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UNDERSTANDING THE COST OF RURAL WATER SERVICES:

Lessons from the Chris Hani and Alfred Nzo District Municipalities

SALGA
South African Local Government Association

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1 Introduction

Ensuring the ongoing functionality of water services in rural areas is a big challenge for many municipalities. Substantial achievements in reducing service delivery backlogs are now being overshadowed by the much harder task of providing effective operational and maintenance support to a large number of settlements over a wide area.

How best should O&M be costed? Without examples to draw on, most municipalities have few benchmarks or indicators on which to draw when budgeting for this important service to the community.

The actual costs associated with operation and maintenance of rural water supply schemes are not well understood, and frequently not known. This lack of clarity is often due to the service not being ring-fenced, with some costs being allocated to other services or departments in a municipality. Further, reported costs do not always reflect what quality of service is actually being achieved; the cost of delivering poor quality services is not representative of the real costs of providing a continuous supply of safe drinking water. Although the national Blue Drop initiative is spurring improvements, few municipalities collect or report detailed data on the quality of water delivered at village level, and the continuity of day-to-day supply is generally not tracked; this makes it hard to assess what quality of service is being provided and at what cost.

The experience of Alfred Nzo District Municipality (ANDM) and Chris Hani District Municipality (CHDM) in using CBO operators, supported by a contracted external support team, provided a unique opportunity to establish the real costs of rural water supply: service provision performance was monitored closely, a consistently high standard of services was provided, and all costs were recorded and ring-fenced. The findings provide important insight into what it takes to provide good quality services in rural areas, and what this costs.

The discussion below identifies the real costs associated with a comprehensive approach to providing a continuous, reliable supply of safe drinking water in rural settlements. This makes it possible to compare service delivery costs in different areas, understand the key cost drivers, and establish some cost benchmarks for service delivery.

This analysis has wider relevance, and can assist other municipalities trying to work out their costs and budget for them.

BOX 1: Summary of key findings

- Providing a continuous supply of safe drinking water requires extensive technical support, and may be more costly than is generally assumed.
- The biggest cost drivers in rural schemes are the nature of the infrastructure used, how spread out the infrastructure is and the location of individual settlements. Gravity fed schemes are generally the lowest cost and require the least support; costs rise rapidly as pumping and treatment are added.

- Electrical / mechanical installations with engines, pumps and motors are more likely to break down than infrastructure with no moving parts; electrical and mechanical installations require specialist technical support skills and have the highest support costs.

- Costs vary widely according to the nature of the source and its associated delivery infrastructure and the location of the settlement. Yet the Equitable Share provides a standardized subsidy based solely on the number of poor households in a municipality.

- While regional schemes may offer 'economies of scale', their real costs can be substantially higher than stand-alone schemes. Large, technologically advanced schemes may be more expensive to develop, and more technically difficult and more expensive to operate and maintain. Without close monitoring and effective management and support, they may perform more poorly than stand-alone systems.

- Raising the level of service to support private connections is likely to incur substantial capital, operating, maintenance and support costs. The cost of managing demand through metering, billing and collection may be less than the income collected, particularly where the costs associated with collecting cash must be factored in.

2 Costing rural water supply in Chris Hani and Alfred Nzo District Municipalities

2.1 Background and context

Alfred Nzo and Chris Hani District Municipalities are both Water Services Authorities. These DMs are characterized by a service delivery challenge that includes many small scattered settlements where people depend largely on wage remittances, social grants and limited subsistence agriculture for their livelihoods.

Each DM expressed interest in exploring the benefits of using CBOs in the provision of water services.

In 2001, ANDM implemented a pilot project to investigate the requirements for successful implementation of a CBO-based service delivery approach in rural areas, using a Support Services Agent (SSA) to provide technical and other support; the project was implemented with the support of the Department of Water Affairs and Forestry's “Implementing Sustainable Water Services Institutions Programme” (ISWIP); it was anticipated that the municipality would pay a stipend to three CBO personnel in each village: an operator, an administrator and a community representative. The salaries of these individuals was based on estimations of the actual time spent carrying out the tasks associated with each position.

The DM identified that this model would require technical and management support. Following a competitive tendering process, it contracted a small engineering firm with good technical expertise, Maluti GSM, to provide this support.

The service provider, known as the Support Services Agent, or SSA, was responsible for ensuring the functionality of services, and undertook numerous tasks ranging from delivering diesel, to repairing pumps and paying CBO members. This approach provided a very high quality of service to users.

Towns within the district continued to be serviced separately with their own technical staff.

This pilot project covered one third of the total area of the district municipality, but was soon expanded and scaled up to include all rural settlements in the district through the appointment of two additional service providers. The project ran successfully until 2005, at which point the DM internalized the function by assigning responsibility for technical support to its own staff.

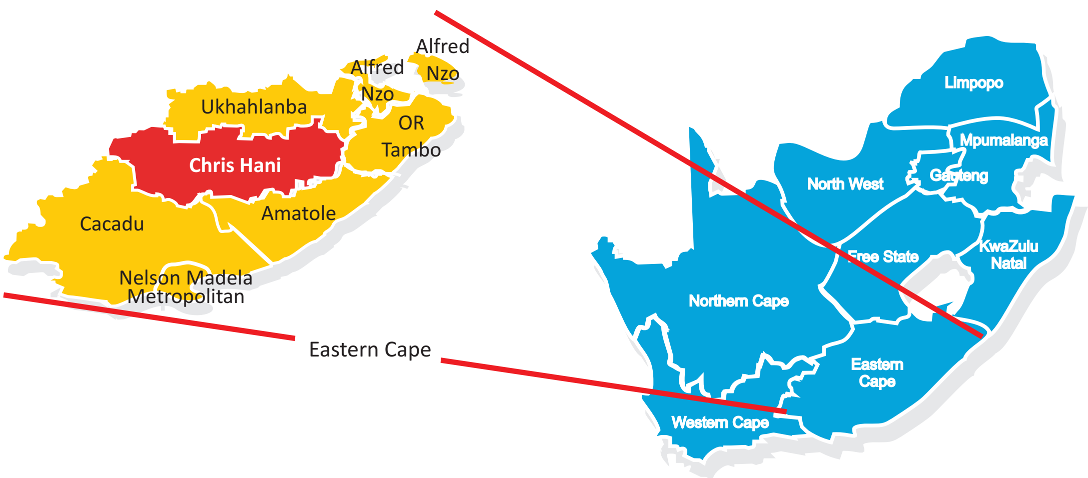
Encouraged by the success of the ANDM programme, in 2004 Chris Hani District Municipality implemented a similar approach. Here the rehabilitation or re-commissioning of many small schemes was necessary before effective O&M could be implemented. Rehabilitating and recommissioning many of the schemes proved to be easier and less costly than anticipated, and showed that many scheme failures were due to relatively minor technical faults. The utilization of CBOs was approached in a similar way to that implemented in ANDM.

Table 1: Settlements supported through the Support Services Agent contracts

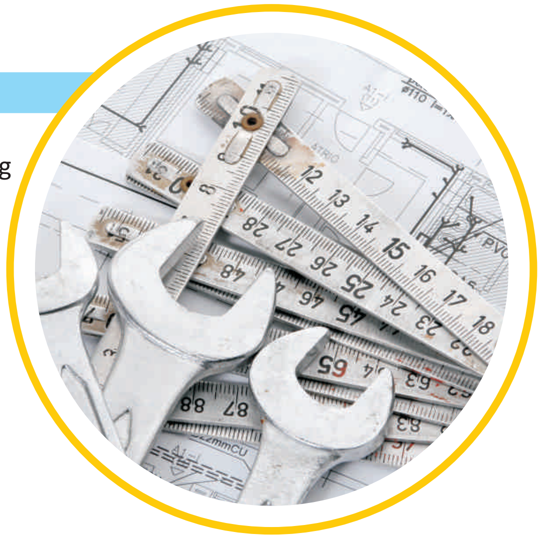
Area	Villages served	Households served
Alfred Nzo DM (2002-2005): Matatiele Local Municipality (formerly uMzimvubu North)	144	27 154
Chris Hani DM (2004-2009) Villages located in three local municipalities – Intsika Yethu, Sakhisizwe and Emalahleni	285	40 283

There are very high levels of poverty in both areas, with over 90% of residents considered to be 'indigent'. Large Equitable Share allocations to each WSA meant it was possible to fund the total cost of rural service operations without any need to recover costs from households.

Figure 1: Map showing the location of Chris Hani and Alfred Nzo District Municipalities



Service objectives



The objective of the SSA contract was to ensure that safe drinking water was supplied reliably. To achieve high performance standards, the SSA was expected to do the following:

- Support local operators in carrying out repairs and maintenance
- Service and repair mechanical and electrical (mech/elec) equipment.
- Deliver diesel where required
- Procure and deliver material and supplies
- Prepare monthly reports
- Provide engineering / technical support
- Facilitate the functioning of CBOs
- Train local operators

These service parameters were monitored and reported on by the SSA each month to the WSA. The activities of the SSA were guided by data and information contained within these reports.

Service achievements

These goals were achieved through close monitoring and quick follow-up where problems were identified.

- Reliability and continuity of supply was provided consistently at, or very close to, a level of 98% assurance, which meant that users enjoyed very few interruptions in their water supply. This was measured through monitoring 'operational tap-days'. Local administrators recorded which taps were working on a daily basis and compared this with a theoretical maximum – i.e. number of taps x days in the month.

- Water quality was maintained at a consistently high standard. This was monitored in two ways. Firstly, the perceptions of each community regarding taste, smell and appearance were monitored continuously and reported monthly. Secondly, monthly samples were taken at each village and driven to a laboratory, often up to 250 km away, where they were submitted for bacteriological testing.

Water quality and CBO performance at every installation were monitored monthly.

Water supply technologies

Schemes included in the SSA programmes varied in technology and extent from large multi-village schemes supplied from dams and water treatment plants, to hand-pump installations. The level of service within settlements was mainly based on communal standpipes.

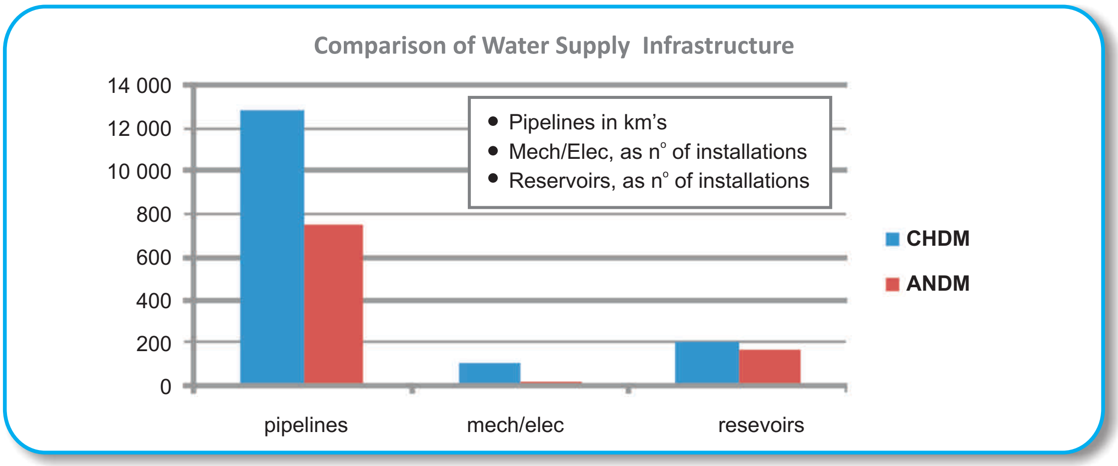
The vast majority of schemes did not require water treatment apart from periodic treatment with chlorine for disinfection purposes, as the source of water in most cases was a good quality borehole or a protected spring.

Table 2: Comparison of water supply infrastructure in the CHDM and ANDM projects

	Chris Hani DM	ANDM
Villages served	285	144
Population served	40 283	27 154
Boreholes	89	30
Weirs and springs	83	49
Bulk pipelines	570	360
Reservoirs	212	176
Water treatment works	2	1
Diesel pump stations	50	16
Electrical pump stations	18	4
Local reticulation networks	285	180

Figure 2 shows the number and proportion of these assets graphically.

Figure 2: Comparison of Water Supply Infrastructure in the ANDM and CHDM projects



Dams were excluded as they are owned by DWA and are not the municipality's responsibility.

The chart highlights the large number of infrastructure assets for which the two district municipalities are responsible. Whereas large towns and water boards have big assets, municipalities serving rural areas typically have very many assets installed over an extensive area; arguably, rural municipalities have a bigger and more complex task.

2.2 Methodology for costing rural water services

Detailed data collected over 4.5 years in ANDM and 5.5 years in CHDM were analysed to identify the real costs of providing rural water services and the main cost drivers.

Because Maluti GSM carried all of the costs of the programme and then billed the respective municipalities, it was possible to establish the 'ring fenced' real costs associated with the delivery of water services in ANDM and CHDM, including operations, maintenance and all expenses associated with administrative and logistical support to the CBOs.

Costs from different years were adjusted to 2010 figures, using industry-accepted escalation norms. These data were then compared to the recommendations of cost and budget estimation tools developed by DPLG (now the Department of Co-operative Governance, D-CoG) and DWA, respectively.

Department of Water Affairs Cost Benchmarks

DWA regularly collects cost data related to the implementation of new projects and O&M associated with the various infrastructural items. Its guideline provides information on cost estimates for schemes in a range from very small (167 households) to large (8,300 households). The basic premise of DWA's 2002 guideline, *Cost Benchmarks for Water Supply Projects,* is that costs are primarily linked to the size of the population served in each settlement.

Department of Provincial and Local Government Cost Estimation Guidelines

The Department of Local Government and Housing (DPLG), now the Department of Co-operative Governance has produced *Guidelines for Infrastructure Asset Management (2006).* It uses an infrastructure Asset Management approach to calculating annual operations and maintenance costs based on a percentage of the Current Replacement Cost (CRC) of each infrastructure component. The Current Replacement Cost is an estimate of the current cost of replacing the infrastructure asset with a modern equivalent of similar capacity, based on unit rates.

BOX 2: Understanding Current Replacement Cost (CRC) - the DPLG approach

CRC is calculated using a detailed breakdown of each component of the scheme, multiplied by the costed norm per unit. The rates are for the overall project costs, and include provision for design and supervision, provisional and general costs, project contingency and VAT.

Asset Category	Asset Description / Type	Unit	Rate
Raw water pump station (Civil Works)	<5	kW	R32 359
	6-10	kW	R17 393
	11-25	kW	R8 251
	26-50	kW	R5 178
	51-75	kW	R4 143
	76-100	kW	R3 640
Raw water pump station (Mechanical Works)	<5	kW	R61 482
	6-10	kW	R33 047
	11-25	kW	R15 678
	26-50	kW	R9 837
	51-75	kW	R7 890
	76-100	kW	R6 917
Raw water pump station (Electrical Works)	<5	kW	R40 449
	6-10	kW	R21 742
	11-25	kW	R10 315
	26-50	kW	R6 471
	51-75	kW	R5 191
	76-100	kW	R4 551

To calculate the CRC of a 12 kW pump station, each of the Civil, Mechanical and Electrical works components would need to be multiplied by the unit cost

12 x R8 251

12 x R15 678

12 x R10 315

= R410 928

Escalated by 1,3 to accommodate industry-accepted adjustments to 2010 costs, the CRC would be R534 206.

The operation and maintenance costs used in this analysis were derived from the DPLG guideline and are detailed below.

Table 4: DPLG O&M Calculation Factors

Item	Annual Operating Cost (as % of CRC)	Annual Maintenance Cost (as % of CRC)
Boreholes	3%	4%
Springs / Weirs	0.4%	0.25%
Bulk Pipelines	0.1%	0.5%
Reservoirs	0.1%	0.7%
Reticulation Pipelines	0.1%	1.7%
Water Treatment Works	n-a to this contract	2.3%
Tap-stands	3%	4%
Diesel Powered Pumps	3%	4.6%
Electric Powered Pumps	2%	2.3%

Water treatment works were paid for by DWA, since the SSA programme was implemented during the transfer process and were excluded from this analysis. The SSA was responsible only for ad-hoc maintenance support.

Activity Based Cost Model

Soon after the start of the ANDM contract, Maluti GSM worked with the municipality to develop an activity based cost model to assist ANDM with annual budget preparations. This was developed to inform the planned expansion of the programme to the two thirds of the district that was not covered by the pilot project.

This cost model allocated resources such as staff time, vehicles, materials and so on the basis of the number and types of scheme to be operated and maintained.

Schemes were categorized into four types, on the basis of the number of villages each served, and their degree of technical complexity. This categorization was drawn up in conjunction with an ANDM official.

Table 5: Activity Based Cost Model Input Parameters

Geographical Extent		Technical Complexity	
A	11 – 17 villages	1	Water treatment / power / reticulation
B	5 – 10 villages	2	Power / reticulation
C	2 - 4 villages	3	Gravity / reticulation
D	1 village	4	Gravity / no reticulation

Rural water schemes in these two areas seldom exceed 17 villages. A notable exception is the Tsojana Regional Scheme that serves more than 40 villages, and is being expanded steadily. That scheme was modeled as a number of type 'A' schemes.

BOX 3: How O&M costs were calculated

Calculation of the CRC for the ANDM and CDHM water schemes involved -

- Identifying and listing every major infrastructure component (see Table 3)
- Identifying the size or length of each major infrastructure component
- Calculating the CRC for each infrastructure component, using the DPLG guidelines, adjusted for price escalations

This is no small task, but is essential to provide a cost base line.

This base line was then used to calculate annual operating and maintenance costs, using a percentage of CRC in line with the DPLG guideline (see Table 4).

This base line was then assessed against a detailed activity based costing for functional operation of the infrastructure, taking into account real support costs, administration and strategic support.

2.3 Cost findings

Much of the work of the SSA programme was concerned with attending to preventative maintenance and operational interruptions resulting from the breakdown of an item of mechanical or electrical equipment, and ensuring good water quality.

However, even simpler technologies, like hand-pumps, required external intervention. Often a component of a hand-pump would break and would require equipment such as a welding kit for repairs. Clearly it would be unreasonable to expect every rural village or CBO to have such equipment and expertise; this illustrates the need for effective support systems. Small welding repair may seem trivial to a technically skilled and appropriately equipped technician, but without this external support intervention the water supply to whole communities would be jeopardised.

A lot of attention is given to operational efficiency and reliability of components in the design of water schemes. However little consideration is given to what the mechanism of repair might be in the event of failure of such components. While such efficiency and reliability are important considerations it must be noted that components will eventually fail. If the only option for diagnosing and carrying out repair (which may be trivial for skilled people) must be sourced from remote urban centres, then rural schemes may remain non-functional for extended periods. Alternatively, in desperation local operators may modify equipment to enable it to operate. Such modifications can easily give rise to secondary damage.

This finding underlines the critical importance of considering the 'repairability' of each component of the infrastructure, and making adequate provision for appropriate support to be made available swiftly.

Actual costs

The actual costs associated with running the schemes are presented below:

Table 6: Actual Support and O&M Cost Data

Project Area	Monthly	Annual	Cost per H-Hold (R/annum)
Chris Hani DM	R1,789,661	R21,475,928	R533
Alfred Nzo DM	R 518,637	R 6,223,647	R229

These costs exclude VAT and have been adjusted to 2010 figures.

Comparison of actual costs between the two project areas shows that operations in the CHDM area cost 3.5 times more than similar activities in the ANDM area. The cost per household served was 2.3 times greater. The reasons for these differences include the following:

- CHDM supplies water in twice as many villages as ANDM, but to only 50% more households
- CHDM has 70% more pipelines
- CHDM has 83% more taps
- CHDM has almost 500% as many mech/elec installations

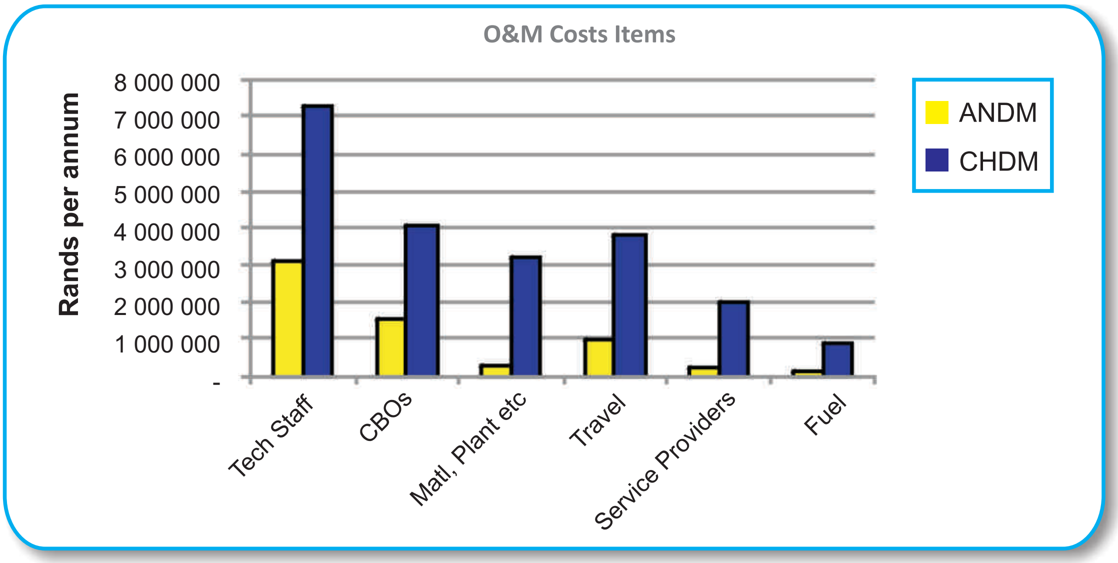
The increased cost in CDHM was shaped strongly by the more scattered nature of the service delivery area and a far higher proportion of mechanical and electrical equipment used on schemes, while ANDM was fortunate to have more gravity fed schemes.

Cost Breakdown

The breakdown of costs shown below illustrates just how much the mech / elec installations shaped support requirements and their associated costs:

- The technical staff requirement in CHDM was 2.4 higher than in ANDM
- Materials costs were 11.5 times higher in CHDM
- Travel costs were 4 times greater in CHDM
- Scheme fuel costs were 7.4 times greater in CHDM
- Service provider costs for outsourced work, such as water quality testing at laboratories, were 9 times higher in CHDM.

Figure 3:Proportional Contribution to Total Support and O&M Costs



Materials and plant costs were much higher in CHDM because the project area has a far higher number of mech/elec installations with rotating equipment. These are far more prone to failure than static infrastructure such as pipelines and reservoirs.

The big difference in travel costs is explained by the fact that the schemes in the ANDM area were, on average, about 50km from the base of operation, compared to about 100 km in CHDM.

This data provides evidence that the support costs required to achieve effective O&M for rural water supply schemes constitute a large proportion of the total costs. This has the following implications:

- The subsidy requirements for financial sustainability may be higher than previously assumed.
- High support costs indicate that the level of technical challenge is greater than is generally assumed.
- Widely accepted methods of budgeting for O&M such as percentages of Current Replacement Costs or allocation of budget per person served might not adequately reflect the real challenges faced in serving many small settlements over a wide area.

Furthermore, differences in the availability and proximity of water sources have a significant impact on what type of scheme is developed. This has a profound impact on the funds required to construct schemes and carry out effective long-term operation and maintenance.

Based on data gathered, the main cost drivers identified were:

1. Technical staff required for technologically advanced equipment.
2. Travel costs associated with scattered schemes located in remote areas or away from service centres.
3. Spare parts and material costs, particularly on schemes utilising engines, motors and pumps.

Capital replacement and O&M costs

In determining the estimates of capital replacement cost (CRC) for each of the infrastructural items in the ANDM and CHDM programmes, significant variations were found in the two 'costed norm' methods used in the DWA and DPLG research studies.

Table 7: Infrastructure Capital Replacement Costs

Project Area	DWA	DPLG
Chris Hani DM	R321-m	R440-m
Alfred Nzo DM	R180-m	R221-m

The DPLG CRC estimates are higher (between 24% and 37% higher) than the DWA's method, the value of bulk pipelines contributing most significantly to the variation in valuation.

Figure 4: Comparison of Engineering Cost Estimate Methods for CHDM

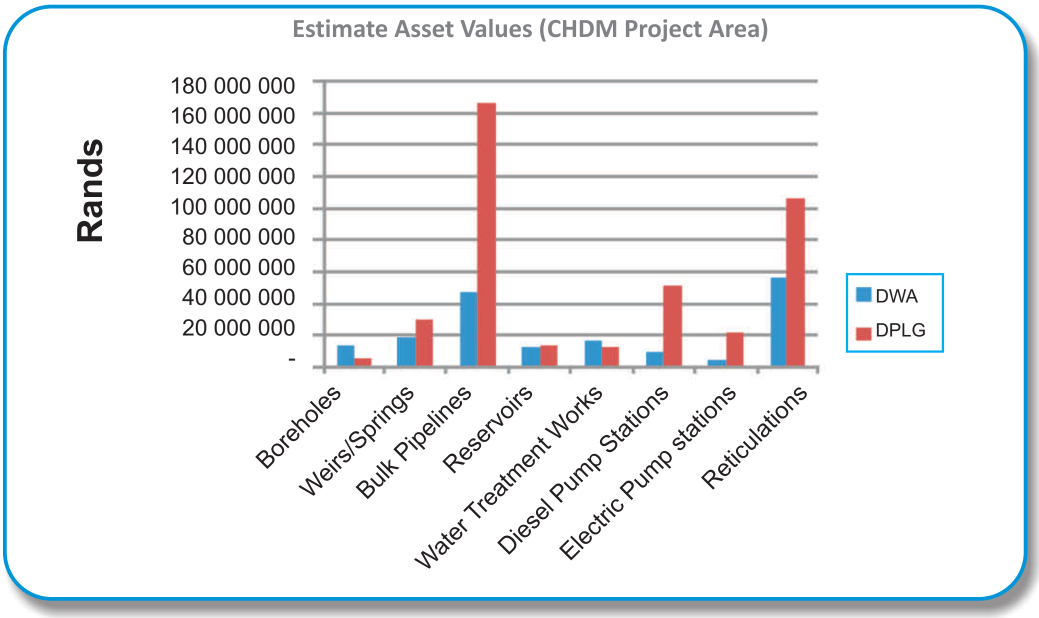
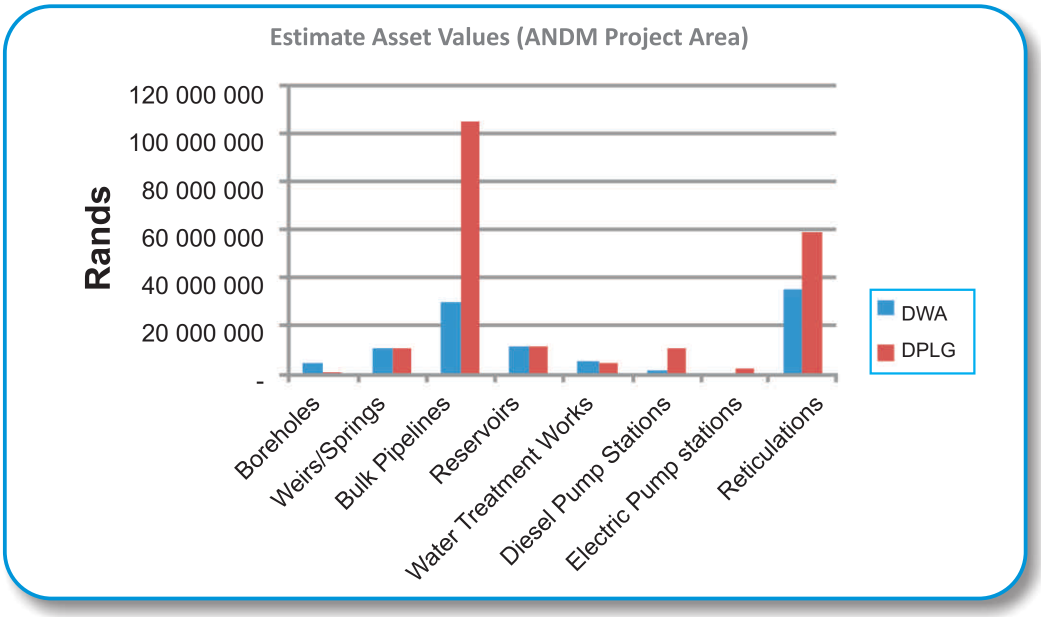


Figure 5: Comparison of Engineering Cost Estimate Methods for ANDM



The chart shows that bulk pipelines, together with rising mains, constitute the single biggest asset cost component.

Further analysis of O&M costs shows the following relationship to Capital Replacement Costs using the DWA and DPLG guidelines, respectively.

Table 8: Operation and Maintenance Cost vs. Capital Replacement Costs

Project Area	DWAMethos	DPLG Method
Chris Hani DM	18.7%	2.2%
Alfred Nzo DM	19.8%	1.5%

This table illustrates the wide variance in estimated O&M costs when these 'costed norm' tools are used at face value. It appears that the DWA data makes provision for a range of administrative and support activities (billing and tariff collection, and a proportion of senior management staff costs) which the DPLG Guideline's infrastructure-only approach might not.

The implication is that 'costed norm' based models should be used with caution by people with skills and insight, since one will never be sure:

1. What tasks are in fact being 'costed', and
2. Whether the norms used are applicable to the situation under consideration.

This highlights the need for insight into local conditions and expertise when assessing costs.

Activity based cost modelling

Further analysis showed the value of taking into account the actual cost of activities associated with providing the service. Looking only at infrastructure maintenance and repair costs does not take adequate account of the institutional environment, the relationship between the WSA and WSP, the cost of funding community-based operators, and the distance between the settlement and the support hub. Activity based costing provides more precise information on the costs of working in a particular context.

BOX 4: How to do activity based cost modeling

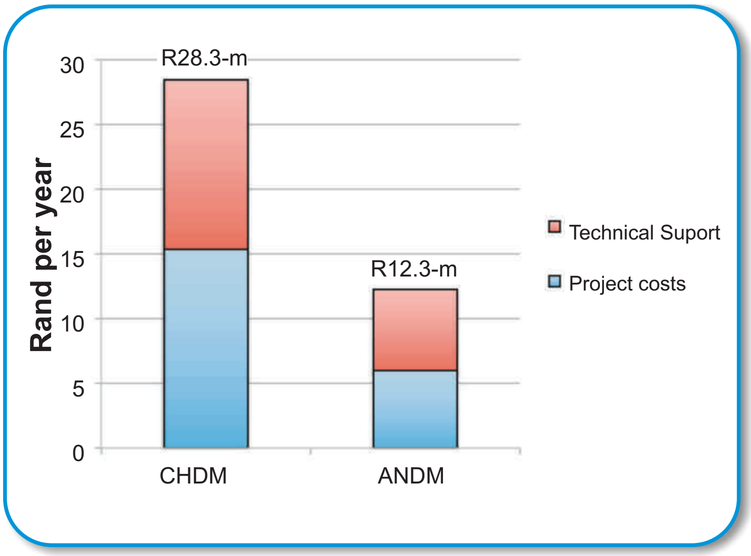
1. Understand the nature of the infrastructure
2. Identify the operation and maintenance tasks associated with each item of infrastructure.
3. Identify the resources required to carry out the tasks (staff, vehicles, equipment, materials, chemicals)
4. Identify the cost of each 'resource’
5. Calculate the total cost.

The activity based cost modeling yielded estimated annual operating costs of R28,5-m in CHDM, and R12,83-m in ANDM. Costs were calculated on the basis of charge out fees that included provision for

- Technical and management staff salaries
- Travel
- CBO salaries

- Materials, fuel and chemicals
- Administration costs

Figure 6: Estimated O&M costs based on activity based cost modeling



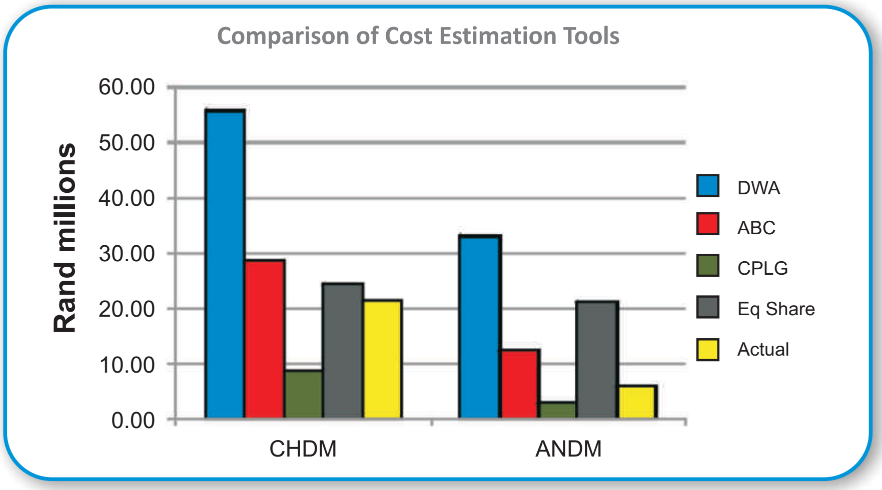
The chart shows that technical support costs represented 54% of the total in CHDM, and 49% of a lower total, in ANDM. The unexpectedly high cost of tech-nical support can be attributed to the following:

- The salary costs of professionally and technically qualified people are significantly higher than the labour costs of local project staff
- The remoteness of rural schemes necessitates large direct travel costs (vehicles) as well as high travel time costs associated systems using technically more with expensive personnel. This is particularly relevant for advanced mechanical and electrical equipment.
- Costs for items such as spares and fuel are relatively low due to the small size of many of the components of the schemes.

Comparison of Cost Estimation Tools

Figure 7 below shows significant differences in the costs calculated using different methodologies. This suggests that generally-accepted cost estimation tools are not necessarily reliable when applied to rural water supply schemes, perhaps because they are derived largely from urban systems. Evidently, the cost structure of rural service provision is very different, and cost modelling requires assessment by skilled and experienced people with insight into rural cost drivers.

Figure 7: Comparison of Various O&M Cost Estimating Techniques



The following comparisons between the respective project areas are relevant:

- The number of households receiving water services in CHDM exceeds that of ANDM by 1.5 times
- The civil infrastructure used to provide water supply services in CHDM exceeds that in ANDM in proportion (more or less) to the additional households served
- The number of mech/elec installations is five times greater in CHDM
- The Equitable share allocation to CHDM is only 16% greater than that for the Alfred Nzo DM
- The actual cost of service provision in CHDM was 3.5 times greater than in ANDM.

This highlights the disproportionate contribution of mechanical / electrical installations to the operational and maintenance challenge.

It appears that the standard costed norms approaches give inadequate consideration to the following factors in rural areas:

- Many small schemes with small-scale infrastructure
- Schemes located at great distances from effective service centres
- The use of, and difficulty of repairing, mechanical and electrical equipment in remote settings.

To implement an effective O&M regime, the municipality should consider the long distances specialist contractors must travel from the major towns where such skills are available, and ensure that skilled personnel such as millwrights and electricians are actually available to perform tasks as required. Equally, the challenge in communicating the nature of faults and failures to such service providers should not be underestimated.

The skills required to identify faults and service mech/elec systems effectively are not found easily within rural villages, and in fact not even in local small towns. The technical nature of such installations is becoming continually more sophisticated, creating a need for even greater technical expertise. The lesson to take from this is that careful consideration of what is the most appropriate technology for a given area must be continually reassessed in project planning and design phases. Equally, the ease of repair of the equipment must be considered, particularly in settlements located far from centres where the necessary skills are found.

Quality of service provided

Analysis of data collected in the final six months of both contracts indicates a high average quality of service

Table 9: Service Standard Compliance

Area	Water Quality	Continuity of Supply
Chris Hani DM	98%	96%
Alfred Nzo DM	83%	84%

At face value, it appears that the level of service supplied in the ANDM area was significantly less than that delivered in CHDM. It should however be considered that this 'lack of performance' may be an inherent function of the infrastructure. For example, surface water sources without treatment facilities will tend to deliver water of lesser quality than those with treatment systems. In such circumstances the available infrastructure may in fact be operated optimally but still be unable to achieve the desired service level. Achieving a higher level of compliance would only be possible through further capital investment and the continuous upgrade of infrastructure.

Equitable Share allocations

Equitable Share allocations from national government make no allowance for the difference in operational and maintenance costs of schemes in different areas. The subsidy is calculated by National Treasury purely on the basis of census statistics, and is not adjusted to account for the actual cost of providing a reliable supply of safe drinking water across different contexts using different technologies.

This finding has important implications for how the WSA allocates the Equitable Share across its operational area, and underlines the importance of knowing the real costs to ensure that the available subsidy is distributed equitably in line with real local O&M costs.

BOX 5: Summary of findings

- Service budgets should be based on the real costs of providing a continuous supply of safe drinking water. Delivering good quality services requires effective technical and management support to rural water schemes to maintain the functionality of the infrastructure.
- Electrical / mechanical installations with engines, pumps and motors are more prone to breakdown, require specialist technical support skills and have the highest support costs.
- The cost of technical support represents a large proportion of the overall cost of operation.
- The recurrent costs associated with materials, spares and fuel for rural schemes comprise a low proportion of the overall cost, particularly where there were few mech/elec installations.
- To enhance reliability and reduce the maintenance costs of rural water supply schemes, the concept of 'repairability' must be given adequate consideration in project design.
- The main cost drivers for O&M of rural water schemes were identified as being:
  - the nature of the infrastructure, particularly if mech/elec installations are utilised (skilled people required)
  - Remoteness of the schemes (travel)
  - Number of schemes under consideration (logistics)
- Basic rural schemes are not necessarily cheaper to operate and manage than reticulated urban networks. In South Africa, this raises particular questions about how to allocate operating subsidies equitably across urban and rural settlements, in ways that take account of the real cost of rural service provision.

Comments on costing approaches

- Cost models often have built-in assumptions that may not be apparent to users.
- Different cost estimating tools and methodologies can yield very different estimates for O&M costs for a known level of service from a given set of infrastructural items.
- Capital replacement cost-based estimates should be used with caution since the generally accepted norm of 3-6% is probably derived from experience with urban projects.
- The use of metrics such as cost per capita served (R/per capita) or cost per volume of water supplied (R/m^3) can lead to inappropriate cost estimates.
- It is extremely difficult to create a generic protocol for estimating and predicting O&M costs, as the local context shapes real costs in very particular ways. Factors to consider include
  - the significant influence of technology choice,
  - scale of the scheme,
  - geographic location of the project relative to centres of technical support;
  - accessibility of settlements, which is shaped by the nature of road access

3 Regional schemes: the impact of the project size and technology choice on the estimated O&M costs and performance

Nationally, many municipalities are voicing frustration at the difficulties associated with the logistics of supporting numerous small rural schemes – fuel deliveries, delivering spares, providing support in remote areas, and so on. As an alternative, many are opting for bigger regional schemes, as they believe these will be easier to operate, using more centralized plant, equipment and support staff. However, the costs can be substantially higher – above R80 000 per household in some instances.

Detailed analysis of cost and performance considerations suggest that there are important trade-offs to consider when comparing regional with stand-alone schemes. Moving from stand-alone schemes to regional schemes can mean that difficult logistical challenges are replaced with more complex technical challenges, and higher costs.

3.1 Methodology of cost estimation

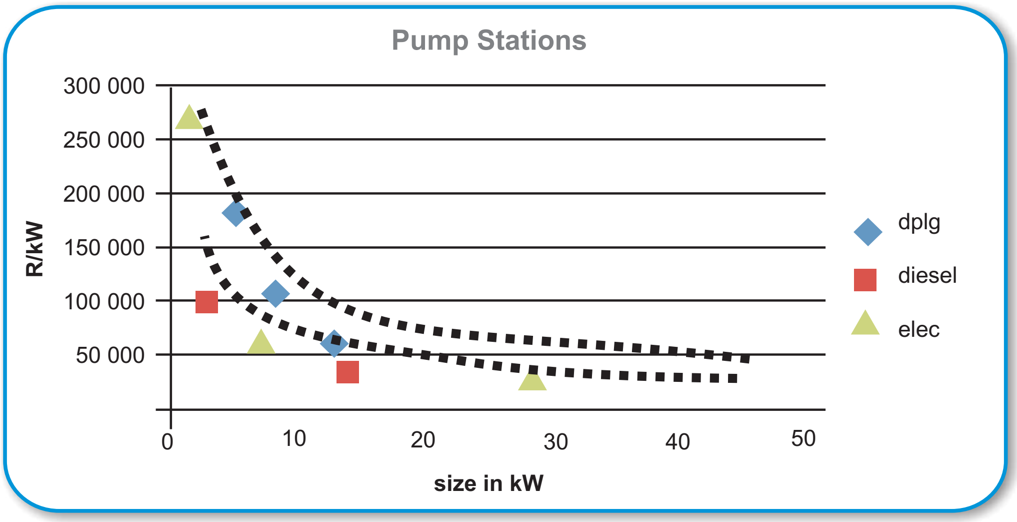
The DPLG, DWA and MIG costing guidelines were used to provide a series of costed norms for each of the components of a water scheme:

- Water sources (dams, weirs, springs and boreholes)
- Water treatment works
- Pipelines (bulk and reticulation)
- Pump stations

These figures were adjusted to reflect current costs using industry-accepted escalation factors.

A representative curve of how costs are influenced by size and scale was then developed for each of the major components. Figure 8 shows how pump station costs are shaped by the size of the engine / motor, given in kilowatts.

Figure 8: The relationship between pump size and pumping cost



This chart demonstrates that the cost of constructing infrastructure is not necessarily linearly related to the size of the asset. In this example, the cost per installed kW of a pump-station decreases as the size of the facility increases. Small pumps serving small areas are considerably more expensive per unit of power than larger pumps.

An idealised scheme was then utilized to develop a fair comparison of a regional scheme and a stand-alone scheme. Two scenarios of how 34 villages may be served were developed. In the first, a regional scheme servicing all 34 villages from a single source and water treatment works was considered. The second assessed the costs for the same 34 villages being served from independent dedicated borehole installations. To ensure fair comparison, an idealised (average) village size of 200 households was considered.

Table 10: Description of Scenarios Considered in Cost Modeling

	Regional Scheme	Stand Alone Schemes
Villages	34	1
Households per village	200	200
Design consumption	60 l/c/d+peak factor(1.2) and provision for losses (1.1)	
Dam	1	0
Water Treatment Works	1 (2.84 Ml/day)	0
Boreholes	0	1
Bulk Pipelines	106km (50mm – 200mm)	3km (50mm)
Pump Stations	13 (various 2kW – 50kW)	1 (5kW) (diesel)
Reservoirs	34 + 2 Break Pressure tanks	1
Reticulation	68km	2km

Operations and maintenance costs were estimated using the recommended percentages of CRC in the DPLG guideline. Anticipated support costs were calculated at 20% of the total operational cost, in line with the experience of Maluti GSM.

3.2 Findings on costs

The capital investment required per household to develop the each type of scheme was R11 655 for the regional scheme, and R7 537 for the stand alone scheme. The regional scheme costs 1.55 times more, primarily because of the greater length of bulk pipeline required.

The chart below illustrates the individual component costs that can be anticipated for the regional and 34 stand-alone schemes.

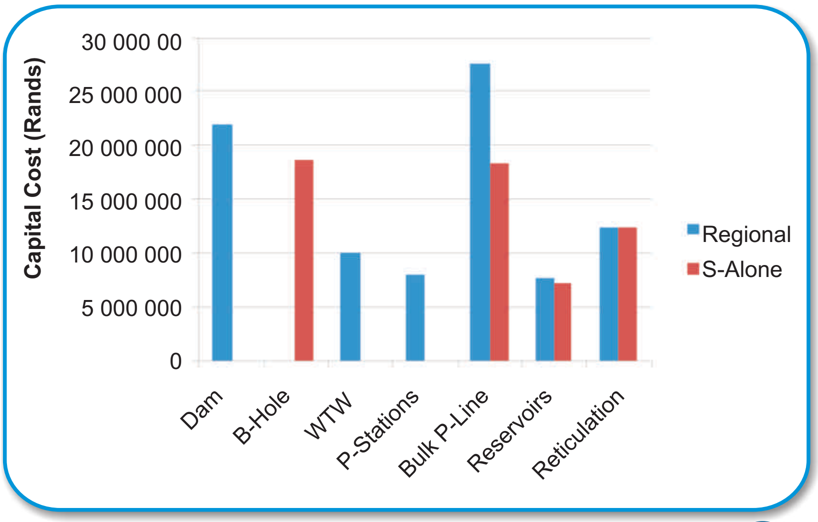


Figure 9: Comparative Capital Costs of Constructing Regional and Stand Alone Schemes

Reticulation costs were the same in regional and stand alone schemes because they were modeled for the same villages.

The significant cost items are the bulk pipelines and rising mains, and accounted for 32% of the total of both the regional scheme and stand-alone scheme. This cost item is dependent on two factors:

- The distance between villages in a regional scheme, which determines the length of the bulk pipeline
- The distance between a village and the borehole, which determines the length of rising main

The ratio of these two parameters will form a crucial part of any comparison between regional and stand-alone schemes.

Operating costs

The annual operating cost of the regional scheme is 1,66 greater than the stand-alone schemes.

The cost of support differs between regional and stand-alone scheme, but there is very little data to inform direct comparisons. However, some considerations are noted below:

Regional schemes

- Engineers needed for hydraulic analysis, water balance and water treatment works management
- Electronics technicians, electricians, millwrights needed to manage complex pumping systems.
- Civil engineering technicians needed to maintain hydraulic balance and analyse operational data
- Special equipment and skills needed for maintenance of big components (e.g. lifting big pipes)
- CBO's to do monitoring and assist with small pipe repairs etc (with support from technicians and maintenance superintendents)

Stand-Alone schemes

- Engineers and Technicians needed for logistics management and simple technical analysis.
- Millwrights / electricians (much lesser skills required than regional schemes due to the reduced sophistication of the technology)
- Fuel delivery (assumed diesel pump stations)
- CBOs to do monitoring and all pipeline repairs with support from technicians and maintenance superintendents

While these roles are significantly different, it is not easy to estimate the cost implications directly since the record of successful implementation is limited and there is even less empirical data.

What is confirmed from this review is that the cost of providing services is largely set at the design stage, because the nature of the infrastructure is the primary driver not merely of capital investment costs, but the full life-cycle cost, including operations and maintenance. This point underlines the vital importance of careful planning and detailed objective consideration of a range of design permutations when considering infrastructure development options; each permutation will impact on the operating and life-cycle cost in different ways.

Life-cycle costs and cost recovery tariffs

A more complete picture emerges when the full life-cycle costs are reduced to an applicable annual cost. Even though the municipality might not charge a tariff, it remains a useful mechanism for comparing the real costs of different schemes.

The costing below is based on monthly costs per household, using a figure of 200 households in each settlement, as a proportion of the total annualized full life cycle cost. This monthly cost was then converted to a consumption cost per kiloliter, based on different assumptions of daily water use. Note that while schemes are designed for consumption of 60 liters per person per day, in reality actual consumption is closer to 12 liters per households per day when water must be carried 100 m or more.

Table 11: Cost recovery tariffs for the modeled Regional and Stand-alone Schemes

	Regional scheme	Stand-alone scheme
Cost per household per month	R140.10	R84.53
Cost per kilolitre at 60 l/c/d	R15.38	R9.23
Cost per kilolitre at 12 l/c/d	R73.88	R45.00

It was found that variable costs such as electricity, fuel and chemicals contribute about 15% of the operating costs, including support. This was discounted in the calculation at lower consumption levels.

This table illustrates the enormous influence of the fixed cost items and hence the degree to which cost metrics based solely on projected, or design, consumption levels can be very misleading. Where households use less water than the design capacity, there is substantial spare capacity in the system, which nonetheless incurs fixed costs.

These figures provide deeply worrying information about the real cost of providing infrastructure for the provision of rural water services.

Of course, the great unknown is the real costs of providing the support needed to achieve a continuous supply of safe drinking water. The nature of the support required will differ in regional and stand-alone schemes.

- Regional schemes require higher-level technical skills to run and repair sophisticated pumping and treatment facilities and networks
- Stand-alone schemes present complex logistical challenges to ensure a regular provision of fuel, spares and technical support to numerous small settlements; the technical skills requirements are lower and less costly.

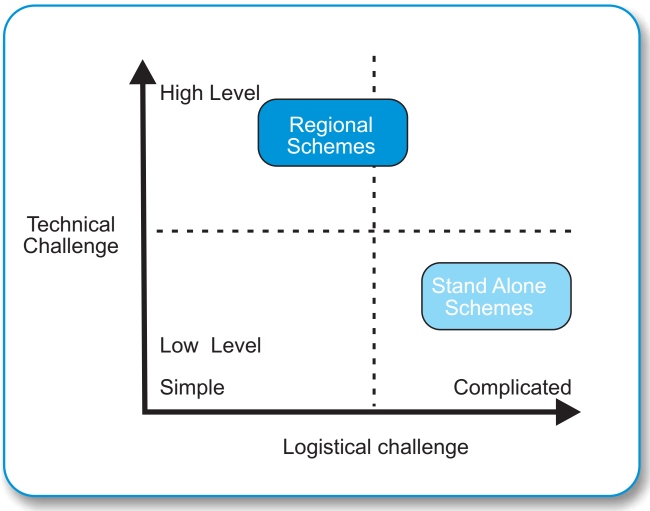


Figure 11: The different challenges of Regional and Stand-alone Schemes

Only with detailed data, and using activity based costing, will it be possible to estimate and compare actual costs more accurately.

3.3 Functionality and service quality

A series of field visits was undertaken in mid-2011 to villages served by three different types of schemes:

- regional schemes
- group schemes (1-5 villages each)
- stand alone schemes
-

During the field visits a questionnaire was completed through interviews with community members. The types of questions asked related to the performance and reliability of the water services, and aimed to assess the effectiveness of water supply across a wide area, and establish whether significant water was being lost through overflowing reservoirs.

This investigation revealed that significant service interruptions were being experienced in many villages.

Table 12: Findings from Functionality Assessments

Observation	Regional 44 villages	Regional 47 villages	S-Alone 45 villages	S-Alone 84 villages	Regional 81 villages	Small* 76 villages
No service on day of visit	32 %	30%	20%	n-a	49%	28%
Overflowing reservoirs	25%	26%	49%	n-a	41%	53%
Percent with significant interruption in past 6 months	64%	68%	40%	29%	n-a	n-a
Interruptions longer than 1 month	25%	21%	11%	n-a	n-a	n-a

* Small – a mix of stand-alone and small group schemes of less than five villages

This data shows a worrying level of dysfunctionality across all schemes. The survey revealed more extensive, more frequent and longer service failures in regional schemes.

The main cause of regional scheme failure is either mechanical / electrical breakdowns, or hydraulic imbalance and inequitable distribution of water throughout the network. Addressing these problems is far from simple when there are numerous pumps, pipelines and reservoirs constantly interacting and influencing the behaviour of each other.

These findings suggest that regional schemes are not necessarily easier to operate, and nor do they necessarily provide a more reliable level of service, even though they are operated and managed more centrally. It seems that the largely logistical challenges of numerous small schemes are traded for a different challenge, which is more technically complex and onerous. This points to the need for fundamental institutional change as the most appropriate response to service delivery failures, rather than technological interventions as the default.

Higher-level technical abilities are required to run a regional scheme effectively. Where these are readily available, the schemes tend to run well; this calls for a clear commitment and ability to resource O&M adequately.

Breakdowns are inevitable in any scheme from time to time. When this happens in a regional scheme, the impacts are likely to be far more extensive and affect more settlements than a stand-alone scheme. The ease of repair is then a critical consideration, and identifying the precise source of the problem can take time. Instrumentation technicians, for example, are seldom available in remote rural areas, and effective repairs can take days, weeks and even months. During this time, operators will often 'make a plan' to keep the scheme operating, but this can at times risk secondary damage to particular items of mechanical equipment.

There is a strong argument for a cadre of technically skilled people to be deployed to manage regional schemes. Equally, though, the role of community-based operators and caretakers should not be ignored. There is immense benefit in engaging locally based people in collecting operational detail and reporting operational performance, and contributing to wider understanding of how the scheme is functioning hydraulically. Equally there is enormous scope to engage local people in assisting with day to day operations and carrying out local repairs.

It is worth noting that the communities surveyed at the smaller schemes were able to identify the cause of the interruption of services with a high degree of certainty (e.g. power failures, lack of fuel, pump failures, and so on). In the case of regional schemes, people at the site of the interruption usually had no idea why the system was not working. This suggests that communities may feel a greater sense of involvement in the functionality of schemes that are located locally and are less sophisticated operationally.

BOX 6: Summary of findings

It seems unlikely that regional schemes will offer lower capital costs than a stand-alone scheme.

A common reason given when opting for a regional solution is that it will eliminate the need to maintain many installations at numerous locations. The evidence suggests that replacing stand-alone schemes with a regional scheme may simply swap an onerous logistical challenge for a more technically complex alternative that requires highly skilled people to operate and maintain the system adequately.

When assessing alternative scheme options, consider the following carefully:

- Compare objectively both the capital and operational costs, noting that the length of pipelines and availability of source are large cost drivers.
- Beware of situations where there will be a large number of reservoirs and widely varying elevations.
- Avoid multiple pump stations for distributing water throughout the scheme.
- Consider how best to achieve hydraulic balance early in the design process and ensure that this is integrated into the scheme's operational management systems
- Ensure that the technical solution chosen aligns well with the skills and resources of the institution that will carry out operation and maintenance.

4 Determining tariffs for rural water supply

The findings from this analysis of rural water costs suggest that

- The type of infrastructure used is the primary cost driver
- Ensuring a continuous supply of safe drinking water requires a high level of technical support
- Actual household consumption is as relevant as the design capacity of the scheme when determining overall costs per kiloliter supplied
- The cost of the type of infrastructure used is more important than the number of people it serves
- The bigger the scheme, the greater the opportunity for scale economies. But overall capital and operating costs increase significantly, especially when the volumes supplied increase. In particular, the greater the pipe length per household, the greater the cost.

The approach used in this study used the following methodology:

- Identification all infrastructure component, and establish their current replacement cost
- Use of the DPLG infrastructure asset guidelines for different infrastructure component to calculate what percentage of CRC to allocate to operational and maintenance costs annually.
- Calculation of the real operating and maintenance cost per year
- Division by average real consumption to get a minimum cost of service provision.

How best should a municipality use these figures?

Where residents take their water exclusively from stand-pipes, average consumption is likely to be well within the Free Basic Water threshold. In this case, the Equitable Share should be sufficient. However, the municipality should ensure that the Equitable Share allocation per WSP and operational area is adequate to provide a good level of service, and so should do the detailed costing necessary to establish real costs relevant to the specific operational challenge and environment.

A growing number of households have private connections – whether authorized or not. Household consumption rises rapidly once people no longer have to fetch and carry water from 100 m away or more, and consequently their consumption will almost certainly exceed their free basic water allocation.

Where people are installing private connections, the municipality should assess the available supply.

Is there sufficient water to accommodate increased demand from private connections?

- If the answer is no, the municipality has at least two possible options for managing demand: penalizing those who make unauthorized connections and removing their connections, or limiting consump-tion through water management devices which cap consumption at a certain limit.
- If there is sufficient water, the municipality should assess how best to manage demand equitably for all users, and against the costs associated with higher consumption.

Introducing metering, billing and payment for services is an effective way of managing demand, but is expensive relative to the likely income that will be collected. Consumption levels are likely to be fairly low, and administering billing and collection is costly; the cost of collection alone to fetch cash payments from each settlement may exceed the total income. Against these costs must be weighed the benefits of effective demand management to ensure available water resources are shared equitably and that operating costs are contained.

Another option is to use a water management device or prepayment device, but again the costs are high.
A different approach is to allocate a certain volume of water to each village per day, and build understanding among residents about the need to limit consumption within that allocated volume. Daily monitoring will be needed be local residents, with follow up action, targeting big consumers, as necessary.

Costs and tariffs beyond the Free Basic Water threshold

What costs should a municipality aim to recover from water users? There are four broad tariff levels to consider:

- **Survival costs:** a minimum tariff that includes day-to-day operating costs, and a portion of overheads.
- **Service provision costs:** this is the minimum required for service provision, and includes provision for periodic expenditure on spares and repairs
- **Sustainability costs:** this is the minimum required for sustainable provision of services, and includes provision for major maintenance such as refurbishment, upgrades, renewals and so on.
- **Developmental tariff for economic growth:** This reflects the full costs of developing and maintaining services where infrastructure must be funded at least partly through borrowing; it includes provision for interest on capital.

Without considering the full range of costs that must be funded, and without allocating the necessary funds to address all cost components, under-funding will result in the steady deterioration of the municipality's ability to ensure good services to all.

Once the municipality understands its own costs and cost drivers, it will then be better equipped to assess which users should pay which tariff. Commercial and industrial users, for example, could be required to pay a 'Developmental tariff' to cover the real costs of providing water in support of growth and development.

Where households have private connections, demand rises rapidly, and cost-recovery policies may need to be reviewed – less to generate income and more to manage demand for water and ensure available water resources are shared equitably.

5 Conclusion

There are four different levels at which water services costs can be calculated. They range from the bare minimum, to the ideal needed to support growth and development. The difference lies in what is to be recovered through the tariff.

- A Survival tariff covers only direct operating costs. No provision is made for maintenance.
- A Service tariff covers operating costs and routine maintenance.
- A Sustainable tariff covers operations and maintenance, and the cost of rehabilitation and upgrades.
- A Growth and Development tariff covers operations, maintenance, rehabilitation and upgrades, as well as the cost of borrowing money to finance investments.

All municipalities should attempt know what their real costs of service provision should be, considering the full extent of what is required as described above.

The municipality may opt to charge a survival tariff for low volumes of consumption by households. As consumption levels rise per user, households could be expected to contribute more to the real costs of long-term service provision.

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The WIN-SA lessons series aims to capture the innovative work of people tackling real service delivery challenges. It also aims to stimulate learning and sharing around these challenges to support creative solutions. To achieve this, the lessons series is supported by ancillary learning opportunities facilitated by WIN-SA to strengthen people-to-people learning.

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