Cite this article
Ruiters C and Amadi-Echendu J (2023)
Water use pricing and financing of water infrastructure systems in South Africa.
Infrastructure Asset Management **10(3)**: 157–170,
https://doi.org/10.1680/jinam.21.00015

Research Article
Paper 2100015
Received 08/06/2021; Accepted 11/05/2023
First published online 15/05/2023

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Infrastructure Asset Management

Water use pricing and financing of water infrastructure systems in South Africa

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This paper investigates water use pricing and financing of water infrastructure, focusing on: (*i*) the role of water use pricing; (*ii*) models for setting water use pricing – namely, charges and tariffs; and (*iii*) the multiplier effects of water use pricing for the financing of the water infrastructure value chain in South Africa. Primary data was collected by quantitative and qualitative methods and secondary data secondary data were collected from reports relating to water infrastructure needs and funding in South Africa. The water infrastructure value chain is hierarchical in South Africa – that is, national, provincial and local governments – based on administrative and political boundaries. Differential water use pricing recognises neither full replacement nor full recovery costs. The mean water use charge for all water-management areas (water basins or catchments) was found to be US\$0.185/m^3 (standard deviation (SD) = ±0.09); for agriculture (irrigation), <US\$0.002/m^3; for forestry, <US\$0.001/m^3 ($\overline{X} = 0.0006$; SD = ±0.0004); and for domestic and industrial, US\$0.0553/m^3 (SD = ±0.066). The mean year-on-year increases for water use was >20%. The mean annual bulk treated water use tariff was US\$0.315/m^3 (SD = ±0.242), and increases varied significantly – that is, 14.33% (SD = ±20.57). The national mean domestic water use tariffs varied from US\$0.238/m^3 (SD = ±0.310) to US\$0.988/m^3 (SD = ±0.450) for the predetermined water use blocks and increased between 13.6% (SD = ±7.7) and 16.9% (SD = ±0.4). Rural municipalities charged approximately 10% below the equivalent water use tariffs compared with urban areas. Commercial and industrial water use tariffs were higher than domestic water use tariffs in the lower blocks and in line in the higher water use blocks – that is, approximately 178.68% (SD = ±256.99). Water use multipliers varied substantially between 3 and 15 – that is, from raw water to municipal retail.

Keywords: developing countries/economics & finance/UN SDG 6: Clean water and sanitation/UN SDG 9: Industry, innovation and infrastructure/water supply

Notation

US\$$x_{1-4}$	tariff/rate structure with four consumption blocks
$\overline{X}$	mean of the sampling variables

Introduction

Water is a scarce resource in South Africa, which has to be managed, protected and developed to ensure beneficial use and sustainability (DWA, 2013; DWS, 2018; UNEP and WRC, 2008). Water is also a key resource to assist in socio-economic development. However, water users have the reciprocal responsibility of sustaining water efficiency and payment for financial allocations and water infrastructure.

Water infrastructure is key in the provision of effective and sustainable water supply systems at acceptable levels of assurance, quality and accessibility, and this requires financial resources, in terms of capital investment, operation and maintenance, regional bulk distribution and reticulation. Thus, to sustain water supply services, full-cost recovery is needed to maintain the financial viability of the water infrastructure value chain. In addition, water use pricing for water supply services is a key economic tool or mechanism for ensuring water conservation and demand management. To achieve sustainability of the water infrastructure value chain in South Africa, appropriate cost-reflective water use pricing must be set by relevant water-management institutions involved in the development and management of the water infrastructure.

Water use pricing, charges and tariffs must meet diverging financial, economic, environmental and social objectives, some of which may conflict with each other (DWS, 2018; Hosking, 2003; Matthews, 2009; Still, 2003). A major challenge therefore is designing water use pricing in a manner that strikes an appropriate balance among competing objectives. This is ultimately a political task and needs to be addressed through a transparent, democratic, participatory process. The current water legislative framework in South Africa recognises that water use pricing should reflect the full cost of providing the services and affords the opportunity for considering new and innovative approaches to water infrastructure financing (Amis *et al.*, 2017; DWAF, 2007; Ruiters, 2013, 2020; Ruiters and Matji, 2015, 2017; Still, 2003). For water-management institutions to be successful and sustainable for the delivery of water infrastructure and supply services, finances must be in order, planning for the financial future, developing and approving the annual expenditure budget, ensuring that revenue is sufficient to cover all operational expenses and ensuring financial viability. Thus, annual revenue must be projected, the operating budget provided and the present financial viability of the water supply service system assessed. The application of economic tools (pricing, charges and/or tariffs) is among the most powerful means of signalling water scarcity and security to consumers/users for addressing water demand management and supply and the necessity for revenue to meet future water infrastructure demands (Amis *etal*., 2017; DWS, 2018; Matthews, 2009; Ruiters, 2013, 2020; Ruiters and Matji, 2015, 2017; Still, 2003). The current water use pricing relies on customer billing, budgets and planning of capital improvements. However, such water use pricing could be challenging given the socio-economic challenges faced by any developed, emerging or developing economy. Thus, this research focuses on

- the role of water use pricing
- water use pricing – that is, charges and tariffs and setting models
- the multiplier effects of water use pricing for the financing of the water infrastructure value chain in South Africa.

Research methods

Quantitative and qualitative methods were used for the analyses and models involved in this research – that is, questionnaires, interviews, documentation reviews (reports), observations, focus group sessions and case studies (Creswell, 2013). The research involved both primary and secondary data collection.

Data collection

The representative sample size for the study population of the research project was finite. The primary and secondary data collection methods for the research involved the following.

- Primary data were collected by conducting a questionnaire survey among the following:
  - individual interviews with representatives from selected national and provincial departments – namely, the Department of Water and Sanitation (DWS), the Department of Cooperative Governance (DCoG) and local governments (municipalities)
  - workshops and discussion focus groups – namely, national, provincial and local government workshops
  - respondent groups and national organisations – the South African Institution of Civil Engineering, Agri South Africa, Consulting Engineers South Africa and so on
  - water institutions – special-purpose vehicles (SPVs), water utilities or boards (e.g. Rand Water, Umgeni Water, Sedibeng Water, Lepelle Northern Water) and catchment (water-management area (WMA) or basin) management agencies (CMAs)
  - local governments (municipalities) – the South African Local Government Association and local, district and metropolitan municipalities.

The survey included a representative sample of several municipalities, also referred to as water service authorities (WSAs). A questionnaire was forwarded to participants and stakeholders, including local municipalities and water utilities, requesting information regarding water tariffs per tariff type (residential, commercial, industrial bulk raw water, industrial potable water and other uses) in the predefined blocks for the past 10 years. Personal interviews, face-to-face, were also conducted with water-management institutions and local government (municipalities). A representative sample size of 201 municipalities was sampled for the study population of the research project. The specific tariff rates for local municipalities were adjusted to comply with the predefined blocks, – namely, 0–6 kl (m^3), 6–20 kl (m^3), 20–60 kl (m^3) and >60 kl (m^3) (Table 1). Stepped water use tariffs are set in South Africa based on the defined blocks of water use pricing. For the financial year, the survey captured water use tariff blocks in the format (number of blocks and actual volume ranges per block) as each municipality applied it. The indigent water use tariff type was added to indicate whether free basic services were part of the water use tariff structure of the municipality and whether it applied to the indigent households only or to all customers.

- Secondary data were collected from review of reports relating to water infrastructure needs, financing and funding in South Africa. The following were examined: (*i*) compiled data on current expenditures and revenue patterns of the national government departments according to the National Treasury – for example, DWS, DCoG, water agencies or entities, water utilities, metropolitan municipalities, district and local municipalities; (*ii*) statistical data on South Africa released by Statistics South Africa (Stats SA, 2019a, 2019b); and (*iii*) private sector data for water supply and infrastructure for the past 10 years (2008/2009–2019/2020). Revenue streams, local debt, expenditure restrictions and other information related to the funding and financing (investments) of water infrastructure were reviewed.

Statistical analysis

For the significance tests, two-tailed parametric statistical *F*-test was used (Creswell, 2013). In the two-tailed statistical method the *F*-test is used in which the critical area of distribution is two sided and tests whether a sample is greater than or less than a certain range of values, at $\alpha = 0.05$. The null hypothesis (H0) assumes that two samples come from two different populations with equal variances or the true mean difference is equal to zero – that is, H0: $\mu = 0$. The two-tailed parametric statistical alternative hypothesis (H1) tests that two samples did not come from two different populations with unequal variances or the true mean difference is not equal to zero – that is, H1: $\mu \neq 0$. For statistical analysis, the various water use block structures were normalised into the most common and standard

Table 1. Three-block water use pricing system for the funding and financing of the water infrastructure value chain in South Africa

Customer classification: dividing customers into groups – namely, residential, industrial and commercial. Many systems have different tariffs/rates for each class of customers/users.
Consumption block: preset quantity (volume) of water at a stated price. See the following example of a tariff/rate structure with four consumption blocks:

- free water supply for the first 6 kl used (free basic water services for poor/indigent communities)
- US$$x_1$ for the first 6 kl used
- US$$x_2$ for 6–20 kl used
- US$$x_3$ for 20–60 kl used
- US$$x_4$ for >60 kl used.

Uniform flat tariff/rate
Customers/users pay the same amount regardless of the quantity (volume) of water used, in unmetered systems.
Example:
Each customer will be charged a uniform flat tariff (rate) of US$*x* per month.
Advantage: it eliminates the cost of installing and reading meters.
Disadvantages: water users pay too much or too little for what they use – mostly those in the agricultural water usage and domestic water usage sectors, for example – and it promotes higher water consumption and wastage.

Single block tariff/rate
Customers/users are charged a constant price per kilolitre (m^3), regardless of the amount used. This is often coupled to a minimum charge for having the service available.
Example:
US$*x* minimum service-availability charge (optional) plus US$*y* per kilolitre ($m^3$) used.
Advantages: it is easy to administer and may encourage water conservation. The costs to the customer/user are in direct proportion to the amount of water used.
Disadvantages: it could discourage high water-consuming industries from being in water-scarce areas or close to communities.

Increasing block tariff/rate
The price of water increases as the amount (volume) used increases. Each succeeding consumption block is more expensive. This structure assumes that water tariffs (rates) should promote water conservation and demand management.
Example:

- US$$x_1$ (e.g. US$0.258) for the first 6 kl (m^3) used
- US$$x_2$ = US$$x_1$ + (US$$x_1$)0.5 (50%) minimum for 6–20 kl (m^3) used (i.e. US$0.258 + US$0.129 = US$0.387)
- US$$x_3$ = US$$x_2$ + (US$$x_2$)1.0 (100%) minimum for 20–60 kl (m^3) used (i.e. US$0.0.358 + US$0.358 = US$0.716)
- US$$x_4$ = US$$x_3$ + (US$$x_3$)1.50 (150%) minimum for >60 kl (m^3) used (i.e. US$0.716 + US$1.074 = US$1.790) and so on.
  Advantage: this promotes water conservation, which is particularly important in areas with limited water supplies or high treatment costs. Lower water use means less waste water and smaller, less expensive waste water facilities. It provides a reasonable amount (volume of water) at a reasonable price and charges a premium for those using more.
  Disadvantage: it is not easy to administer but could encourage water conservation and demand management. This option mostly applied throughout South Africa.

structures – that is, 0–6 kl (m^3), 6–20 kl (m^3), 20–60 kl (m^3) and >60 kl (m^3) – as independent variables, and this enabled the following water use pricing calculations:

- national average block water use tariffs
- water use tariff averages per province
- water use tariff averages per water user types
- water use tariff averages in rural and urban areas
- water use tariff geometric means – that is, mathematical, populated-weighted and volume-weighted modelling
- maximum and minimum water use tariffs per block
- year-on-year changes to the block structures – that is, water use tariff increases per annum.

Statistical data transformation techniques were used. This was the application of a deterministic mathematical function to each point in the data set so that the data appeared more closely to meet statistical inference assumptions – that is, a replacement that changes the shape of a distribution or relationship (Creswell, 2013; Gioia *et al*., 2012). The research data were $\log_{10}(x + 1)$ and arcsine $x^{1/2}$ transformed – that is, each data point z_j was replaced with the transformed value $y_j = f(z_j)$, where f is the different water use charges and/or tariffs per water user, province and/or block structure. The study also applied modelling techniques for the social and financial impacts of the water use pricing, including obtaining the mathematical average by adding the water use pricing of all municipalities within each block and then dividing the sum by the total number of municipalities (returns). In addition, the population-weighted average considered the number of people affected within each municipality and by each water use tariff block. The volume-weighted average considered people and their service levels, thus representing the mean value of a kilolitre (m^3) of water used in each of the blocks.

Results and discussion

The water legislation of South Africa recognises that water use pricing should reflect the true cost of providing the service and provides an opportunity for new and innovative approaches to water infrastructure provision (DWAF, 2007; DWS, 2018; NT, 2019a; Ruiters, 2013). Closing South Africa’s funding gap of US$82.5

billion for water and sanitation (AfDB, 2018; DPWI, 2022; DWS, 2018; WB, 2010; WEF, 2018) inevitably requires reforms to reduce or eliminate the inefficiencies of the water sector value chain system. Only then can the water infrastructure sector become attractive to a broader array of possible investors and the country can benefit fully from the additional availability of finance. If not, what is the use of pouring water into a leaking bucket? Substantial evidence indicated that much more can be done within South Africa's existing water infrastructure financial resource envelope of US$2.5 billion per annum.

Water use pricing

Water infrastructure development, management and supply services are hierarchical concerns in South Africa based on administrative and/or political boundaries – that is, national, provincial and local water-management institutions and governance system (Figure 1) (DWAF, 1997; Republic of South Africa, 1997, 1998). The hierarchy ranges from the national level to the local level with the responsibility for the implementation of each level varying from the government of the administrative boundaries to a combination of different aspects of the public and private sectors (Figure 1). The various water use tariffs and charges in the water infrastructure value chain accumulate to the end water user/consumer and all the sub-cost elements must be evaluated in the water-pricing value chain (Figure 2). Water pricing, use charges and tariffs are approved in compliance with national legislation (DWAF, 1997; Republic of South Africa, 1997, 1998, 1999, 2003). Based on this, a three-block pricing system of water supply services is applied in South Africa (Figure 3). Specific principles have been identified that have fundamental impacts on the appropriate water use pricing (Figure 4), – that is, water use charges and tariffs – and the financial health of water infrastructure and financing of existing and future water infrastructure (Basson, 2010; CE, 2002; Eales, 2011; Hosking, 2003; Ruiters and Matji, 2015, 2017; Still, 2003; Vawda *et al*., 2011). Depending on the implementation environment, the financing principles may fall short of raising the complete capital investment required for a water infrastructure development project (Figure 5). Considering a combination of sub principles would therefore be more advisable. Using financial (pricing, charges and tariffs) and economic efficiency modelling, in combination with the principal drivers, it was possible to quantify the funding requirements for the different services (capital and operational) for water infrastructure categories (high, medium and low capacities) (Figures 4 and 5; Table 2). This provides a sense of the differentiated water use pricing requirements for each category.

Raw water use pricing

The results for the raw water use charges indicated that the highest mean domestic and industrial charges were predominantly in the

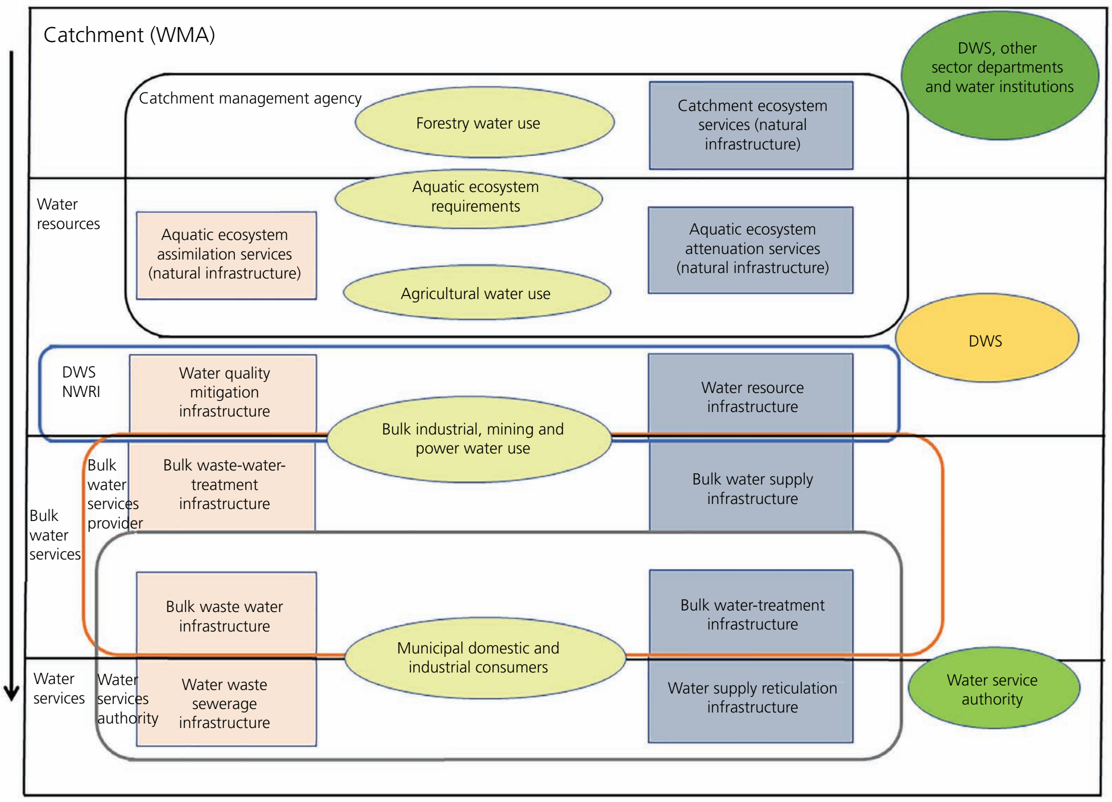


Figure 1. Water-management institutional hierarchical model with roles and responsibilities for the water infrastructure value chain in South Africa. NWRI, national water resource infrastructure

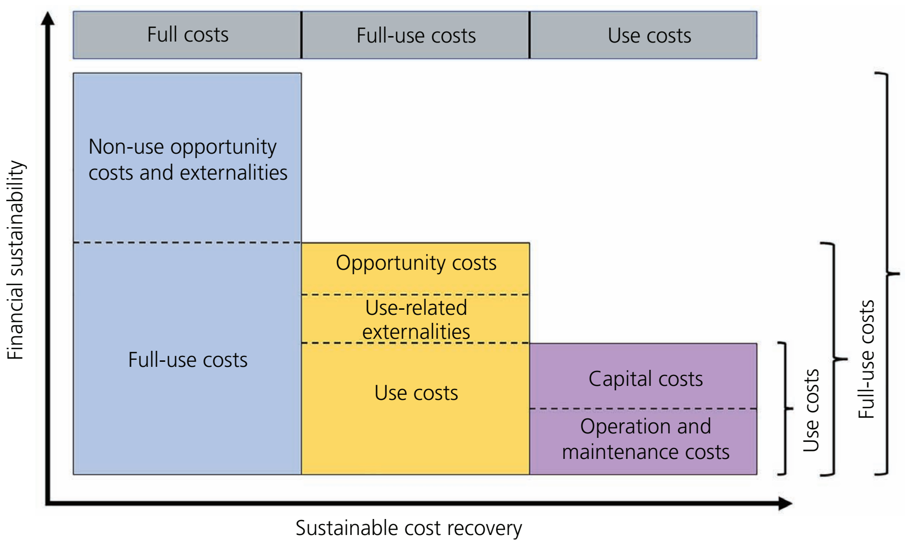


Figure 2. Components or constituent units of the cost-recovery model for water infrastructure value chain in South Africa

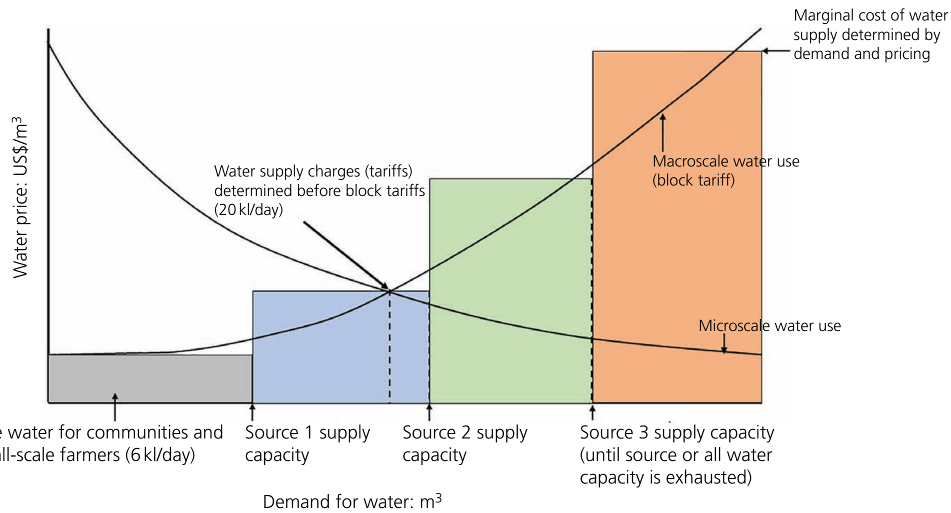


Figure 3. Water demand management (m^3) and water pricing (US\$/m^3) for the water infrastructure value chain in South Africa

WMAs (catchments or basins) of Western Cape province, followed by Limpopo, Free State and North West provinces (Figure 6). The mean raw water use charge for all the WMAs was US\$0.185/m^3 (standard deviation (SD) = ±0.09). The mean raw water use charges for the agriculture (irrigation) water use sector in the WMA were substantially small – that is, US\$0.001/m^3 (SD = ±0.0004) – and were not significantly different ($F_{0.05,\ 1,\ 36} = 0.0044$; $N = 38$; $p > 0.25$) from those of the domestic and industrial sectors. The raw water use charges for the forestry sector, the only declared stream flow-reduction activity in South Africa, were generally less than US\$0.001/m^3 ($\overline{X}$ = US\$0.0006; SD = ±0004). However, the water charges for forestry were not significantly lower ($F_{0.05,\ 2,\ 54} = 0.0012$; $N = 57$; $p > 0.25$) than those for the other water users. The mean annual raw water use charges for water supplied from water infrastructure (e.g. dams, canals, tunnels) was US\$0.0553/m^3 (SD = ±0.066) for domestic and industrial water users. They were not significant different ($F_{0.05,\ 1,\ 254} = 0.0256$; $N = 256$; $p > 0.25$) from the mean increases of 15.39% (SD = ±70.42%) year after year. The mean year-on-year increases for the water use sectors were generally >20%, far above the consumer price index (CPI) target of 6%.

Water use tariffs

Three water use tariff block structures are applied in South Africa (Table 1; Figure 3). There are, generally, challenges associated with these water use tariff blocks/structures and increases. However, customers/users have a clear understanding of the

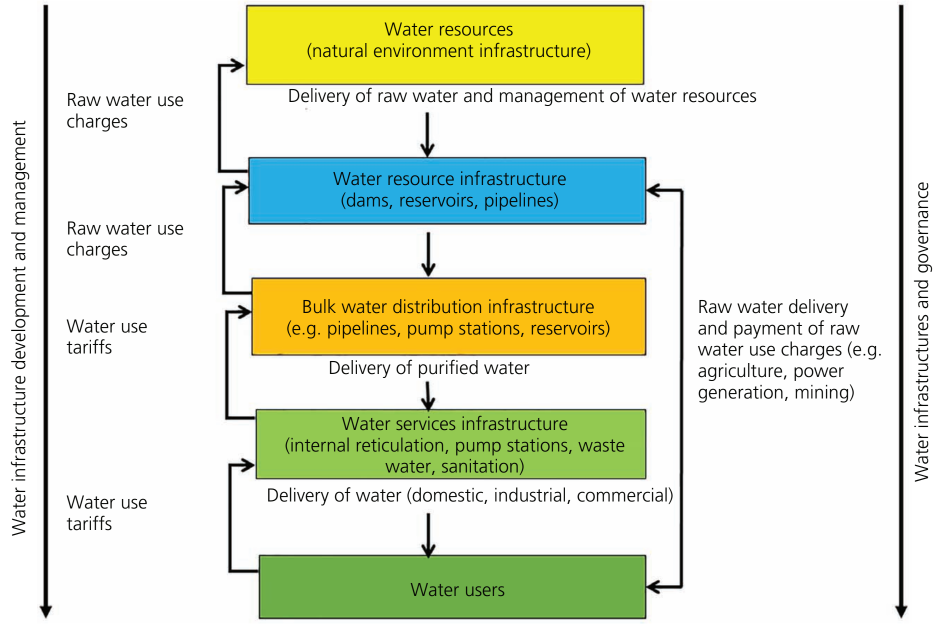


Figure 4. Conceptual model of water infrastructure development, management and supply service principles of water infrastructure investment in South Africa

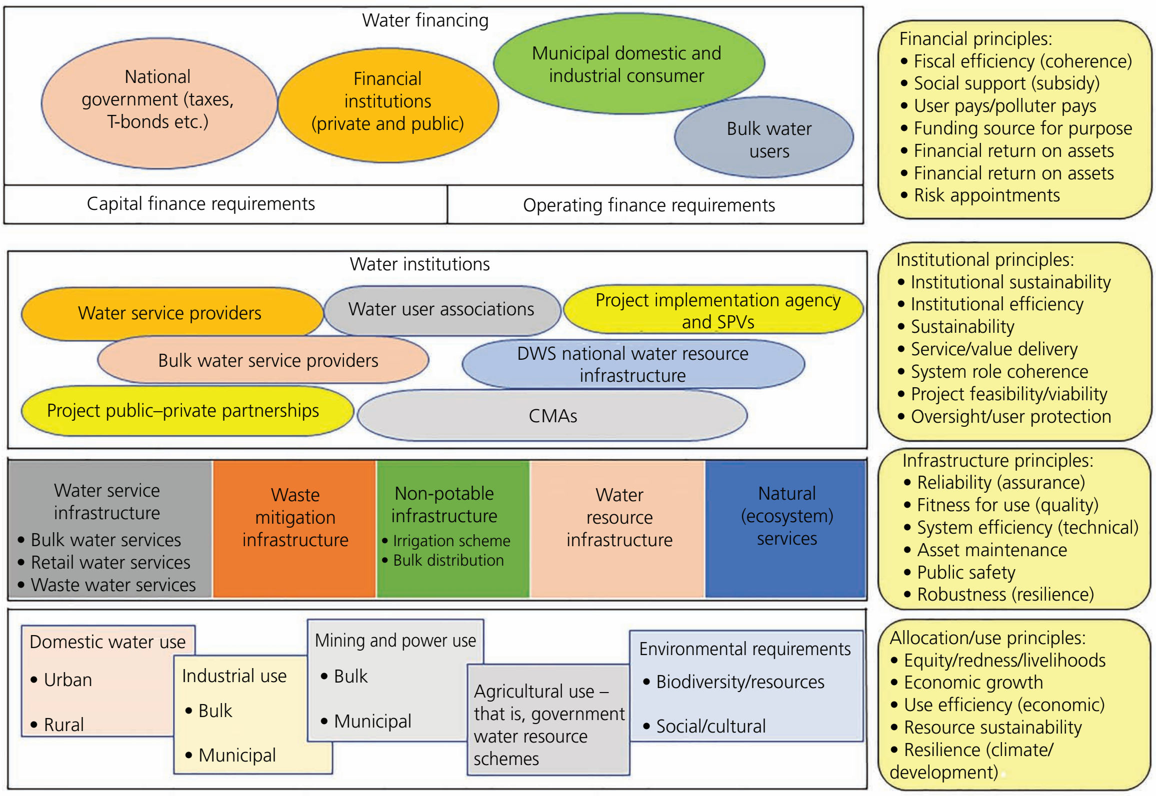


Figure 5. New national water infrastructure investment (funding and financing) framework model for water infrastructure in South Africa

Table 2. Capital investment requirements (US$ billions) for the water infrastructure value chain of high-, medium- and low-capacity municipalities in South Africa

Infrastructure by sector	Municipal category by capacity							
	Low capacity		Medium capacity		High capacity		Total	
	New	Rehabilitation	New	Rehabilitation	New	Rehabilitation	New	Rehabilitation
Water	1.051	0.903	1.409	1.348	4.897	3.793	7.358	6.044
Sanitation	0.981	0.624	1.164	0.843	3.620	2.181	5.765	3.648
Total	6.235	1.670	8.202	11.593	25.719	16.004	40.156	43.268

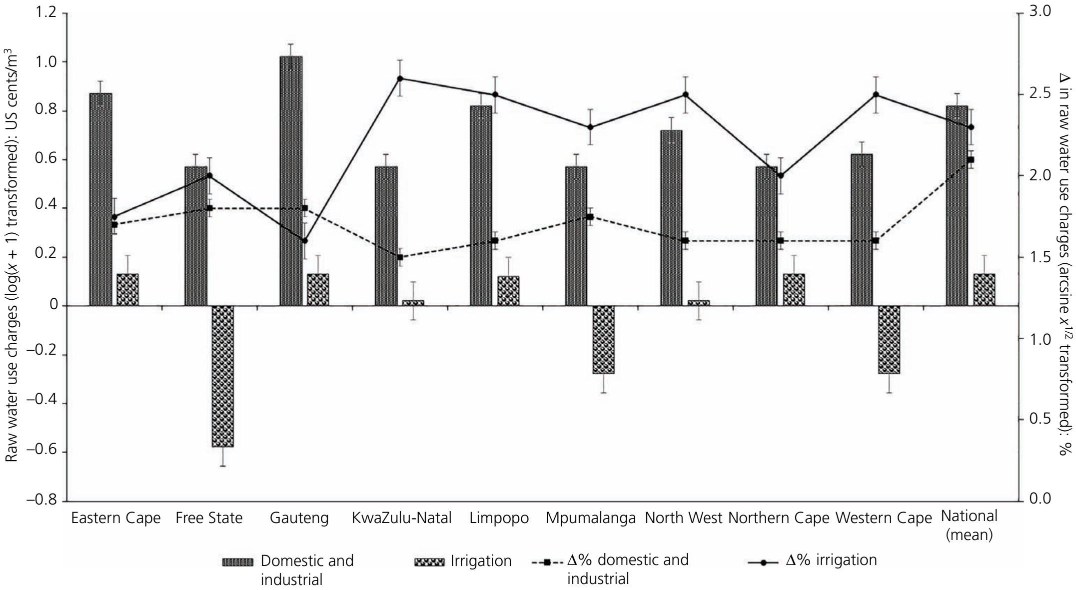


Figure 6. Mean annual (±SD) raw water use charges for water uses (log(x + 1) transformed) and % changes (increases) (arcsine $x^{1/2}$ transformed) for the sampled period (2008/2009–2018/2019) per province in South Africa

proposed water tariff structure and appreciate that the water use tariff structures are necessary to operate the system on a financially sustainable and viable basis. All classes of customers/users pay proportionally to the costs, which make it easier to gain support from all in the water infrastructure value chain and the public (Figure 5).

The mean annual bulk treated drinking water use tariff was US$0.315 (SD = ±0.242) per water utility, and the increases varied significantly, with the mean increase of 14.33% (SD = ±20.57) being above the CPI of 9.5% (SD = ±5.2) for the period surveyed. However, most water use tariffs varied, and the increases were between 2 and 57% above the CPI, although not significantly different ($F_{0.05,\ 1,\ 34} = 2.239$; $N = 36$; $p < 0.10$). The main customers of each water utility intersected the supply areas of local municipality boundaries to create a first-order linkage of water use tariffs with municipalities. These water use tariffs are normally indicative since they vary significantly in every government water scheme. Specific water use tariffs are normally negotiated between water utilities and municipalities.

The national mean residential domestic water use tariffs were US$0.238 (SD = ±0.310) for the 0–6 kl/month block, US$0.717 (SD = ±0.300) for 6–20 kl/month, US$0.868 (SD = ±0.352) for 20–60 kl/month and US$0.988 (SD = ±0.450) for usage >60 kl/month ($F_{0.05,\ 2,\ 24} = 4.17$; $N = 27$; $p < 0.05$) (Figures 7 and 8). In comparison, the provincial mean water use tariffs increased on average by 13.6% (SD = ±7.7) for the 6–20 kl block, 13.1% (SD = ±9.6) for the 20–60 kl block and 16.9% (SD = ±10.4) for the >60 kl block. These increases were above the corresponding CPI of 9.5% (SD = ±5.2) year on year for the surveyed period. In addition, budget formats in South African municipalities draw a clear distinction between operating and capital budgets (Figure 9). The water service function is an important municipal function, which makes up 16–20% of total municipal budgets (NT, 2019a, 2019b, 2019c). There has been constant growth in capital expenditure on water services and municipalities budgeted to spend US$0.525–0.817 billion for the 2018/2019–2020/2021 medium-term expenditure framework (NT, 2019a, 2019b, 2019c). The total investments in water and sanitation infrastructure in the past 20-year period (1998/1999–2019/2020) have been approximately US$48.36 billion, with the public sector contributing approximately US $44.32 billion (91.64%). The contribution of the private sector was approximately US$4.04 billion (8.36%) (Figure 9). Overall,

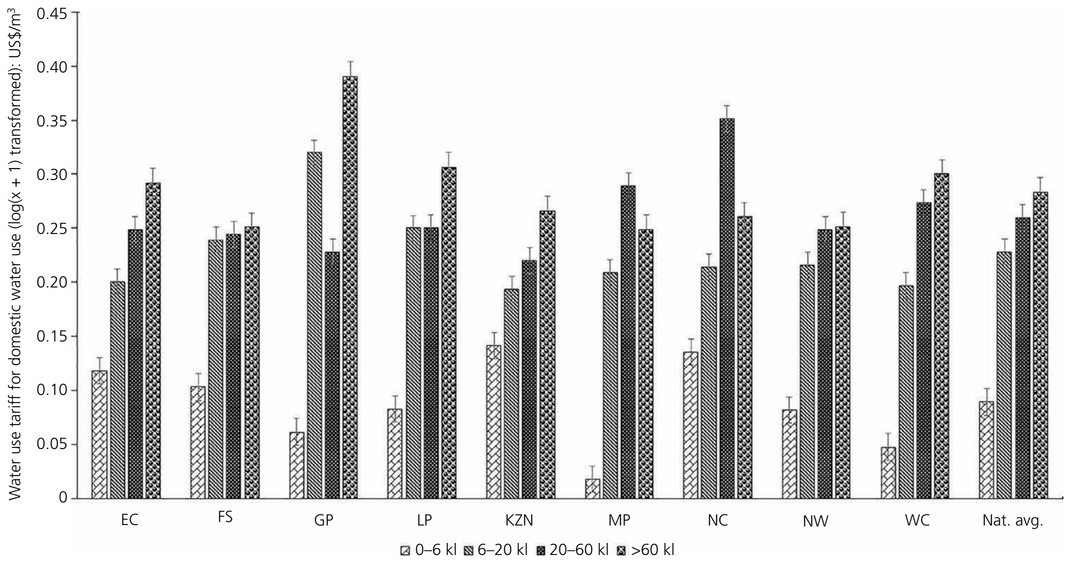


Figure 7. Mean municipal water use tariffs for domestic water users per province in South Africa. EC, Eastern Cape; FS, Free State; GP, Gauteng province; KZN, KwaZulu-Natal; LP, Limpopo province; MP, Mpumalanga province; NC, Northern Cape; NW, North West; WC, Western Cape; Nat. avg., national average

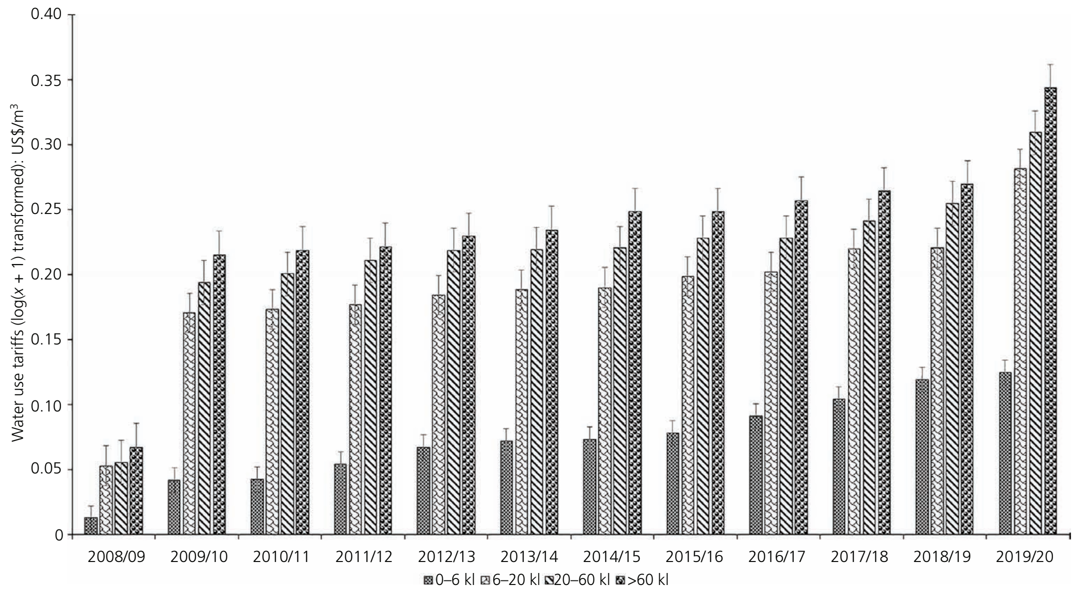


Figure 8. National mean residential domestic water use tariffs for the differentiated block structure for the sampled time period in South Africa

the general expenditure on water infrastructure in South Africa was high, with an average of US$2.42 billion/annum (SD = ±0.999). Most was paid by domestically sourced investments: (*a*) an average of US$2.24 billion/annum (SD = ±0.463) expenditure was financed by South African taxpayers and water users and (*b*) a further US$0.179 billion/annum (SD = ±0.085) was from external private sources. It has grown very strongly in the past decade, and budgets continue to grow at 13.5%/year. Most municipalities' capacity to budget reliably for water infrastructure spending was weak because of inadequate or poor infrastructure planning with appropriate time horizons, resulting in significant underspending of capital budgets by US$1.874 billion in the indicated time period. The Municipal Infrastructure Grant (MIG) contributed 28.3% to metropolitan municipalities' capital budgets and achieved a healthy balance because of sufficient revenue (equity) through appropriate and affordable

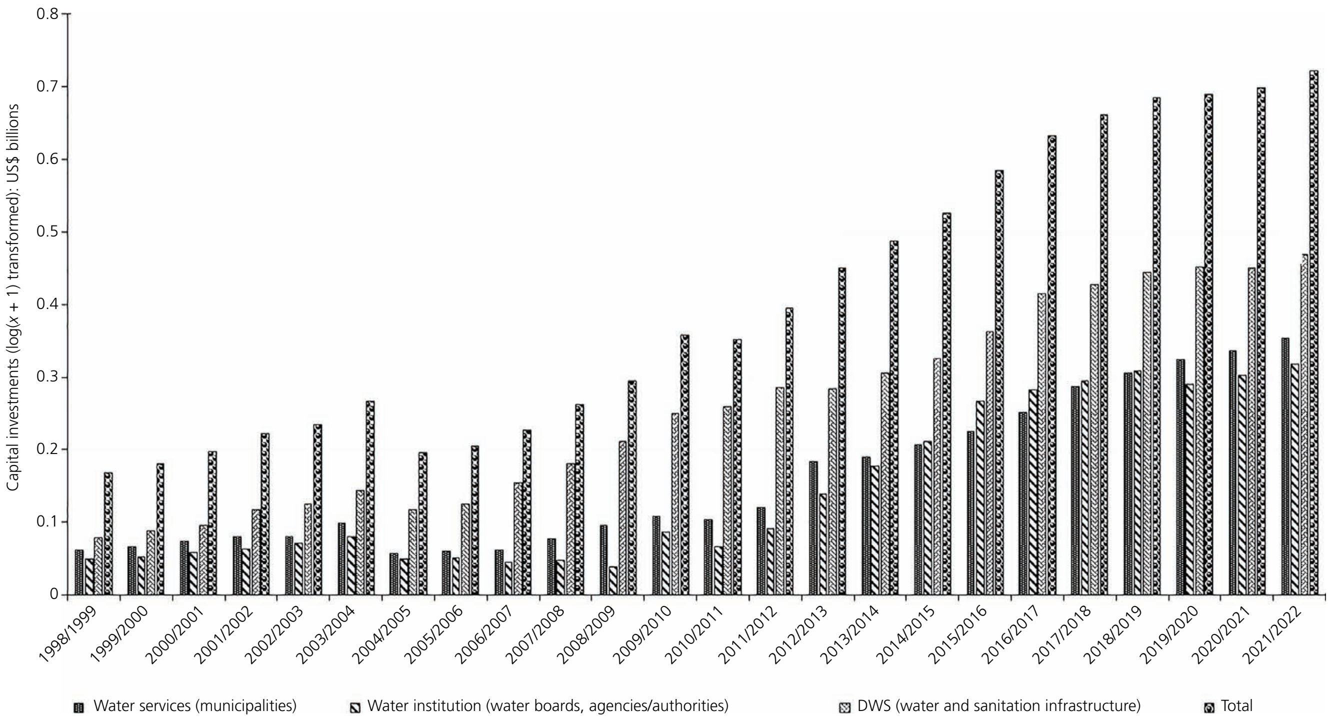


Figure 9. Water infrastructure investments in the last 20 years and current medium-term expenditure framework (2019/2020–2021/2022) in South Africa

water use tariffs (Figure 9) (NT, 2019c). However, for secondary cities, the MIG contribution to capital budgets was approximately 75.6% (SD = ±5.3%) for the research study time period. These municipalities were grant dependent with unsustainable water use pricing, resulting in inadequate cost recovery and revenue. The capital budgets in towns and rural and district municipalities constituted 100% of MIG. This indicated serious weaknesses, as they did not correctly reflect the MIG in their capital budgets and return on assets for water supply and infrastructure. The highest water use tariffs were in Gauteng province, where the cost of water supply services was generally associated with vast distances through inter-WMA (basin or catchment) water infrastructure delivery systems. Furthermore, the steep rises in block water use tariffs indicate a demand-management approach (Table 1). Low water use tariffs are generally associated with areas that have elevated levels of poverty and low levels of affordability.

In relation to the above, 57% (115) of municipalities increased their water use tariffs within the CPI range, 23% (46) of them increased their water use tariffs below the CPI and a further 20% (40) of municipalities increased their water use tariffs at levels above the CPI range. Comparison of the different water use tariff blocks showed that the percentage increases were higher for the high-volume blocks, which indicated increased demand management and utilisation of income from high-volume users to cross-subsidise the low-volume water users (Figures 3, 7 and 8). In addition, comparison of urban and rural municipalities showed that rural municipalities charged about 10% below the equivalent water use tariffs compared with urban areas.

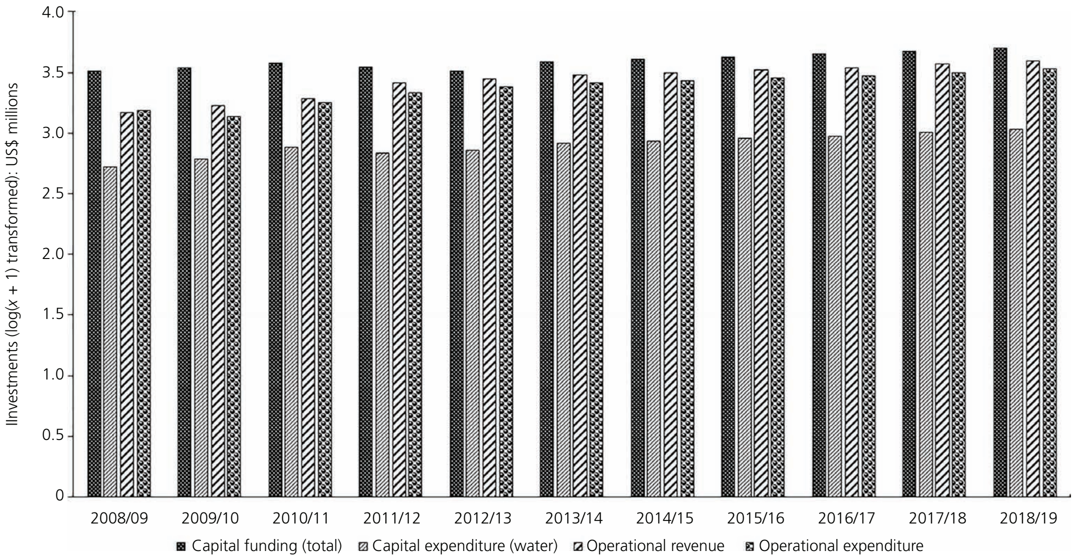
Gauteng, KwaZulu-Natal and Western Cape provinces, the urbanised provinces of South Africa, had the highest water use tariffs, while Limpopo, Mpumalanga, Northern Cape and North West provinces (rural provinces of South Africa) were at the lower end (Figure 7). Eastern Cape province had the highest annual increases – namely, 37% in the lower blocks and up to 57% in the higher blocks – reflecting water scarcity and security in the region and demand-management intervention. Limpopo, Free State and Gauteng provinces had increases of 17–34% from the lower to the higher blocks. The other provinces had increases within the CPI. These water use tariffs should be compared with cost recovery, as the urban areas benefit from economies of scale and should have a significantly lower tariff than rural areas. However, this suggests that rural municipalities are not applying efficient water-use-tariff-setting models for efficient cost recovery and revenue (Table 3).

In terms of the return on capital generated by water use tariffs, WSAs' (municipalities) own revenues grew strongly over the research period – that is, US$2.71 billion for water supply and US$1.12 billion for sanitation or approximately 18.6%/annum (Table 3; Figure 10). These constituted approximately 28% of municipal revenue and normally cross-subsidise other services. The overriding principle is always to apply revenues to fund ongoing

Table 3. Financial position and contributions by the key water sector role players in water infrastructure in South Africa in 2019/2020

Water institution	Revenue: US$ billions/annum	Operating expenditure: US$ billions/annum	Capital expenditure: US$ billions/annum	Loans (current): US$ billions
Municipal water supply	2.71	5.60	0.93	0.47
Water boards (entities)	1.87	1.68	0.65	1.12
Water agencies/authorities (e.g. TCTA)	1.12	0.93	1.03	3.27
DWS: water-trading entity	0.93	0.84	0.37	2.61
DWS: water supply	—	0.19	0.93	—
Total water supply	**6.63**	**9.24**	**3.91**	**7.47**
Municipal sanitation	1.12	2.52	0.93	0.28
DWS and water board sanitation	—	0.09	0.28	—
Total sanitation	**1.12**	**2.61**	**1.21**	**0.28**
Total water sector	**7.75**	**11.85**	**5.12**	**7.75**

TCTA, Trans-Caledon Tunnel Authority



Note: capital funding (total) is the total budgeted revenue/funding for all water infrastructure consisting of grants, subsidies, loans, revenue donations and other funds.

Figure 10. Capital funding, budgeted expenditure (capital, operational, repairs and maintenance) and revenue of the water infrastructure value chain at the municipal level (local government) in South Africa

operational requirements, reduce debt (current and future) and thus minimise future finance costs. In addition, the analysis exemplified that approximately US$2.75 billion/annum was available based on the current financial arrangements, leaving a finance gap of US $2.83 billion/annum in the water infrastructure value chain, – that is, approximately 50% of the requirements (Figures 10 and 11). However, the rapid increases in water use tariffs have squeezed these revenue surpluses. This highlights the need for the stricter application norms and standards relating to surcharges on these municipal services, so that this 'surplus share' that municipalities rely on to cross-subsidise other services can be made transparent and protected. The most serious misalignment in budgets involves underinvestment in refurbishments, repairs and maintenance. Furthermore, addressing under-maintenance in the water infrastructure value chain can save US$0.25 billion/annum in rehabilitation, or spending US$1 on maintenance can result in savings of about US$4 to the economy (Goodman and Hastak, 2006). On average, 30% of South Africa's water service infrastructure assets need rehabilitation (DCoG, 2021; SAICE, 2022). In general, the state of rural water service infrastructure is substantially worse than the rest, with 35% of assets in need of rehabilitation, compared with 25% elsewhere. Wide differences also exist across the, country and in best cases, ≤10% of assets need rehabilitation and in the worst cases >40%. If water use tariffs are

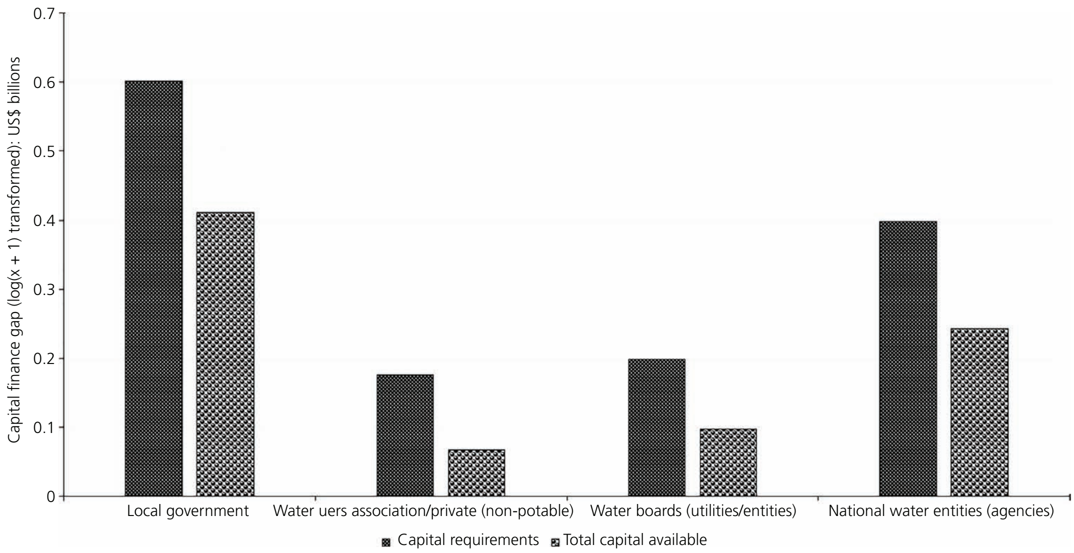


Figure 11. Capital finance gap (US$ billions log(x + 1) transformed) for water infrastructure investment (funding and financing) in South Africa

not tapered rapidly to a reasonable economic level with explicit subsidies and water (social) use pricing as inherent ingredients, the operations and maintenance may continue to decline and stagnate with profound consequences not only for health but also for the population and livelihoods whether they be agricultural, industrial or others (Ruiters, 2013; Ruiters and Matji, 2015, 2017; Vawda *et al*., 2011). While it is difficult to quantify and measure the cost of the probable impact of climate change on the country's water system, it is acknowledged that possible climate change impacts complicate the planning for future water supplies which also present challenges to water infrastructure and investment needs. The most likely scenario is that climate change will reduce water availability, although these effects will be unevenly distributed across the country, which will consequently lead to an increase in the unit cost for water from different water sources. This cost will need to be passed through the water infrastructure value chain, which will ultimately result in increases in water use charges and/or tariffs. Furthermore, more extreme hydrological cycles – that is, extreme wet and dry cycles – will cause greater impact on water infrastructure, resulting in a greater need for rehabilitation and replacement.

These water infrastructure investment problems are further compounded by the fact that many municipalities do not strategically manage their assets, unaware of what assets they have, the location of assets, the age of assets and what investments are needed to extend the useful life of these assets. Without this information, it is almost impossible to determine the investment needs required. It is a general rule in South Africa for municipalities to allocate approximately 5–12% of their annual operating budgets for rehabilitation and maintenance (CIDB, 2007, 2014; NT, 2019c) (Figure 10). However, in terms of opportunity cost when water-management institutions experience any kind of financial stress, invariably, the first category of expenditure to be cut is operations (repairs), maintenance and capital expenditure. However, the medium- to long-term consequences of underspending on operations and maintenance include

- deteriorating reliability and quality of services
- moving to more expensive crisis maintenance, rather than planned maintenance
- increasing the future cost of maintenance and refurbishment
- shortening the useful life of assets, necessitating earlier replacement – that is, high capital costs
- cost influence on charges and/or tariff calculations and models.

However, the substantially high water use tariffs and correcting some for below-inflation increases were due to increased financial

Table 4. Mean annual water use tariffs (US$/m^3, value-added tax inclusive) for domestic water use in Africa for the surveyed period 2008/2009–2019/2020

Urban or rural dominance	Tariff (0–6 kl)	Tariff (6–20 kl)	Tariff (20–60 kl)	Tariff (>60 kl)
Rural	0.25 ± 0.30	0.63 ± 0.24	0.78 ± 0.30	0.83 ± 0.36
Urban	0.18 ± 0.27	0.94 ± 0.38	1.15 ± 0.32	1.50 ± 0.57
Mean	0.23 ± 0.12	0.68 ± 0.15	0.79 ± 0.16	0.89 ± 0.19

Note: 0–6 kl (m^3) should be free at the municipal level and therefore a refund from the equitable share

Table 5. Applied modelling for the surveyed period water use tariffs (US$/m^3, value-added tax inclusive) per block for domestic water use in South Africa

Unit of analysis	Tariff (0–6 kl)	Tariff (6–20 kl)	Tariff (20–60 kl)	Tariff (>60 kl)
Mathematical average (geometric mean)	0.19 ± 0.12	0.67 ± 0.15	0.92 ± 0.18	1.02 ± 0.22
Population-weighted average (geometric mean)	0.21 ± 0.32	0.70 ± 0.27	0.97 ± 0.33	1.31 ± 0.41
Volume-weighted average (geometric mean)	0.17 ± 0.36	0.64 ± 0.26	0.78 ± 0.33	0.89 ± 0.39

pressures in municipalities and the use of high commercial water use tariffs to cross-subsidise residential water use tariffs in low-affordability areas (Figure 3; Tables 4 and 5). The high water use tariffs in the upper blocks indicate the introduction of stronger water-demand-management measures for this water user group (Tables 4 and 5). This was to be expected, as many of the new domestic water services were for the low-income and indigent customers. The population-weighted and volume-weighted average tariffs were higher in the upper blocks, as the number of people using water to such an extent (high levels of service) was relatively low compared with most people using water in the lower two blocks (Tables 4 and 5).

In addition, the larger municipalities (i.e. metropolitan and secondary cities) have separate water use tariffs for commercial and industrial water users (Figure 12). The mean commercial water use tariffs were US$0.434 (SD = ±0.777) for 0–6 kl, US$0.958 (SD = ±0.506) for 6–20 kl, US$1.090 (SD = ±0.599) for 20–60 kl and US$1.348 (SD = ±0.860) for volumes >60 kl/month. The commercial and industrial water use tariffs were higher than the domestic water use tariffs in the lower blocks and in line with those of the higher water use blocks, thus indicating cross-subsidisation of the domestic water use sector. The respective increases for the commercial water use tariff blocks were 17% in the 0–6 kl block, 14% in the 6–20 kl block, 17% in the 20–60 kl block and 19% in the >60 kl block, which were in line with the increases in the domestic water use tariffs and about 20–70% higher than the CPI for the same reporting period. The mean (average) water use tariffs for industrial water users were the highest in Gauteng province, followed by Western Cape and KwaZulu-Natal provinces. The mean industrial water use tariffs were US$0.340 (SD = ± 0.830) for 0–6 kl, US$0.503 (SD = ±1.031) for 6–20 kl, US$0.576 (SD = ±1.245) for 20–60 kl and US$0.710 (SD = ±1.510) for volumes of >60 kl/month, with a mean of about US$0.432/kl (SD = ±0.503/kl) across the different blocks. The lowest industrial and commercial water use tariffs were in Eastern Cape, Free State and Northern Cape provinces. The increases in industrial bulk potable water use tariffs were significantly higher than the residential and commercial water use tariff increases. The mean average annual increase for this water use was on the order of 178.68% (SD = ±256.99%) for the sampled time period.

Multiplier effect of water use pricing

Table 6 shows the multipliers in the water infrastructure value chain – that is, the average of water use tariffs from raw water to

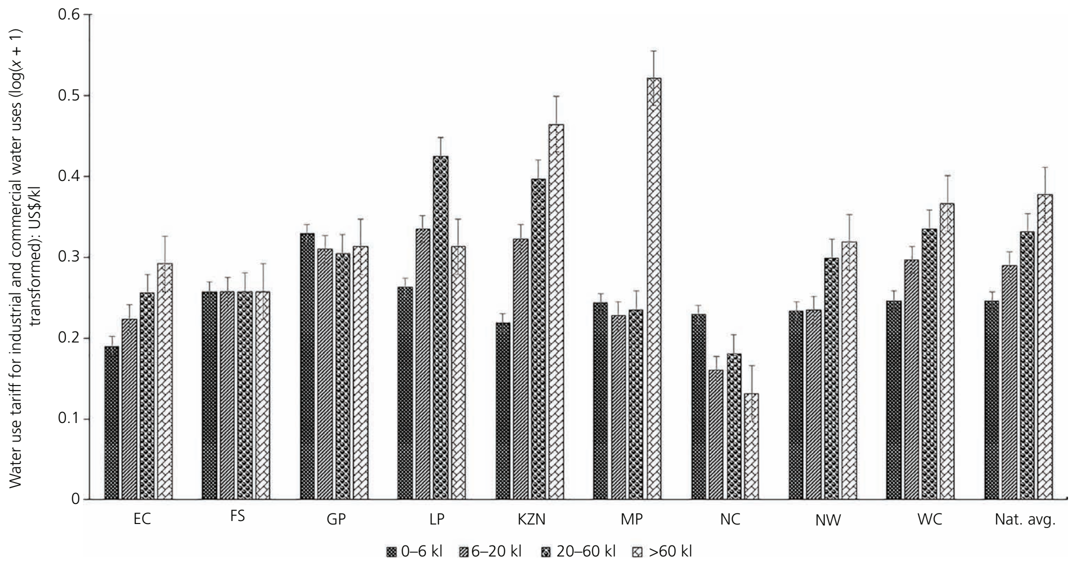


Figure 12. Mean provincial water use tariffs for industrial and commercial users in South Africa for the sampled period. EC, Eastern Cape; FS, Free State; GP, Gauteng province; KZN, KwaZulu-Natal; LP, Limpopo province; MP, Mpumalanga province; NC, Northern Cape; NW, North West; WC, Western Cape; Nat. avg., national average

Table 6. Mean annual water use tariffs (US$/m^3, value-added tax inclusive) and multipliers for the water infrastructure value chain per province in South Africa

Province	Average water resources management charges domestic	Average raw water cost	Average water board tariff	Average municipal tariff (i.e. 20–60 kl)	Average of multiplier: raw to bulk water	Average of multiplier: bulk water to municipal tariffs	Average of multiplier: raw water to municipal tariffs
EC	0.002	0.088	0.488	0.754	5.57	1.54	8.61
FS	0.002	0.032	0.466	0.737	14.52	1.58	22.94
GT	0.002	0.110	0.371	0.674	3.35	1.82	6.11
KZN	0.001	0.034	0.325	0.647	9.63	1.99	19.18
LP	0.002	0.074	0.335	0.760	4.51	2.27	10.23
MP	0.002	0.004	0.366	0.917	10.66	2.51	26.74
NC	0.001	0.075	0.614	1.193	8.21	1.94	15.95
NW	0.002	0.062	0.396	0.752	6.41	1.90	12.17
WC	0.003	0.041	0.504	0.853	12.25	1.69	20.74
National average	0.002	0.076	0.410	0.797	5.39	1.94	10.48

EC, Eastern Cape; FS, Free State; GP, Gauteng; KZN, KwaZulu-Natal; LP, Limpopo; MP, Mpumalanga; NC, Northern Cape; NW, North West; WC, Western Cape

bulk water to municipal retail and between the three spheres of government. With proportional inclusion of raw water use charges for Gauteng, Free State, Northern Cape and Western Cape provinces, the multipliers are varied and substantially high with values between 3 and 15 for the sampled period. Only the Gauteng province multiplier of 3.35 can be considered moderate – that is, 'raw water to bulk water use' tariffs. However, this province is mostly urban, and its water use tariff model is highly dependent on economies of scope and scale. The high multipliers for the water use charges of KwaZulu-Natal and Mpumalanga provinces are for the Usutu and Tugela inter-WMA water infrastructure transfer schemes to the Vaal River system for power (electricity) generation, industrial and domestic water use. Although cost models have been derived for these inter-WMA water infrastructure transfer schemes, in general, the multipliers for the raw water to municipal water use tariffs are exceptionally high – that is, >6. There are continual refinements of these models that give a comparative framework and analysis of the water infrastructure value chain per province in South Africa.

Conclusion

The economic view is that all water costs must be reflected in pricing. South Africa needs to retain the 'user pays' principle by charging users for the utilisation of water infrastructure – that is, full-cost recovery through water use pricing. This will provide the benefit of enabling revenue collected for financing water infrastructure while also leading to proper market-based pricing signals being employed, which can drive more efficient use of water infrastructure. South Africa should have differential charges for different water quality – for example, irrigation water (saline water, waste water and/or fresh water) – adjusting prices to reflect water supply reliability and implementing a resource-depletion charge. The DWS adjusted water use charges to reflect regional differentiation in water supply costs. Water use pricing has the two aims of expanding water supply and encouraging more responsible use of the water resources. Review processes must address the setting of water use charges and tariffs and the allocation of recovered revenue for water infrastructure development and management (operations and maintenance) – that is, 'ring-fencing' of water services, policies with regard to overt subsidies for specific water users, free basic water, hidden subsidies and so on.

The application of water use pricing as a tool for managing demand in a municipal (domestic) and industrial (commercial) context needs to factor in affordability. In terms of affordability, municipal-level water use pricing should consider the characteristics of customer classes and their ability to pay higher water use tariffs. Water use pricing can be used to encourage water conservation and demand management and to achieve efficiency gains. The pricing options must include (*a*) the repeal of water use charge capping; (*b*) review of block water use tariffs; (*c*) water use scarcity charges and/or tariffs for higher water use during dry seasons and/or droughts; and (*d*) seasonal water use charges and/or tariffs for peak (holiday) seasons. Municipal water use tariffs cannot be evaluated in isolation of the sequence of charges and/or tariffs in the water infrastructure value chain.

Although water use pricing of various types partially funds some of South Africa's water infrastructure, the link between costs and use is not well established. Reinforcing awareness of this relationship could lead to water conservation and demand measures and would also make it much easier to create stable funding vehicles that do not depend solely on general tax revenues. It is unlikely that water use pricing will ever totally reflect the 'full-cost' pricing approach favoured by environmental economics, but some 'directionally correct' pricing structures can be designed to encourage water use efficiency. Strategic pricing of water use can play a greater role in meeting the investment needs of South Africa's water infrastructure and raise revenues to support critical capital water infrastructure and revenue collection to support critical water infrastructure investments. In the water infrastructure value chain, these imperatives are now greater than ever before.

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