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 Beira, 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 second stage of AltWater involves assessing the current and potential future water supply and demand situation (and thereby quantifying water balances) in AltWater Follower Cities (Beira and Gresik). 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 Beira, 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 Beira is fairly advanced, but faces non-revenue water in the order of 46%, and a coverage of about 57% 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 Beira are becoming increasingly utilised, with diminishing 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 Beira of about 385 000 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 Beira, 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 Beira, 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.

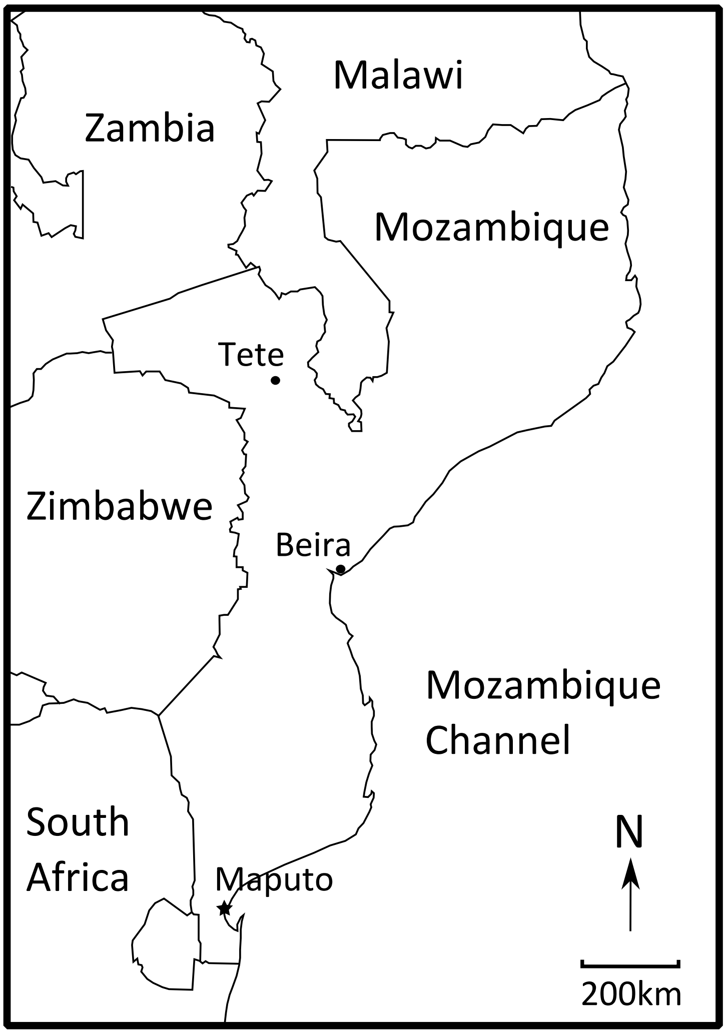

Figure 1: map showing Mozambique and the location of Maputo and Beira.

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, Beira, lying in the middle of Mozambique (Figure 1), has a population of c. 443 000 (2007 census data; www.ine.gov.mz). According to the National Statistics Office (INE) projections, in 2017, the population is approximately 463 000 and by 2030 it will be about 522 000 million (INE projections).

3. Present-day water supply and demand

3.1 Description of the Beira water system

In Beira, the company responsible for water services is Fundo de Investimento do Partimonio de Agua (FIPAG), which supplies to the city.

The Beira Operational Area, located in the province of Sofala, is the largest operational area in the Central Region, with the highest number of customers and the biggest water supply system which supplies the cities of Beira and Dondo, including part of the village of Mafambisse. The water supply system has nominal capacity of abstraction, production and storage of 60,000 $m^3 d^{-1}$, 50,000 $m^3 d^{-1}$ and 36,590 m^3, respectively.

Beira and Dondo Village have 704 139 inhabitants. The coverage rate of the supply system is under 57% it means still need some work improvement to grow up close to 100% of coverage.

3.1.1 Intake

The water collection to the Mutua Treatment Plant is done in a channel that works as a raw water reservoir. The raw water comes from the Pungwe River and can be transferred to this canal from two distinct catchments, an old one belonging to the Sugar Firm of Mafambisse and another recently built by FIPAG, located in Dingue-Dingue. The Dingue-Dingue intake (Figure 1) consists of 3 + 1 submersible pumping groups with a nominal capacity of 1,350 m3 h-1 and a head of 17.2 m.

Figure 1 – Dingue-Dingue Intake (courtesy FIPAG)

The pipeline between the capture in the Dingue-Dingue and the discharge chamber (Figure 2) in the channel is GRP DN900 mm and has an extension of about 10,700 m. This pipeline has only the capacity to transport the water from two pumps running at the same time, and it is planned in future to install a new DN700mm pipeline to operate in parallel with the existing one. The abstraction in the pre-sedimentation channel (Figure 3) consists of 3 + 1 pumping group with a nominal capacity of 1013 m3 h-1 and a head of 28 m.

Figure 2 - discharge chamber (courtesy FIPAG)

Figure 3 – Pre-sedimentation channel (courtesy FIPAG)

3.1.2 Existing treatment works

The water treatment works (WTW) is located in Mutua, village of Mafambisse, district of Dondo and has an installed treatment capacity of 50,000 m3 d-1. It has three treatment lines, two of which are in operation, namely ETA1 and ETA3 and one out of service (ETA2). ETA1 has a nominal treatment capacity of 22,800 m3 day-1 and ETA3 27,600 m3 day-1. It should be noted that ETA2 is out of service due to structural problems, however, it has been designed for a nominal treatment capacity of 10,000 m3 day-1.

Figure 4: Mutua WTW (courtesy FIPAG)

The cistern is composed of two cells, with3 entry lines each, coming from its corresponding treatment lines. The pump station consists of 5 electro-pumps of 800 m3 h-1 and 6.5 bar which discharge to a single collector. There are 2 branches coming from the main collector, one is DN700 in pre-stressed concrete (over 50 years old) and a newer DN1000 in GRP (fiberglass reinforced polyethylene).

3.1.3 Main pipelines

There is a water pumping station downstream of the treated water reservoir in Mutua WTW. It consists of 5 electro pumps (Q = 800 m3 h-1, H = 65m) which discharge to a single compression ma collector. From this collector come two pipelines in parallel, one in concrete DN700, which is more than 50 years old and the other in DN1000, the latest fiberglass reinforced polyester (GRP) DN1000.

The ground elevation at the pump station is around 14.5m. The two pipelines go in parallel, for an extension of about 14.2 km, to the Mezimbite Reservoir. This 900 m3 reservoir consists of 3 cells of 300m3 each, interconnected each other. These cells are slightly elevated relative to the soil, in order to gain piezometric elevation. The sill of this reservoir is at a height of 63.0 m and a level of full storage at the elevation of 66.4 m.

Between the Mutua WTW and the Mezimbite reservoir, there is a deviation in the old pipeline that supplies the sugar-cane factory and the Mafambisse neighborhood. Between the Mezimbite reservoir and the Dondo, the two pipelines go in parallel to the railway line in an extension of about 7.2 km, being the old DN600mm in concrete pipeline and the new DN900 in steel pipeline.

In Dondo there is a set of valves and a by-pass that allows the transfer of water between the old pipeline and the new pipeline. The Dondo Distribution Center is supplied through a new pipeline in Ductile Cast Iron DN500, with an approximate extension of 500m.

The old DN600 concrete pipeline continues along road no. 3501 and then enters road no. 3559 where it will connect to the Manga distribution center (extension of the pipeline of about 22.4 km). Between Dondo and Manga there is a diversion supplying the Inhamizua distribution network, where there is a buried reservoir (40 m3), a small lift station (36 m3 h-1) and a small water tower (20 m3).

Downstream of the bypass node that supplies the Manga distribution center, the old concrete pipeline runs in DN500 to the bypass that supplies the neighborhoods of Alto da Manga, Vaz and Aeroporto (extension of the pipeline of about 1.6 km). At downstream of this deviation, the old pipeline reduces to DN430, following an extension of about 2.4 km to the Munhava distribution center. The new pipeline, downstream of the Dondo by-pass, continues on GRP DN850 for an extension of about 13.9 km, then moving on to DN750 before reaching Inhamizua.

The pipeline DN750 then follows along the road No. 3251, in an extension of about 9.7 km, until the branch node, from where a pipeline in FFD DN400 leaves to the reservoir of the Manga DC. This pipeline has an approximate length of 2,100m. Downstream of this derivation, the GRP pipeline runs in DN600 to the Munhava distribution center (conduct extension of about 7.2 km).

Along the old pipeline, there are a number of branches, some of which are deactivated, others in operation that supply some customers, such as the following:

- Barracks of the Dondo (between the R. of Mezimbite and the D.C. of the Dondo)
- Cements of Mozambique (between Dondo and Inhamizua)
- Barracks (between Dondo and Inhamizua)
- Extension that supplies 4 fountains and Social Center of Nazaré, and Fábrica Papas (between Dondo and Inhamizua)
- Branch that supplies IMAP and the Mobil Pump (between Dondo and Inhamizua)

• BP pumps (between Inhamizua and Manga).

3.1.4 Distribution centres

3.1.4.1 Dondo DC

The Dondo Distribution Center consists of two ground reservoirs, one with a capacity of 250m3 and the other with a capacity of 2000m3, the threshold of which is 52.42m high, a high tank with 250m3, the threshold of which is at elevation of 71,57m and a lift station that transfers water from the two ground reservoirs to the tower. The pump station consists of two pumping groups, one of which is standby pump, with a piezometric height of 25 m, and flow rates of 250 m3 h-1 and 350 m3 h-1.

3.1.4.2 Manga DC

The Manga Distribution Center is supplied by the two water mains, which are interconnected in a box inside the DC site, from where a pipeline supplies the ground reservoir constituted by two cells of 10000 m3 each, which are approximately 13.0m high. The water is then collected from this reservoir and pumped to a 500 m3 elevated reservoir through a pumping station consisting of 3 pumps (Q = 630 m3 h-1, H = 30m). In the same box that was built at the entrance of the Manga DC, there is a by-pass that allows the transfer of water from the mains directly to the outlet pipeline without passing through the reservoirs and the pump station.

3.1.4.3 Muhava DC

In the Munhava distribution center, the two pipelines supply a ground reservoir constituted by 9 circular cells of 1000 m3 each, whose threshold is at a height of 6.65 m. From this reservoir, the water is pumped directly into the network through a pump station consisting of 3 + 1 pumps of 700 m3 h-1. There is also a 500 m3 pressure tower, with a threshold at the elevation of 39.5 m, which has been built to functions as a pressure releasing tank. In the meantime, a DN600 steel by-pass was built in Munhava, which allows the transfer of water directly from the new pipeline to the distribution pipeline, thus taking advantage of the high pressure in the main pipeline.

3.1.4.4 Macuti DC

From Munhava DC, water pumped to another small Distribution Center of Macuti with two ground reservoirs of 115 m3 each and a tower composed of two cells of 100m3 each. This DC supplies the districts of Macuti and Estoril and the Beira Central Hospital.

3.1.4.5 Inhamizua DC

The Inhamizua neighborhood used to be supplied by a small distribution center built in 1994. It had an underground reservoir with a storage capacity of 40 m^3 and a metal tower of 20 m^3. This DC used to serve 1692 connections and 6 standpipes, with an average delivery of 7 hours day-1. The infrastructure had the following limitations:

• Low pressure;

• Limited capacity to supply the entire Inhamizua neighborhood;

• No capacity to supply new areas;

Hence, with the financing of the World Bank and the Government of Mozambique, a new DC of Inhamizua was built from 2014 to 2017, and was officially inaugurated by the President of the Republic, His Excellency Filipe Jacinto Nyusi on 10th March 2017. The project consisted of:

• Construction of a ground reservoir with storage capacity of 1000 m³;

• Construction of a water pressure tower of 500 m³;

• Construction of a pump station including electromechanical equipment and chlorin system;

• Construction of a DN 400 mm PVC inlet pipeline connected to the main pipeline Mutua-Beira;

• Construction of offices and houses for technicians.

3.1.5 Distribution network

AO-Beira's water supply system has about 945 km of distribution network, including primary, secondary and tertiary network. Part of this network is obsolete, in asbestos-cement (AC), over 50 years old, being vulnerable to ruptures. In addition to AC, there is also galvanized iron, HDPE and PVC pipes with diameters ranging from DN600 to DN50 (Figures 5-7).

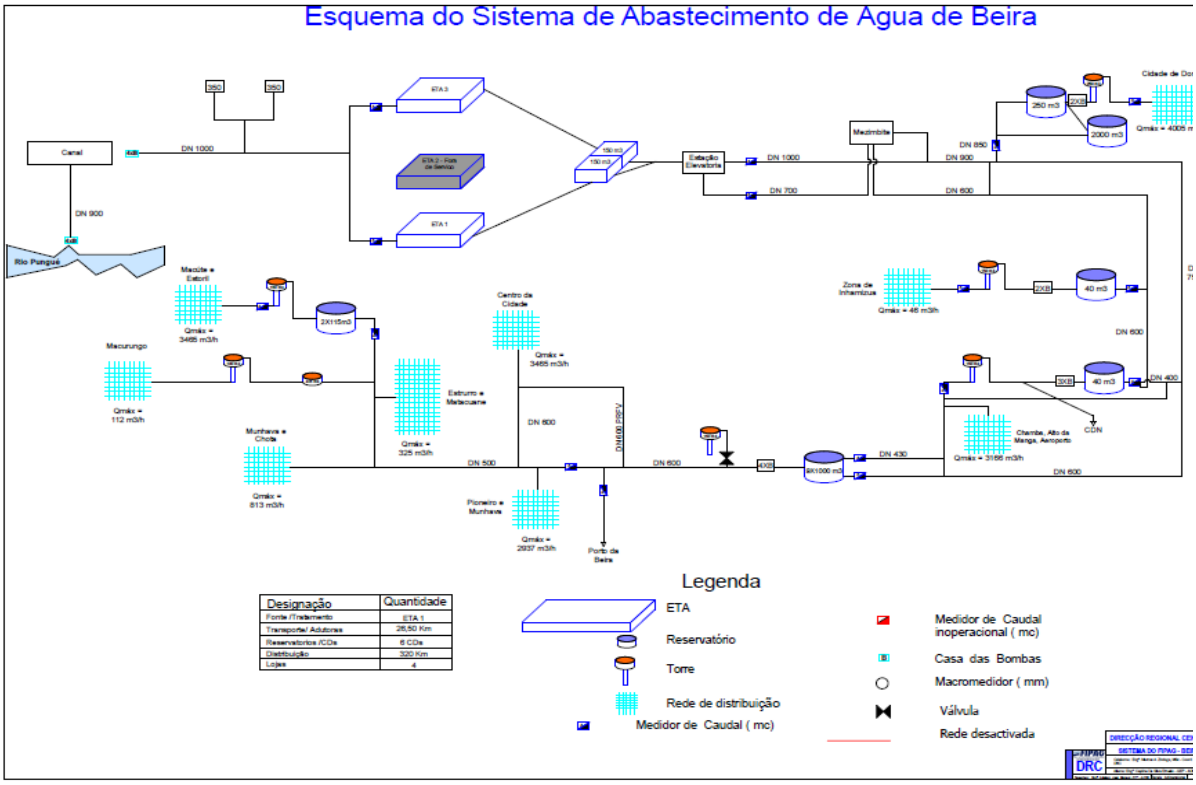

Figure 5: Schematic of the Beira water supply system (courtesy FIPAG).

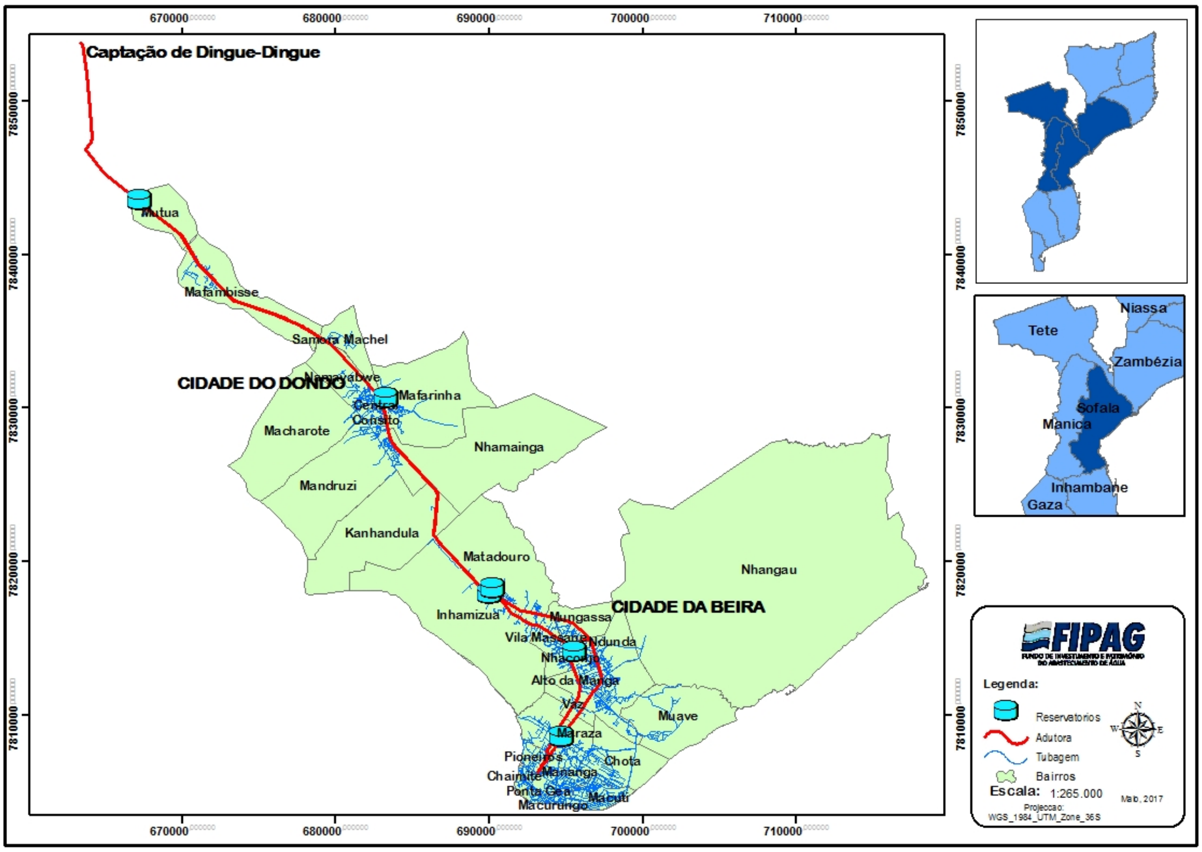

Figure 6: schematic of the Beira distribution network (courtesy FIPAG).

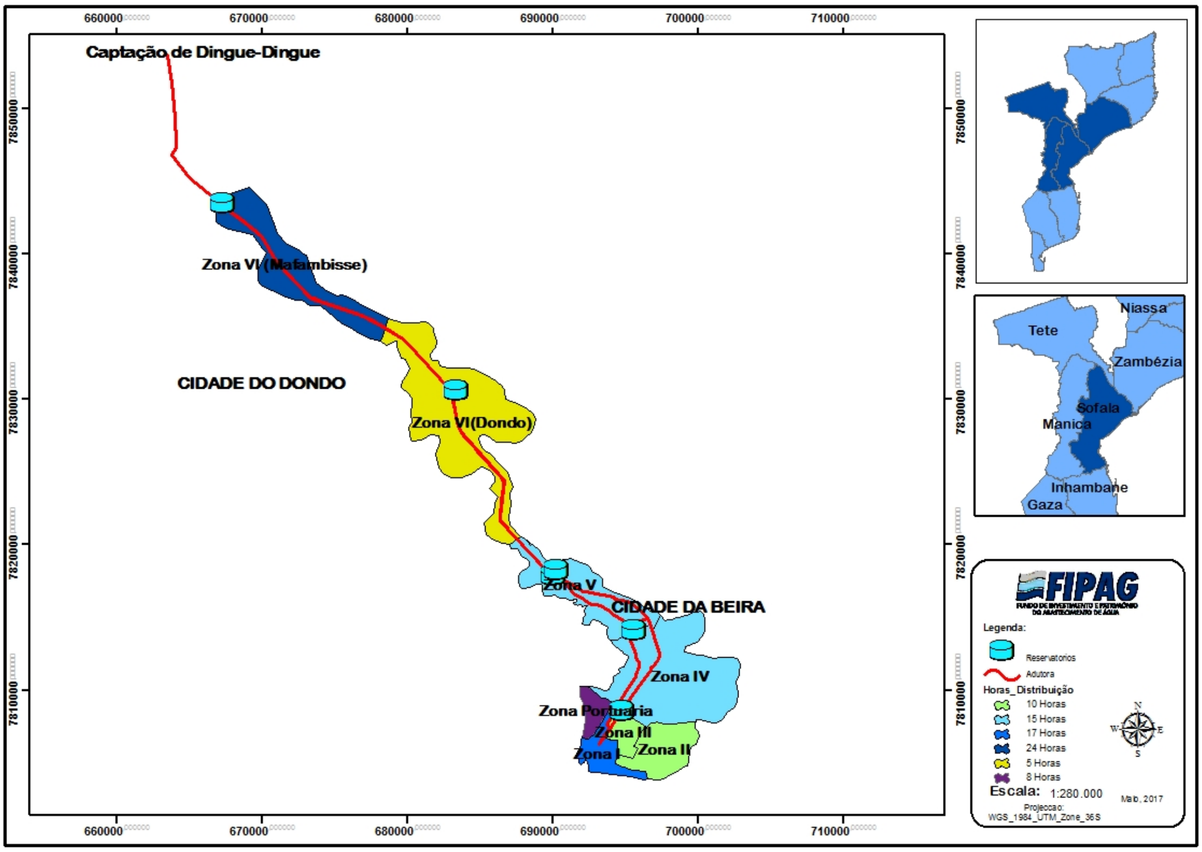

Figure 7: map showing the current hours of water supply per day in the Beira water supply network (courtesy FIPAG).

3.1.6 Water loss reduction projects

In a partnership with Vitens-Evides International (VEI) and Water and Sanitation for the Urban Poor (WSUP), a losses reduction project has been put in place since 2015 at FIPAG AOB-Beira. It comprises:

• Visit to 100,000 houses in the cities of Beira and Dondo to detect anomalies such as damaged water meters, illegal connections, clients that do not receive invoices, etc;

• Replacement of 13,000 household water meters;

• Reduction of physical losses by replacing air valves in the main pipeline and replacing 30 km of obsolete network;

• Installation of bulk-meters and creation of 24 DMAs.

The works also includes:

• Elaboration of the master plan and respective executive project;

• Rehabilitation of water catchment and Mutua WTW, including the pre-sedimentation channel

• Construction of 100 km of distribution network (30 km of Replacement and 70 km of expansion).

The expected Impacts of these works are:

• Increase of production by 10000 m^3 day-1, thus replacing the WTW nominal capacity of 60000 m^3 day-1;

• Improvement of water quality;

• Expansion of water supply to new areas;

• Reduction of water losses.

3.2. Supply:Demand balance

The demand concerns are directly linked to the need of water to supply the entire population in the area as well as the needs of the commerce and service industries that we now call as other categories of consumption. Considering the current capacity of water production verses the water demands, the supply:demand balance is negative – the demands are greater than the supply. In view of this situation, the search for alternative sources is recommended to ensure a supply not only to the present population of 80 liters per person per day, as per regulation document recommendations, but also for the future population. Figure 8 and Table 1 exemplify this situation, where the customer demand is shown to be considerably lower than the actual supplied volume of water.

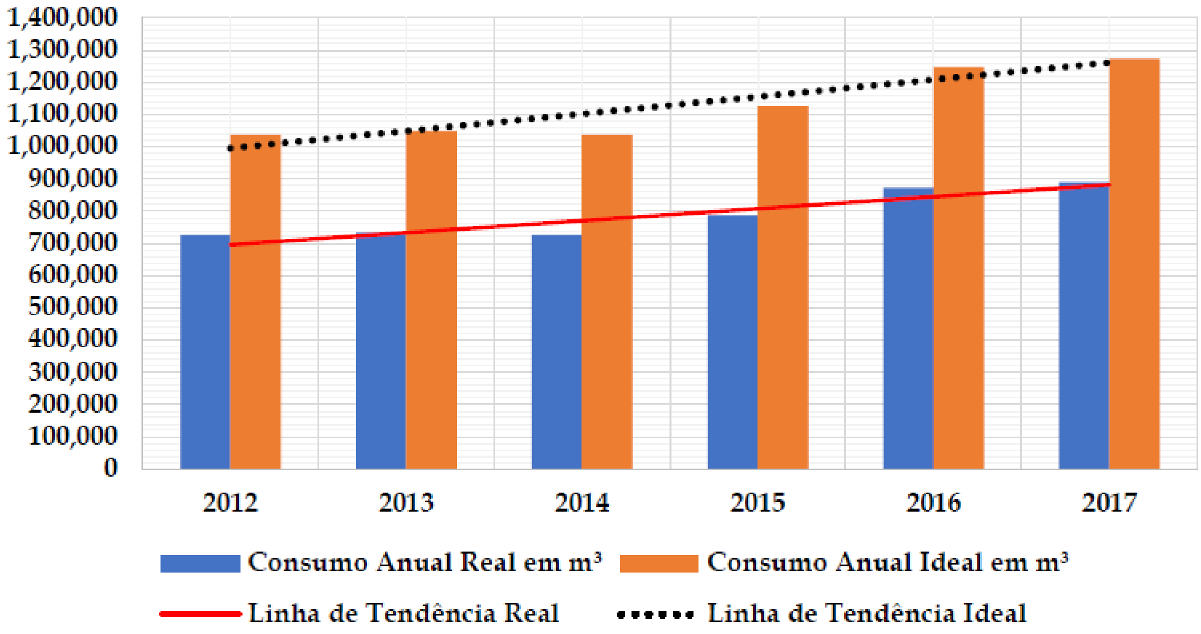

Figure 8: historical data on the customer water demand (orange bars) and actual supplied water (blue bars). The supply:demand gap is obvious. (Courtesy FIPAG).

Table 1: recent historical supplied water volume in Beira, and customer demand (data from FIPAG).

Year	Customer demand (m3)	Actual supply (m3)	Gap (m3)
2012	1038703	726365	312338
2013	1047902	732799	315103
2014	1039163	726688	312475
2015	1126074	787464	338610
2016	1247034	872052	374982
2017	1273898	890838	383060

For the determination of the future population, Mozambique is running from 1 to 15 August 2017 a population census. In the following phases of the projects we will be able to make projections of future demand and the appropriate actions to supply the demand based on the most up-to-date data.

FIPAG have used statistical linear regression analysis to forecast the potential customer demand and supply to 2030. The results of this analysis are shown in Table 2, and demonstrate a continuing and widening supply:demand gap. That is, demand is expected to grow faster than supply increases.

Table 2: Forecasts of water supply and demand in Beira to 2030. Data from FIPAG.

Year	Projected customer demand (m3)	Projected supply (m3)	Projected gap (m3)
2018	1314824	919457	395367
2019	1367975	956626	411349
2020	1421126	993794	427332
2021	1474276	1030963	443313
2022	1527427	1068131	459296

2023	1580578	1105299	475279
2024	1633729	1142468	491261
2025	1686880	1179636	507244
2026	1740031	1216805	523226
2027	1793182	1253973	539209
2028	1846333	1291142	555191
2029	1899484	1328310	571174
2030	1952634	1365479	587155

The consumption per capita according to the national regulation of water supply is 80 liters per person per day, so the demand presented takes in account this consumption factor. The relationship between the volume produced and the volume invoiced shows that there is a loss in the system of about 46%, as already above mentioned in the NRW analysis mater. Actions to recover the not invoiced volume are necessary in order to achieve more than 64% of billed water. This means that there is a need of investing in order to renew all the metering system, for this purpose FIPAG is anticipating implementing a pre-paid meters system.

4. Acknowledgements

We gratefully acknowledge all FIPAG staff who in part contributed to the data collected and presented in this survey, especially Diogo Muquito. This study was funded by DUPC2, the programmatic cooperation between the Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs and IHE Delft Institute for Water Education in the period 2016-2020. The study was carried out by IHE Delft, AdeM and FIPAG. It has not been subjected to peer and/or policy review by DGIS or IHE Delft, and, therefore, does not necessarily reflect the views of these institutions.

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