewitson et al., 2005).

Climate change studies inherently have to consider the significance of uncertainty. This does not mean that there is no confidence in the understanding, or that the understanding is not certain enough to allow for the development of appropriate adaptation strategies and policies for resource management. Rather, current research would suggest that the political and planning response is lagging the understanding of climate change (Midgley et al., 2005).

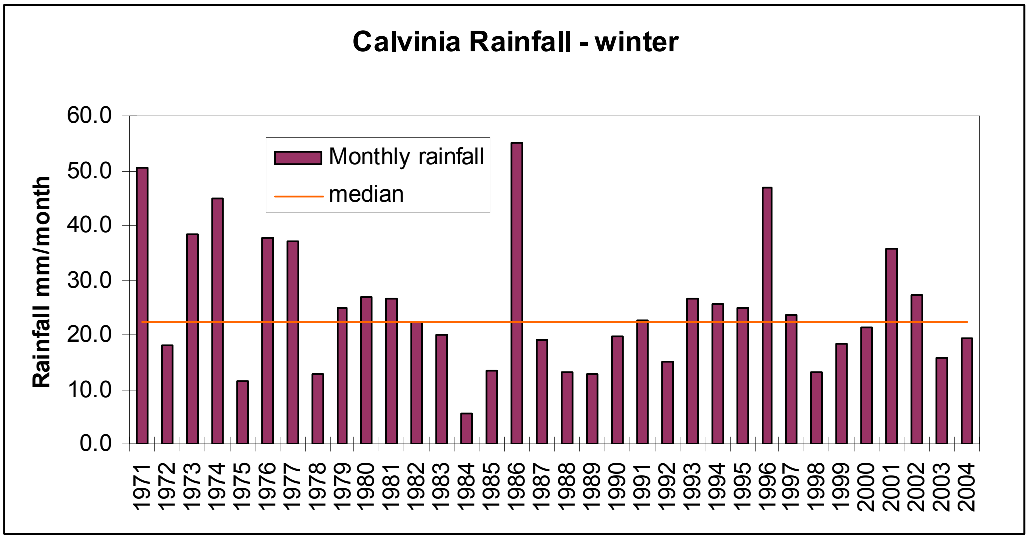

Figure 1: Average winter monthly rainfall trends for Calvinia between 1971 and 2004

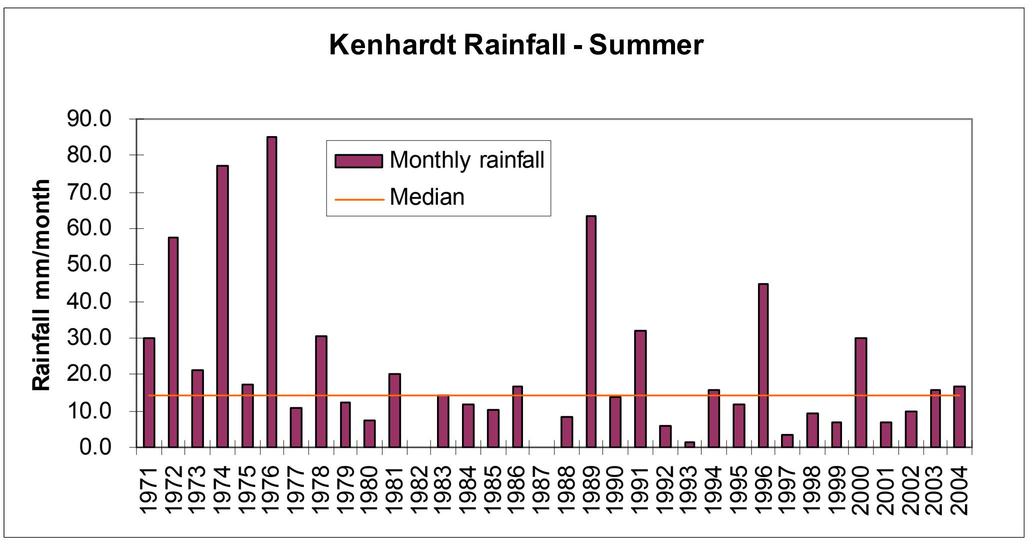

Figure 2: Average summer monthly rainfall trends for Kenhardt between 1971 and 2004

Impact of climate change on groundwater

The South African Country Study on Climate Change (Kiker, 2000) found that when running global circulation models (GCM) and the Agricultural Catchments Research Unit model (ACRU) (Schulze & Perks, 2000), runoff was found to be highly sensitive to changes in precipitation. Groundwater recharge was found to be even more sensitive. Under one of the hotter drier GCM scenarios, decrease in runoff of up to 10% in some areas could be experienced. A decrease of this magnitude could occur in the western area of the country by as early as 2015.

Climate change is expected to have a bigger impact on groundwater resources than do weather variables, as groundwater is buffered against short-term variations (Cave et al., 2003). In drier areas where annual rainfall is less than 500 mm, a 10% decrease in rainfall could translate into as much as a 40% decline in recharge. This has serious implications where rainfall is already low, and is predicted to decrease with projected future climate change and where groundwater is over-exploited at present.

Using long-term records of past climate-recharge interactions is difficult to apply in southern Africa, since there are very few locations where records of climate and groundwater have been kept in sufficient detail to allow for this analysis (Selaolo et al., 2003).

Methodology for long-term strategy development

A key challenge to water security is the reconciliation of water demand and supply both for the medium and long term. Short term responses might be seen as coping strategies, whereas longer term actions that help to deal with future variability under climate change could be collectively called adaptation strategies.

Callaway (2004) suggests that there are more conceptual similarities than differences between the adjustments that are made to cope with climate variability and those made to adapt to climate change. The obvious similarity is that the aim of both types of actions is to avoid meteorologically induced damages when predicting them is subject to some error. Both actions have the potential to improve society, whilst making decisions under some risk, both involve reallocating scarce resources to make the adaptive adjustments. The major difference, according to Callaway, between variability and change is that historical records are more reliable for planning for variability than the reliability attached to climate prediction models. The variability in the existing climate is much easier to plan for than the variability associated with alternative climates.

By applying an initial filtering tool (as is illustrated in Figure 3) which is qualitative, the responses to climate variability can be evaluated for their long term suitability to ensuring resilience to future climate impacts, and also ensuring that the local development goals are achieved.

The highest ranked options should then be evaluated against quantitative criteria such as capital and operational costs, cost effectiveness in R/kℓ and volume water actually provided or saved. The most commonly used tools for this are cost benefit analysis (CBA) or cost effective analysis (CEA).

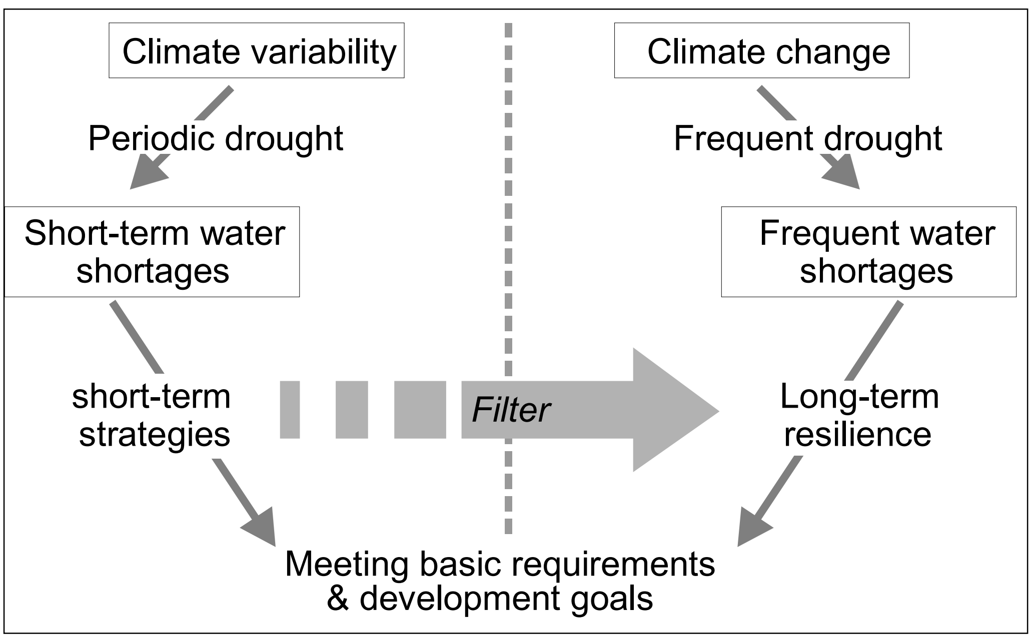

Figure 3: Diagrammatic view of the relationship between climate variability and climate change

Criteria for analysis

By using a number of qualitative criteria against which the strategies would be rated would ensure that those selected addressed the development goals as well as the demands of the customers. The challenge is to use a tool that deals with conflicting decision making in a structured and systematic manner. Resource management usually involves variables which cannot be fully quantified, but are nonetheless determinant factors in the decision making. In such cases multicriteria decision analysis (MCDA) is considered to be the quickest and most appropriate method for addressing vulnerability strategies. Pietersen (2004) cautions that the application of MCDA methods in water resource management should be used circumspectly by planners and decision-makers, since the tool should not be viewed as a "black box".

By using the MCDA methodology the strategies most likely to be appropriate to the Northern Cape were identified. This was done in consultation with representatives of the various Local Municipalities in the Northern Cape Province and members of the Provincial Drought Task Team and involved defining a number of selection criteria.

The National Department of Water Affairs and Forestry (DWAF) have set a number of objectives against which strategies to influence the water demand and usage of water should be measured (DWAF, 2004a) viz.:

- economic efficiency;
- social development;
- social equity;
- environmental protection;
- sustainability of water supply and services;
- political acceptability.

These were further expanded for this study and the list of criteria given in Table 1 was developed and discussed with the stakeholders.

Table 1: Definitions of criteria for strategy analysis

Additional yield / saving	How will the intervention impact on water supply through additional yield and/or savings?
Technology required	Is the technology for the intervention readily available?
Additional capital expenditure	Will the intervention require additional capital expenditure?
Additional running costs	Will the intervention incur additional running costs?
Local employment	To what extent will the intervention impact on job creation?
Local capacity to implement	What level is the institutional capacity currently at with respect to the intervention?
Acceptability to local community	What is the consumer acceptability of this intervention in terms of additional cost to them and convenience?
Impact on local water resources	What impact will the intervention have on the water resources and the environment in the area?
Long term applicability	What is the period of impact of the intervention? (short - long term)

The ninth criteria, long-term applicability, was included as final screen to establish which strategies have the potential to address long term climate change impacts.

The criteria were weighted from 1 to 5, where 1 was deemed to have a low importance, and 5 a high importance. In Figure 4 the relative weight is provided. As can be seen from the figure, different sectors placed varying importance on the different criteria for evaluating the strategies. A good example of this would be local employment, where the local government officials placed a higher priority on this weight compared to the officials from DWAF. (It should be noted that the officials were responding in their private capacities).

Almost all parties agreed that the following were of highest importance, i.e. > 3.5:

- additional yield/saving
- additional capital expenditure
- additional running costs
- acceptability to the local community
- impact on local resources
- long term applicability.

It is interesting to note that the criteria for local employment received the lowest weighting. This may be attributed to the fact that those present at the meetings were not local councillors, who would be in direct contact with local beneficiaries.

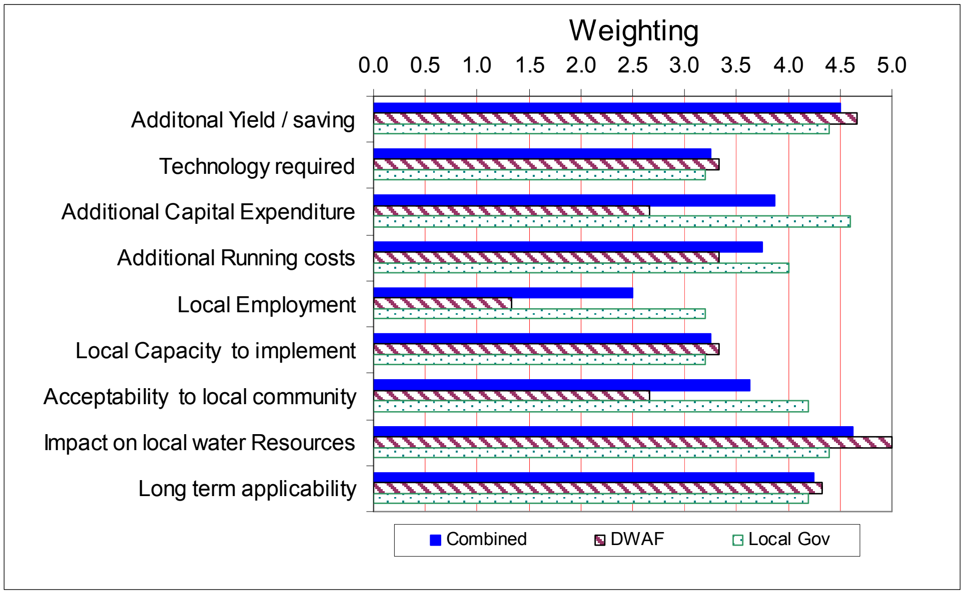

Figure 4: Graphical representation of weightings for criteria

For each criterion, the strategies were scored against the ranges shown in Table 2.

Table 2: Ranges for scores against the criteria

1. Additional yield / saving	1 = None 2 = Low 3 = Significant 4 = Very high
2. Technology required	1 = Not available 2 = must be imported 3 = available in SA 4 = locally available 5 = already installed
3. Additional capital expenditure	1 = High cost 2 = medium cost 3 = Low cost 4 = No cost
4. Additional running costs	1 = High costs 2 = medium costs 3 = Low costs 4 = No O&M costs
5. Local employment	1 = Loss of jobs 2 = Neutral 3 = Few jobs (<10) 4 = Many jobs (10-30)
6. Local capacity to implement	1 = Very low 2 = Low 3 = Adequate 4 = High

7. Acceptability to local community	1 = None (high additional costs) 2 = Low (some additional costs or inconvenience) 3 = Neutral 4 = High (no additional costs)
8. Impact on local water Resources	1 = Negative 2 = Neutral 3 = Positive 4 = Highly positive
9. Long term applicability	1 = <2 years 2 = 2-5 years 3 = 5-15 years 4 = 15-25 years 5 = >25 years

Identification of strategies

Eight Municipalities in three district municipalities were identified in the Northern Cape as being drought prone viz. Pixley ka-Seme (Karoo)(DC7): Kareeberg; Namakwa (DC6): Hantam, Kamiesberg, Khâi-Ma, Nama Khoi, Richtersveld, Karoo Hoogland; and Siyanda (DC8): Kai! Garib (Van Dyk, 2004; Visser, 2004). Interviews were held with relevant stakeholders and consultants who operate in this region in order to capture the current measures adopted to ensure an adequate supply of water in times of drought. A list of strategies was compiled that best represented those currently being implemented at a local level, as well as others being implemented in other parts of South Africa (Element Raadgewende Ingenieurs, 2001; Karoo District Municipality, 2003; Ninham Shand & Octagonal Development, 2004a,b,c,d,e; Van Dyk, 2004), viz.:

- Artificial groundwater recharge
- Conjunctive use of surface and groundwater
- Desalination of groundwater
- Drought relief and aid funding from RSA National Treasury
- Dry sanitation systems such as pit latrines and urine diversion toilets
- Dual flush toilets
- Education programmes on water saving measures
- Local water resource management and monitoring
- Rainfall enhancement such as cloud seeding
- Rainwater harvesting at the household level
- Reuse of grey water
- Reduction of leaks programmes both at household and distribution levels
- Regional water resource planning
- Saline water for toilets
- Standby relief under critical conditions i.e. disaster planning
- Delivery of water by tanker
- Tariff structures to reduce water demand
- Water restrictions on outdoor use to reduce water demand.

Analysis of strategies against combined criteria

The analysis of the strategies was done using the simple multi-criteria analysis tool discussed above. The set of criteria against which to rate the strategies was developed by the author and discussed with the twelve stakeholders who attended the monthly Provincial Drought Task Team Meetings in 2005. These were weighted with input from the stakeholders. The stakeholders were requested to score each strategy against the each criteria using the scoring system discussed above.

Results

The results were standardised and the average scores were used for comparison purposes. As can be seen from Figure 5, nine strategies scored above 0.5 on the weighted combined rating scale. Notably the delivery of water by tanker scored the lowest, followed by drought relief and desalination.

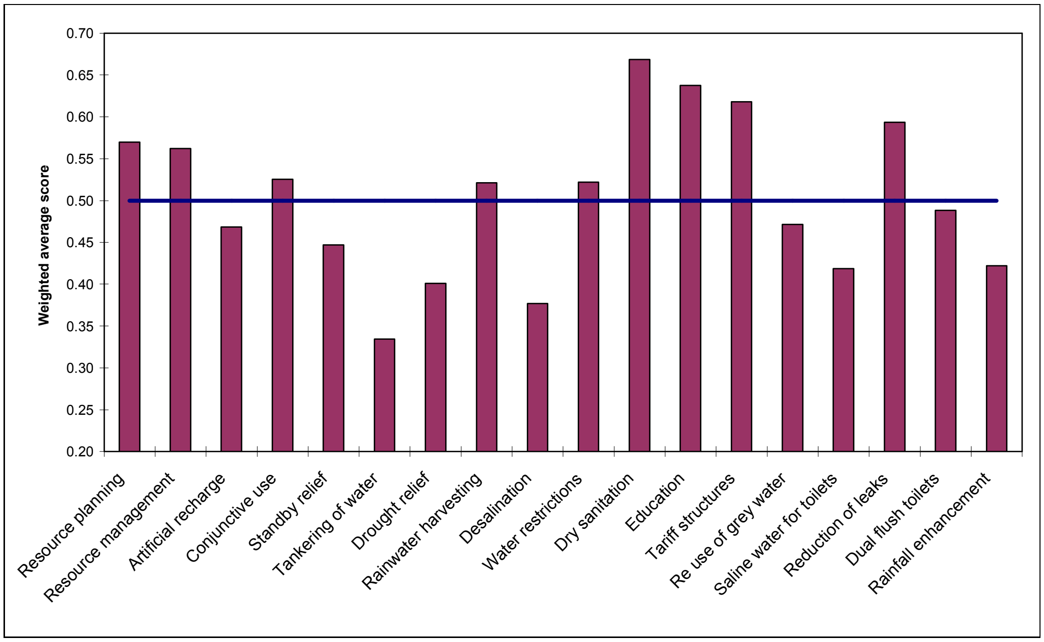

Figure 5: Graphical representation of all strategies using weighted average against all criteria

The Table 3 summarises the obstacles and limitations to implementing these strategies at a local level. The most notable factor affecting the viability of these strategies is the perceived lack of local capacity to implement them. This is further exacerbated by the low financial resource base to cover the capital and running costs of most of the strategies. Implementing water restrictions and dry sanitation would require the local authority to address user acceptability of the strategies. Some of these strategies do not contribute much to local employment and this would need to be addressed in some other ways.

Table 3: Summary of obstacles and limitations for the top nine strategies

Strategy	*Capital expenditure*	*O&M expenditure*	*Local capacity*	*Acceptability*	*Employment*	*Technology*
Supply side:						
Regional water resource planning	X	X	X		X	
Local water resource management	X	X	X			
Conjunctive use of surface & groundwater	X	X	X			X
Reduction of leaks programmes	X	X	X			
Rainwater harvesting			X			
Demand side:						
Dry sanitation systems				X		

Education programmes		X	X			
Tariff structures			X		X	
Reduction of leaks programmes	X	X	X			
Water restrictions				X	X	

Key recommendations and conclusions

Climate change models are not predictions of the future, but are rather projections of how the future global and local climates may evolve and how these scenarios could affect local water resources. It is therefore important that planners, investors and decision-makers take into account the potential effects of climate change on the water resources and in so doing, adopt strategies that ensure the long-term sustainability of the water supplies and the local resources.

A number of recommendations in this regard emanate from this study:

- There is a need for proactive strategies at local and national level to deal with the impacts of drought and climate change on water resources rather than the current reactive strategies, such as providing water by tankers.
- Emphasis should be placed on demand side management given the finite amount of water. This is reinforced by the fact that the top three strategies rated by the stakeholders were all on the demand side. However, that is not to reduce the responsibility for better management by the water service providers to reduce wastage and losses in the delivery systems
- Strict groundwater management systems should be put in place, with early warning mechanisms to report depleted groundwater reserves. Continual monitoring of the aquifer against climate conditions will provide some knowledge of the future potential under projected climate conditions.
- In order to successfully implement any of these strategies, the lack of personnel and financial capacity at local level must be addressed.
- Strategies that are finally identified not only need to be social, environmentally and economically acceptable, but they need to have long-term applicability if they are to provide adequate resilience to climate change impacts.
- A climate change awareness programme should be developed that is targeted at local government officials to equip them with the necessary tools to engage with this issue and implement the strategies that are identified.
- The climate induced impacts on water resource should be integrated into local integrated development planning (IDP) so that adequate strategies are identified to reduce potential risks in future.

Finally, before developing any implementation plans, the high ranking strategies should be assessment quantitatively in terms of additional cost and actual water delivered or saved.

Acknowledgements

This research was made possible through the funding by the Water Research Commission of the project “Climate variability, climate change and water resource strategies for small municipalities”, WRC Report No. 1500/1/06.

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