DUPC2 Deliverable

Enabling the assessment of alternative water supply systems to promote urban water security in the Global South (AltWater)

Water supply and demand in Maputo, Mozambique: current situation and future scenarios

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Executive Summary

Many cities in the global South are rapidly expanding, already facing water stresses, with the poorest often lacking access to reliable and safe water. There is a clear need to improve the sustainable sourcing and use of water in cities to secure supply in view of depleting resources, growing demands, and climate change pressures in the long term. Resilience to future change can be increased through diversification of supply sources. Alternative water supply systems represent an important opportunity in this respect.

The first stage of AltWater involves assessing the current and potential future water supply and demand situation (and thereby quantifying water balances) in AltWater Leader Cities (Maputo and Surabaya). Understanding current situations, and having an idea as the medium-term developments, is critical in water resources and water supply planning. This report presents the baseline and potential future assessments for Maputo, Mozambique. It will form the critical basis for the work to be carried out in later stages of the project concerned with the identification and assessment of potential alternative water supply solutions, and their contribution to addressing current and future water shortage issues in the city.

The water system in Maputo is fairly advanced, but faces non-revenue water in the order of 35%, and a coverage of about 60% and also faces a projected rapid increase in demand over the coming 15-25 years due to population growth and industrial expansion. At the same time, the water resources used to supply Maputo are becoming fully utilised, with little apparent scope for continued expansion. Climate change and upstream users may also further increase the pressure on water resources.

At present, there is an apparent water supply-demand deficit in Maputo of about 22 000 000 m^3 yr^{-1}. It is possible that some of this deficit is fulfilled with private vendors and through non-piped water supplies, and some may be covered through supply expansion. However forecasts of supply and demand to 2040 and beyond suggest that the supply-demand gap may increase. It is unclear how the gap will be filled. Achieving the NRW reduction will be essential, but will require funding, capacity and political support.

Alternative water supply sources such as from rainwater harvesting, stormwater harvesting and wastewater collected, treatment and re-use could prove useful in helping to close the supply-demand gap and in reducing the pressure that the current traditional supplies are facing. Such water sources would expected to be used for non-potable uses.

By using alternative water supplies for traditionally non-potable water uses that currently consume potable resources, the demand on traditional water supplies is lowered, freeing up freshwater for a number of purposes including expanding potable service delivery and for ecosystem services.

Which alternative water supply systems would be feasible, affordable and acceptable in Maputo, how much water they could *potentially* contribute, and how much water they might *realistically* contribute (which is a function of implementation and uptake depending on a wide range of factors) is still a matter of research, and is something that AltWater will actively investigate at later stages in the project.

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1. Introduction

Many cities in the global South are rapidly expanding, and already face water stresses, with the poorest often lacking access to reliable and safe water. There is a clear need to improve the sustainable sourcing and use of water in cities to secure supply in view of depleting resources, growing demands, and climate change pressures in the long term. Resilience to future change can be increased through diversification of supply sources. Alternative water supply systems represent an important opportunity in this respect.

AltWater will investigate ways to increase the self-reliance and sustainability of cities in the global South with regard to water supply by relieving pressure on traditional sources through the implementation of alternative water systems (for example rainwater harvesting, wastewater reuse, desalination). With partner cities in Mozambique and Indonesia, AltWater will develop a tailor-made approach in each city to evaluate the potential of alternative systems to contribute to urban water supply and security. Assessment of site-specific aspects of potential systems, including yield (water volume) and reliability, cost, institutional and socio-environmental factors across the city area will be carried out.

AltWater will address an important gap in the development and uptake of alternative water systems, which lies in the lack of assessment frameworks for these schemes. This project adopts a novel "Leader-Follower" City approach whereby Maputo and Surabaya are designated as leader cities. These two cities will then become primarily responsible for developing and training capacity in the Follower City (Beira and Gresik respectively). Local partners will gain knowledge and expertise in alternative supply assessment and planning through participation in the research. Collaboration and knowledge exchange between partners will be strengthened, increasing capacity and networks.

The first stage of the project involves assessing the current and potential future water supply and demand situation (and thereby quantifying water balances) in AltWater Leader Cities (Maputo and Surabaya). Understanding current situations, and having an idea as the medium-term developments, is critical in water resources and water supply planning. This report presents the baseline and potential future assessments for Maputo, Mozambique. It will form the critical basis for the work to be carried out in later stages of the project concerned with the identification and assessment of potential alternative water supply solutions, and their contribution to addressing current and future water shortage issues in the city.

2. Case study setting and description

Mozambique is located in south-east Africa (Figure 1). It covers about 800 000 km^2, and has a population of 28 751 000 (in 2016; http://data.un.org). Mozambique experiences a typical sub-tropical climate, with two seasons per year: winter between May-November, and summer from November to May. Rainfall is variable through the country, with the north generally being wetter, receiving up to 2000 mm rainfall per year, and the south being drier, receiving on average 750 mm per year (Tadross and Johnston, 2012). Between 2014-2015 and again between 2015-2017, rainfall totals in the Maputo area were low, corresponding to a regional drought. The annual rainfall has been up to 200 mm per year lower than average, with implications for water distribution in this period.

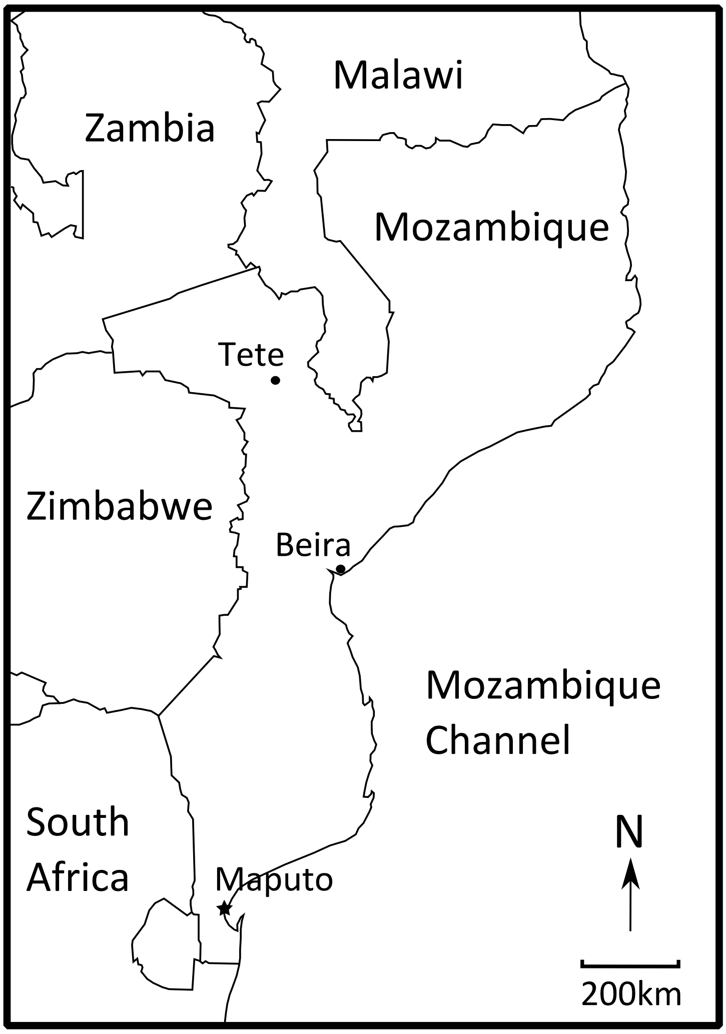

Figure 1: map showing Mozambique and the location of Maputo and Beira.

Mozambique has many large river basins, however almost half are the downstream parts of transboundary river basins (Tauacale, 2002), meaning that Mozambique is very dependent on upstream basins for its water supply (both in terms of quantity and quality. In the south of the country, which is drier than the north, and which contains the capital, Marques (2006) suggested that of the 21 km^3 of annual runoff, only 4 km^3 can be sustainably abstracted. As a result, cities such as Maputo and Beira are susceptible to: upstream countries' water use patterns and consequent downstream releases; climate change impacts on the water resource; and increasing demand for water from a growing population and rising living standards. Across Mozambique, agriculture accounts for approximately 70% of water demand, with the rest being split between domestic/municipal supply and industry. It is projected that across the nation, domestic water demand will increase by as much as 40% by 2030, and industrial demand by up to 65% (Global Water Partnership, 2015).

Against this context, Maputo, lying in the south of Mozambique and also the capital city, has a population of 1.1 million (2007 census data; www.ine.gov.mz). According to the National Statistics Office (INE) projections, in 2017, the population is approximately 1.27 million and by 2030 it will be about 1.5 million. Being in the south of the country, Maputo receives about 600-700 mm rainfall a year. Maputo covers an area of about 320 km^2, and has an economy centred on trade and the harbour.

3. Present-day water supply and demand

3.1 Description of the Maputo water system

In Maputo, the company responsible for water services is Aguas de Regiao de Maputo (AdeM), which supplies to Maputo city and Matola town, and the village of Boane under concession from Fundo de Investimento do Partimonio de Agua (FIPAG). These three areas have a combined population of 2 237 760. Out of these inhabitants, the current service coverage rate is 61%. The rest of the population rely on so-called 'small systems' – local, small scale groundwater sources – for their water supply.

The water supply system in Maputo, Matola and Boane, comprises of:

- The Umbeluzi System, consisting of the catchment, water treatment plant (ETA), transmission mains, distribution centers (at Boane, Belo Horizonte, Matola, Matola, Machava, Tsalala, Chamanculo, Alto Maé, Maxaquene and Laulane) and elevated towers. This is the main water source for Maputo, and is described in more detail below.
- The Ka Tembe Autonomous System;
- The Autonomous System of Vila Olimpica;
- The Intaka Autonomous System
- The Small Systems of Zona Verde, Kongolote, Matola Gare in Matola, and Magoanine and Albazine in Maputo.

The Autonomous Systems are comprised of holes, small reservoirs and distribution networks. The water, after being collected, is treated near the hole and stored in small reservoirs that feed a distribution network of relatively small extension.

Since this type of solution is based on underground sources, the Autonomous Systems are located in places that are difficult to reach from the Umbeluzi System (such as Ka Tembe and Vila Olímpica) and in areas without a distribution network and with abundance of underground resources (e.g. the northern part of the city of Maputo).

The Autonomous System of Ka Tembe has a production of 760 m^3 day^{-1} while the Small Zona Verde Systems, Kongolote, Matola Gare, Albazine and Magoanine have a total production estimated at about 6500 m^3 day^{-1}. In these smaller systems with holes, electric pumps are used to bring water to a reservoir which in then gravity fed for distribution.

General description of the Maputo water supply system

For the Umbeluzi System, water is collected downstream of the Pequenos Libombos dam, with a maximum production capacity of 240 000 m^3 day^{-1}, and treated in the Umbeluzi Water Treatment Plant Water Treatment Plant (WTP).

The Umbeluzi WTP (UTP) has three treatment lines built in phases: UTP 1, built more than 50 years ago, has a capacity of 3000 m^3 hr^{-1}; UTP 2, about 20 years old, has an installed capacity of 3000 m^3 hr^{-1}, although it currently operates at 2700 m^3 hr^{-1} due to the unavailability of 2 filters (in the process of rehabilitation); and UTP 3, which came online in 2011, with a maximum production capacity of 4000 m^3 hr^{-1}. All treatment lines have the same sequence of processes and unit treatment operations, namely pre-oxidation with chlorine gas, rapid mixing with addition of aluminum sulphate and polyelectrolyte for coagulation/flocculation, decantation, filtration, pH correction and disinfection with chlorine gas.

The produced water at UTP is elevated through a lifting system located immediately downstream of the UTP and transported along the transmission main system for about 115 km.

The transmission mains system integrates pipes and their fittings and the storage system, reservoirs, pumping stations and pressure towers. From the treated water pumping stations, the flow is pumped to the distribution centres through three parallel pipes. Figure 2 shows a schematic overview of the entire Maputo water system.

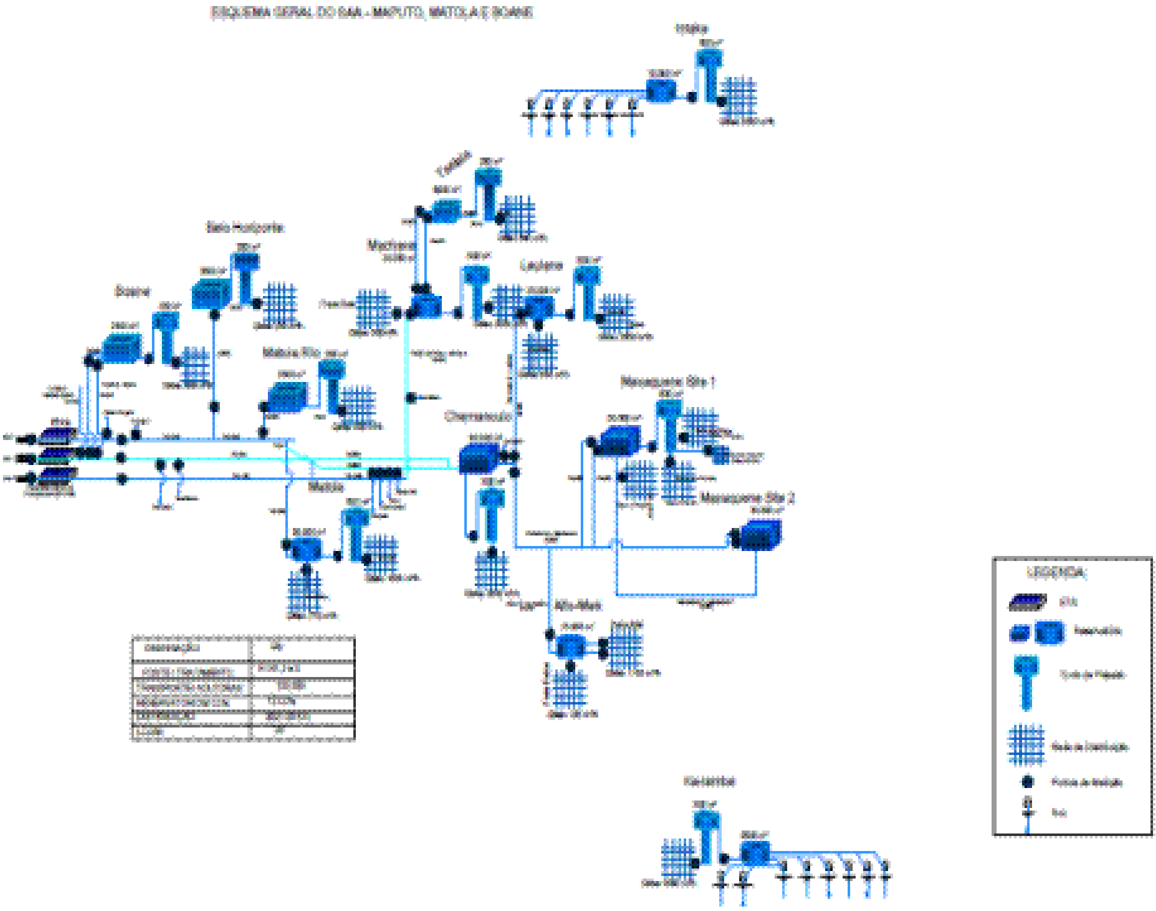

Figure 2: schematic of the Maputo water system (courtesy of AdeM).

The distribution networks operated by AdeM have a total length of about 3000 km, and have diameters varying between DN50 and DN400 mm, which reflects the historical evolution of network expansion.

The area of influence of the distribution networks associated with each Distribution Centre (DC) is generally constituted by two distinct altimetry zones: the High Zone, usually fed by a pressure or equilibrium tower, and the Low Zone, fed by gravity directly from reservoirs. However, the existence of distribution networks is not a guarantee of the quality of water supply service provided.

The Maxaquene and Alto Maé networks are currently operating at capacity, and near-term expansion of these networks is not foreseen. The area of influence of the Chamanculo Distributor Centre is extremely extensive, currently serving a large area of Maputo. There is a necessity to expand to areas where there is no network, thus ensuring service in these areas and improving the quality of service in some neighbourhoods. The situation of the distribution network of the area served by the Matola Distributor Centre is similar to that of Maxaquene and Alto Maé. These are areas already consolidated with an extensive network, but which need improvement and remodelling works to replace the smaller diameter pipes. These interventions will improve service levels.

Although the water supply system for Maputo, Matola and Boane municipality is described above and covers the entire water supply chain, here, we focus only on the Umbeluzi System, in particular on WTP, and on the Chamanculo Distributor Centre and associated infrastructure and equipment. This report will focus on water sourced from the Umbeluzi River as the predominant water source for Maputo.

The Maputo water source, Umbeluzi treatment plant and water distribution network

The main source for the Maputo water supply is the Umbeluzi river. The river basin covers a total area of 5 460 km^2, of which 41% is located in Mozambique, 58% in Swaziland and 1% in the Republic of South Africa (Figure 3). The Umbeluzi river has an annual average flow of about 490 x 10^6 m^3 at the mouth and 360 x 10^6 m^3 at the border into Mozambique. The catchment average annual rainfall is 736 mm. The river has two major hydraulic works, namely the Mnjoli Dam in Swaziland and the Pequenos Libombos Dam in Mozambique.

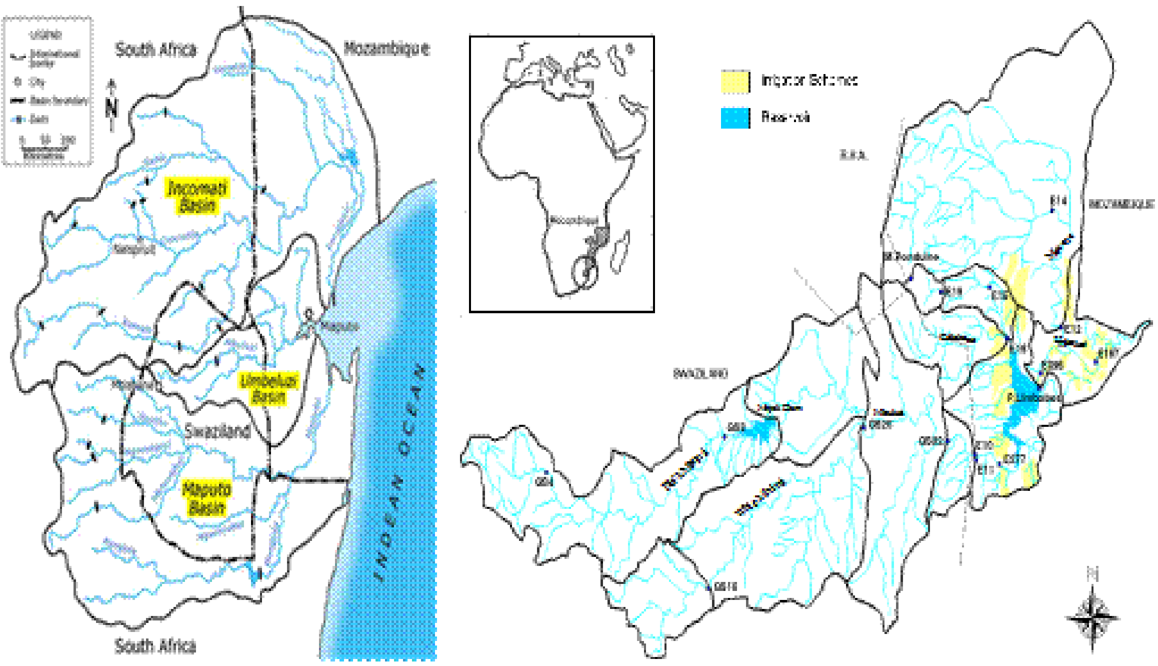

Figure 3: Map showing the Umbeluzi river basin (courtesy of AdeM).

The Umbeluzi treatment plant (UTP) is designed for a total flow of 10 000 m³ hr^{-1} (240 000 m^3 day^{-1}). Current daily average production is approximately 207,000 m³. The UTP is currently composed of three facilities: UTP 1, UTP 2 and UTP 3, with UTP 1 being the oldest. The first installation was built in the 1900s, having been successively enlarged since. Figure 4 shows the intake for the UTP.

Figure 4: intake for the Umbeluzi water treatment plant that serves Maputo (courtesy of AdeM).

Once source water has been collected and treated at Umbeluzi, it is transferred via a network of mains pipelines to 11 distribution centres (three for Boane, three for Matola and five for Maputo). Each distribution centre has reservoirs, pumping stations and pressure towers (expect for one centre). From these distribution centres, an extensive water distribution network transports water to customers. This network is over 3000 km in length, and consists of pipes of various diameter and material. Figure 5 shows a schematic overview of the Maputo water distribution network.

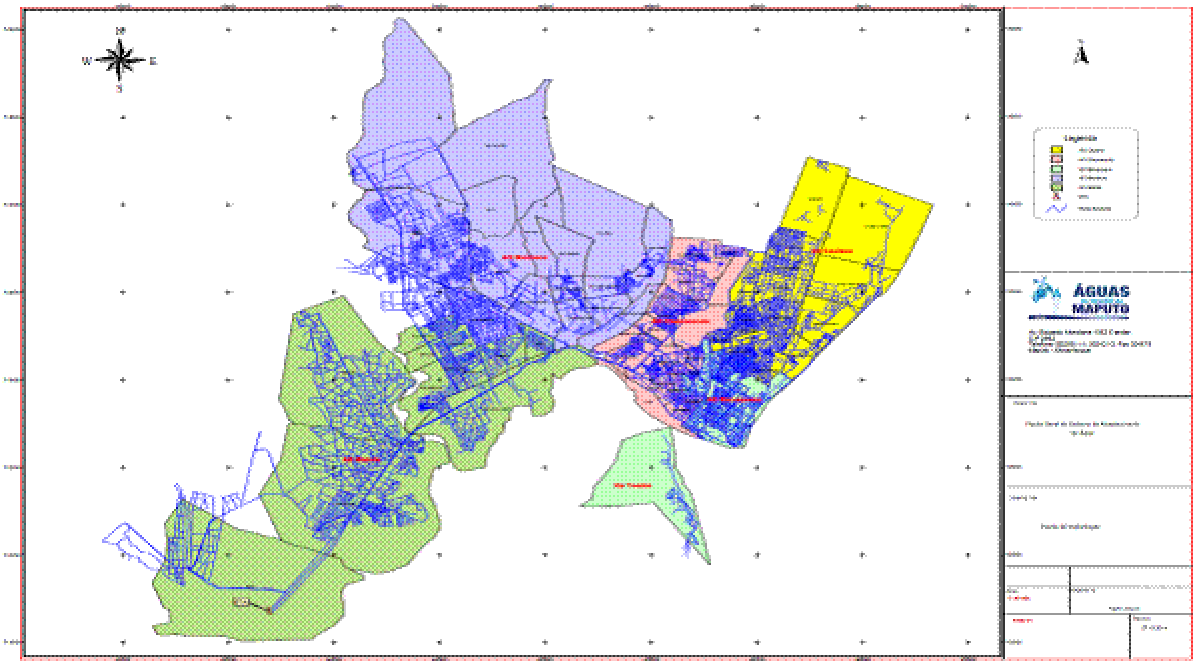

Figure 5: schematic plan of the Maputo water distribution network (courtesy of AdeM).

Maputo water metering

Following AdeM's strategy to control the network and enable quick and easy identification of losses in the network, metering of the network has been undertaken, beginning with the largest supply areas, and gradually moving to smaller areas. In an environment where less than half of the population has access to potable water, it is as important to manage expectations as it is to manage results. Institutional stability and transparency will enhance the trust of all stakeholders that progress is being made and that, in time, people will have universal access to safe potable water. It is hoped that metering will move towards this customer transparency.

Also under the metering program, non-revenue water (NRW) management, customer meters and distribution network meters were established, including the installation of 44 electromagnetic bulk meters in the whole system and main components, namely (Figure 6):

- In the raw water pipes before treatment;
- In the trunk mains after treatment;
- In the trunk main, at the entrance of the Distribution Centres;
- At the outlets of the distribution centres.

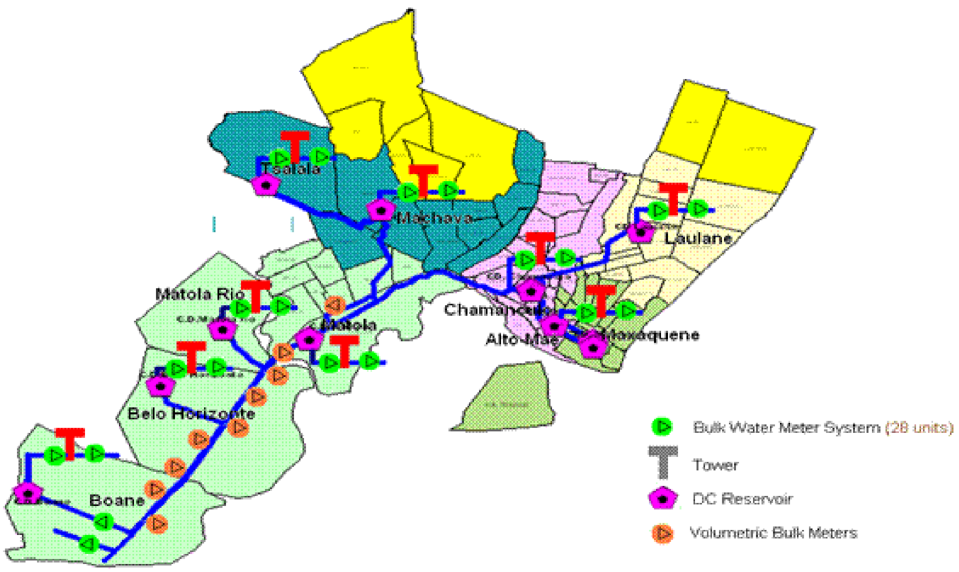

Figure 6: water bulk meters in the Maputo water system (source: AdeM).

With the installation of these meters the main impacts and results have been the following:

1) Reduction of the losses in trunk main from 8 to 3%;

2) Following the reduction stated above, it was possible to conclude that recent rehabilitation was effective. Consequently the transference of the connection from the old to the new structured network became a critical activity to implement.

Thus the whole network operating efficiency has been improved as a result of the installation of a metering system. As the result of the implementation of the water bulk meter system, and through an improved ability to measure of the network components, AdeM are better to monitor and control the delivery of potable water to customers. At present, non-revenue water is about 36% (Figure 7), which AdeM are looking to reduce as metering and control becomes more widespread, and as funds and income from bills are more reliably collected as a result of transparent metering.

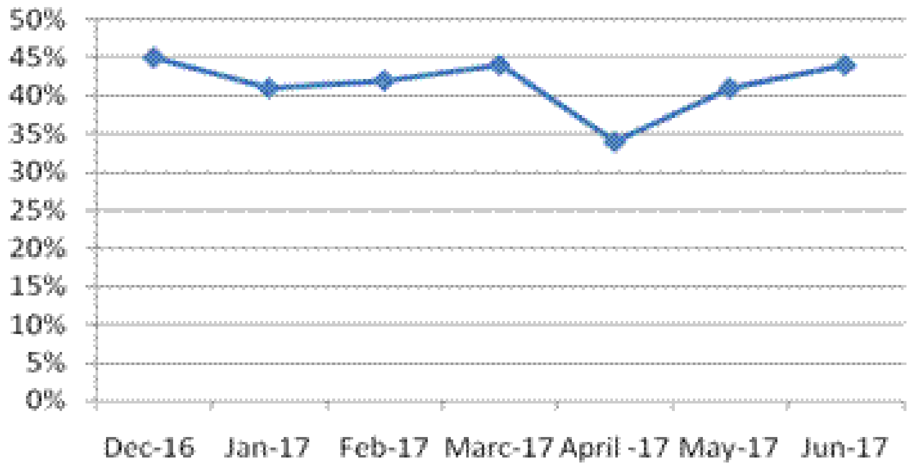

Figure 7: showing non-revenue water in late 2016 to mid-2017 in the Maputo water distribution system. The current annual average is around 36%.

4. Present day and estimated future urban water supply and demand for Maputo

This section of the report analyses present day water supply and demand figures for the Maputo case study in AltWater. Knowledge of the current state of the water system is critical in understanding where the main gaps and issues lie, how it might evolve in the future, and how alternative supplies could play a role.

Baseline (present day) supply and demand estimates

The city water demand is directly linked to the water requirements of the population in the area as well as the needs of the commerce and service industries. Using statistics and information from AdeM and looking at the current capacity of water production verses the expected water demand across the whole population, we see that the water balance (in terms of water supplied against that demanded) is negative (Table 1). In view of this situation, the search for alternative sources is recommended to ensure a supply not only to the present population (80 litres per person per day is quoted by AdeM as the average water consumption figure in Maputo), but also for the future population.

Table 1: 2017 water supply and demand balance in Greater Maputo, Mozambique (data from AdeM).

Maputo water supply and demand statistics, 2017		
Description	**Normal water supply**	**Emergency water supply**
Total population under FIPAG concession	2 237 760	2 237 760
Total population served by AdeM system	1 465 866	1 465 866
Water supply statistics		
Total monthly produced water volume (m^3)	5 741 667	4 814 016
Distributed monthly volume to domestic customers (m^3)	3 157 916	3 104 046
Distributed monthly volume to other customers (m^3)	2 583 750	1 709 969
Total monthly billed volume (m^3)	3 674 666	3 041 691
Domestic monthly billed volume (m^3)	2 583 750	2 140 721
Other monthly billed volumes (m^3)	1 090 916	900 969
Monthly NRW (m^3)	2 067 000	1 772 324
Water demand statistics		
Monthly per-capita consumption (m^3)[1]	2.4	2.4
Monthly population demand (m^3)	5 370 624	5 370 624
Monthyl water needs for other uses (m^3)	2 255 662	2 255 662
Monthly total demand (m^3)	7 626 286	7 626 286
Monthly water supply:demand balance (m^3)	-1 884 620	-2 812 271

[1](based on an average consumption of 80 l cap^{-1} day^{-1})

The relationship between the volume produced and the volume invoiced/supplied shows that there is a loss in the system of about 36%, as mentioned in the NRW analysis above. Actions to recover the NRW are necessary in order to achieve more than the current 64% of billed water, to increase revenue and therefore to have additional funds for further network rehabilitation.

Another way to estimate demand is from AdeM databases. In this context, Table 2 shows demand estimated using this information. It is noted that water demand for energy and agricultural uses are not included in this estimation as these users are not under the remit of AdeM.

Table 2: Maputo water demand estimations for 2017 from the AdeM database.

Client group		**Grand Maputo**	
	City	**Province**	**Total**
Domestic	134 069	109 008	243 077
Commerial and services	8242	2565	10807
Public	671	187	858
Industrial	632	996	1628
Sub total	143 614	112 756	256 370
Total water supplied (Mm^3 yr^{-1})	**34.7**	**40.8**	**75.5**
Population served	779 549	604 790	1 384 339
Population	1 216 122	1 053 910	2 270 032
Coverage	64%	57%	61%
Water demand (Mm^3 yr^{-1})	**53.27**	**46.16**	**99.43**

The estimates in Table 2 were calculated according to a methodology set out in the Mozambique Decree 30/2003, which recommends a per-capita consumption figure of 50-80 l cap^{-1} day^{-1}. Based on AdeM databases, average consumption is 125 l cap^{-1} day^{-1}, leading to a rough estimate of demand in Greater Maputo of 103.5 Mm^3 $year^{-1}$, which is not too far from the total presented in Table 2.

Most of the water produced in the Umbeluzi system supplies the outlying provincial areas, and the city centre of Maputo. In more outlying districts to the north, the small systems (holes) are used to supply this demand.

In addition to the above, AdeM is responsible for a limited number of the small systems, while the majority are privately owned. At present, AdeM has three active systems, with a production capacity of 9370 m^3 day^{-1} (and a capacity of 10930 m^3 day^{-1}). In 2018, these will be expanded, with an additional capacity of 39200 m^3 day^{-1} (total capacity will therefore be 50130 m^3 day^{-1}).

A third way to arrive at demand estimates is using information from FIPAG, which is responsible for water related investments in urban areas in Mozambique. Figure 8 shows the annual Maputo water demand, according to the records of FIPAG. For 2015, the estimate is lower than that of the AdeM sources in Tables 1 and 2. Even the 2020 estimate is somewhat lower than current estimates.

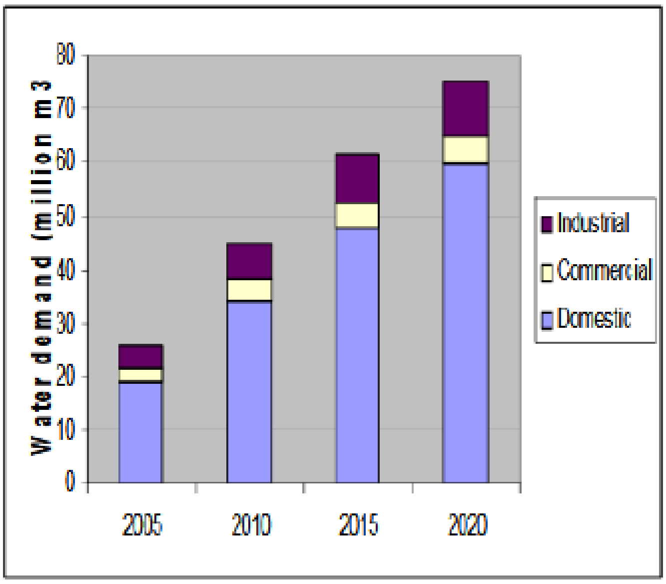

Figure 8: estimated Maputo water demand from FIPAG.

Although the baseline analysis in Tables 1 and 2 suggest net water shortage, and that service coverage is currently at 61%, it is probable that some users source water from informal means and/or from non-piped water supplies which may not show up in official statistics (e.g. from the small systems that are privately owned, especially to the north of the city). In addition, customers may get water, but perhaps not for 24 hours a day, seven days a week. Improving the NRW figures and collecting greater revenue could contribute to network maintenance, expansion and enhanced supply performance. It is the objective of AdeM to eventually supply all residents in Maputo from the piped water supply system with maximum efficiency and low losses. Reducing NRW and expanding the network are two focal points for short-term investment to achieve these goals.

Future supply and demand estimates

Looking to the future, there are plans to expand the capacity of the Umbeluzi system from 75.5 to 91.5 Mm^3 $year^{-1}$, which will certainly help improve service coverage. At the same time however, NRW must be reduced, and an expanding population served. It is expected that the domestic and industrial sectors will experience rapid growth over the next 20 years and more, leading to a dramatic water demand increase (Figure 9).

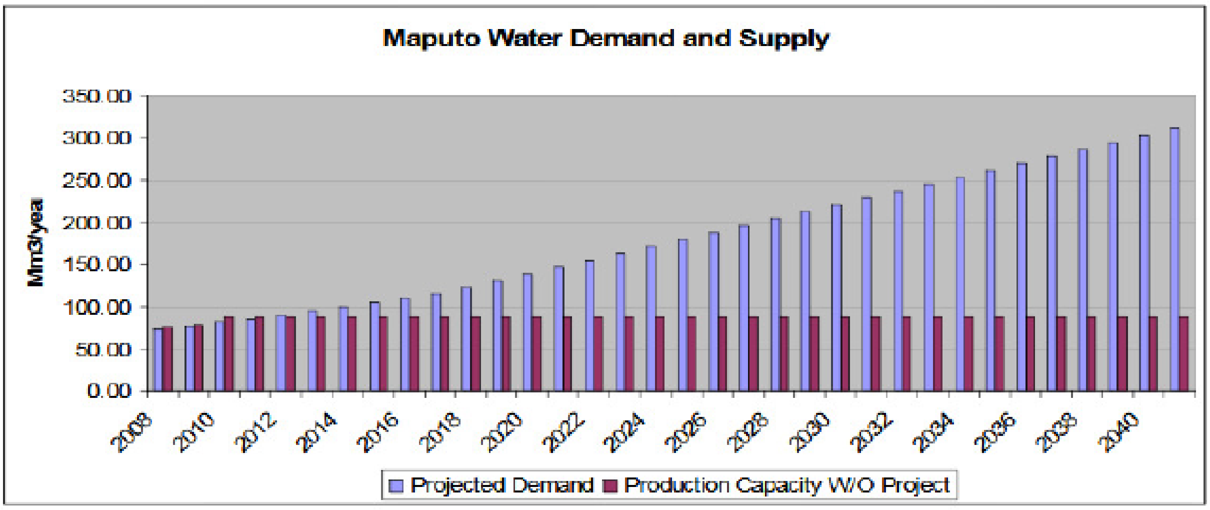

Figure 9: water supply and demand projections for Maputo (source: Preliminary Economic Analysis of the development of large water sources in Maputo. July 2007).

The largest areas for growth are expected to be in Maputo city itself. This is due to rapid urban growth, and a boom in peri-urban growth to the north. From Figure 9, it is clear that either demand will have to be managed, or supply will have to dramatically increase. In reality, some combination will probably be implemented. The potential role of alternative water supplies is obvious here: if more water can be sourced from alternative supplies, there may be less demand placed on the traditional sources, offering scope to improve coverage to the community and increase system resilience by 'spreading the load' across many supply sources. It would be anticipated that most alterative water would be used for non-potable uses, but this can represent 40-70% of urban water use. Such a potential saving with respect to a demand reduction on traditional sources would greatly help reduce the existing pressure and would indirectly boost coverage.

5. Conclusions and further work during the AltWater project

The water system in Maputo is fairly advanced, supplying throughout the city, however coverage is currently about 61%, and needs to be improved – something that is in the city-wide strategy. However, the water resources used to supply Maputo are becoming fully utilised (namely the Umbeluzi water system). At present, supply is not sufficient to meet estimated demand, and while there are plans to expand supply capacity, demand is expected to outgrow this supply expansion. Some residents do at present source water unofficially, using small holes (wells) to draw water for domestic use, but a more structured approach would be preferable, offering better accounting and boosting revenue for AdeM, giving greater re-investment opportunities to improve system performance. The implication is that the water supply is resource-limited, and could get worse if climate change has negative impacts on the major water sources. Expected rapid population growth, especially in peri-urban areas and in industrial zones, and lifestyle changes in Maputo is expected to put increasing pressure on the resources and the supply system by increasing average per-capita demand and by extension, total domestic demand.

At present, there is a monthly water supply-demand deficit in Maputo 1.8 million m^3 $month^{-1}$ (about 22 000 000 m^3 yr^{-1}). It is possible that some of this deficit is fulfilled with private vendors and through non-piped water supplies, and so go 'unaccounted' for in official figures. Quantifying exactly how much water is supplied in these other means is not trivial however. Therefore, it is likely that most, if not all residents receive sufficient water, but the supply in some cases may not be of suitable pressure, may not be 24 hours a day and/or may not be seven days a week.

Forecasts of supply and demand to 2040 and beyond show some interesting features. On the supply side, the supplied volume is estimated to grow to over 90 Mm^3 yr^{-1} from the Umbeluzi system, which will help meet demand, but may still be insufficient to meet 100% of the demand. On the demand side, population is expected to increase along with per-capita demand, and industrial demand is also expected to grow, leading to a demand increase. However, AdeM are also planning to improve service coverage and reduce the NRW, currently at about 36%. If this is achieved, then the NRW reduction partially compensate the increase in demand from population and per-capita demand growth.

Alternative water supply sources such as from rainwater harvesting, stormwater harvesting and wastewater collected, treatment and re-use could prove very useful in helping to close the supply-demand gap and in reducing the pressure that the current traditional supplies are facing. While it is not anticipated that such sources would be used to replace or augment potable supply, they would likely play a role in replacing/augmenting non-potable water uses. Therefore by using alternative water supplies for traditionally non-potable water uses (e.g. flushing toilets, watering gardens, vegetable patches and municipal parks) that still consume potable resources, the demand on traditional water supplies is lowered, freeing up water for a number of purposes including: i) expanding potable service delivery; ii) returning water for environmental flows and; iii) recharging aquifers (where applicable). The traditional supplies are less pressured, and can be returned to a state of being more sustainably utilised.

Which alternative water supply systems would be feasible, affordable and acceptable in Maputo, how much water they could *potentially* contribute, and how much water they might *realistically* contribute (which is a function of implementation and uptake depending on a wide range of factors) is still a matter of research, and is something that AltWater will actively investigate at later stages in the project.

6. Acknowledgements

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