

**The Malawi Priorities Project**

# **A Cost-Benefit Analysis of Interventions to Improve Water Service Reliability in Blantyre Malawi - Technical Report**

National Planning Commission Report with technical assistance from the Copenhagen Consensus Center and the African Institute for Development Policy



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## Malawi Priorities: Background

Malawi Priorities is a research-based collaborative project implemented by the National Planning Commission (NPC) with technical assistance from the African Institute for Development Policy (AFIDEP), and the Copenhagen Consensus Center (CCC) to identify and promote the most effective interventions that address Malawi's development challenges and support the attainment of its development aspirations. The project seeks to provide the government with a systematic process to help prioritize the most effective policy solutions so as to maximize social, environmental and economic benefits on every kwacha invested. Cost-benefit analysis is the primary analytical tool adopted by the project. Cost-benefit analysis will be applied to 20-30 research questions of national importance. Research will take place over the course of 2020 and 2021.

Research questions were drawn from the NPC's existing research agenda, developed in September 2019 after extensive consultation with academics, think tanks, the private sector and government. This sub-set was then augmented, based on input from NPC, an Academic Advisory Group (AAG) of leading scholars within Malawi, and existing literature, particularly previous cost-benefit analyses conducted by the Copenhagen Consensus Center. The research agenda was validated and prioritized by a Reference Group of 25 prominent, senior stakeholders. The selection of interventions was informed by numerous consultations across the Malawian policy space, and one academic and two sector experts provide peer review on all analyses.

Cost-benefit analyses in Malawi Priorities consider the social, economic and environmental impacts that accrue to all of Malawian society. This represents a wider scope than financial cost-benefit analysis, which considers only the flow of money, or private cost-benefit analysis, which considers the perspective of only one party. All benefit-cost ratios (BCRs) reported within the Malawi Priorities project are comparable.

The cost-benefit analysis considered in the project is premised on an injection of new money available to decision makers, that can be spent on expanding existing programs (e.g. new beneficiaries, additional program features) or implementing new programs. Results should not be interpreted as reflections on past efforts or the benefits of reallocating existing funds.

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# Contents

|   |           |
|---|-----------|
| <b>1. SUMMARY</b>   | <b>4</b>  |
| <b>2. INTRODUCTION</b>  | <b>5</b>  |
| 2.1 Challenges within water sector  | 6         |
| 2.2 Policy and regulatory framework around water provision                        | 8         |
| <b>3. BLANTYRE WATER BOARD</b>  | <b>10</b> |
| 3.1 The Malawi Priorities Project   | 10        |
| <b>4. COST BENEFIT ANALYSIS</b>   | <b>13</b> |
| 4.1 Intervention 1: Construction of a new water source from the Shire River ..... | 13        |
| 4.2 Intervention 2: Roll-out of e-Madzi kiosks across Blantyre                    | 17        |
| <b>5. CONCLUSION</b>  | <b>20</b> |
| <b>6. REFERENCES</b>  | <b>21</b> |

# 1. Summary

Despite the recent completion of the Likhubula water supply project, Blantyre is plagued by water shortages (Mkandawire, 2020). The new infrastructure increased the Blantyre Water Board's capacity to 122 million L of water daily. However, this is still less than estimated average demand of 140 million L per day (private correspondence, Blantyre Water Board). Additionally, large physical water losses mean that 40% of water supply is lost before it reaches the consumer, exacerbating the shortfall. Unreliable water imposes costs on water users. Mpakati-Gama and Mkandire (2015) show that due to the unreliable nature of supply, consumers store water in their homes or are forced to travel to other water sources to meet their needs. The latest integrated household survey notes that across Malawi around 16% of urban dwellers get their water from boreholes which are typically outside of the main water board's supply system (Government of Malawi, 2020b), a phenomenon confirmed by the Blantyre Water Board. All of these coping strategies require extra costs, extra time or both. The largest burden of insufficient supply falls upon Blantyre residents living in informal settlements, who are serviced from the city's water kiosks. Despite the fact residents in informal settlements make up around 60% of inhabitants in Blantyre, kiosks only provide 4% of supplied water. This forces these residents to seek alternative sources. This compares to consumers from permanent housing areas and industrial, businesses and institutional customers who receive a higher share of the water they demand.

This study conducts cost-benefit analyses on two interventions that can address the challenges of insufficient water supply, particularly for those living in informal settlements. The first intervention is to substantially increase the supply of water by 230 million L daily with a new facility from the Shire River. This is one of the future projects identified by the Blantyre Water Board and is currently only 47% financed with a loan from India's Exim Bank (BWB, 2021). The second intervention is the installation of E-Madzi kiosks across Blantyre, similar to the ones that have recently been rolled out in Lilongwe. These E-Madzi kiosks are automated water dispensers that replace in-person kiosks while ensuring increased access to water and lowering water costs by 65% (World Bank, 2020b).

The results show that increasing the supply of water is economically justified, supporting older findings from the Government of Malawi's (2012) Water Investment Plan for Blantyre. For an upfront investment of MWK 122,925 million and recurrent costs of MWK 17,865 million rising to MWK 33,708 million, the new supply of 230 million L per day would likely be sufficient to meet demand in Blantyre until 2036, even after accounting for 40% physical losses. Most of the new water would go to residential consumers – both those living in informal and permanent housing areas – since they are the ones with the largest percentage demand gap currently. Industrial, institutional and commercial customers would also have their water demands met. This would generate benefits worth MWK 44,770 million in 2023, in the assumed first year of operations, rising to MWK 306,887 million by 2052. These figures are around 0.6% of projected GDP. Being the commercial center of Malawi, ensuring Blantyre has sufficient water is essential for both the city and the country's economic growth. The return-on-investment from the intervention is 2.8, meaning that for every kwacha spent on the project, Blantyre receives 2.8 kwacha in economic benefits.

The results from the cost-benefit analysis of the second intervention show that E-Madzis generate a modest return on investment under the situation where water supply remains constant and kiosks continue to receive 4% of supplied water. Essentially, for an upfront investment of MWK 3,351 million with MWK 163 million in recurrent costs annually, the benefits in terms of reduced costs of water and time spent are only 1.5 times the costs (benefit-cost ratio = 1.5). However, in a scenario where residents of informal settlements are receiving increased supply – specifically, after the installation of the new supply facility from the Shire River mentioned above – the incremental BCR of E-Madzis jumps to 22, meaning that every kwacha invested yields 22 kwacha in benefits. The policy implication is that BWB should wait until the new supply is provided, and that a sufficient proportion goes to informal settlements, before considering any rollout of E-madzis. The combined intervention, both the water supply and the E-madzis, compared to a counterfactual of neither intervention has a BCR of 3.2, higher than either intervention by themselves.

## 2. Introduction

The 2018 Population and Housing Census was the bearer of good news regarding access to water: Overall, 88.3% of households had access to improved water sources, with 64.5% boreholes as their main source of drinking water, followed by 17.8% from stand pipes.<sup>1</sup> This is considerable progress: between 1992 and 2017, the population without access to an improved water source within 30 min walking distance decreased from 57 to 22% (Cassivi et al. 2020). From the Fifth Integrated Household Survey (2019/20), we learn that the proportion of households with portable water within 30 minutes walking distance is now 93% for urban households (Government of Malawi, 2020b). As determined by the World Health Organization, a household is considered to have access to improved drinking water source if it is piped into the dwelling, piped into the yard or plot, collected from a communal standpipe, a protected well in yard or plot, protected public well, borehole, tanker truck or bowser and bottled water.

The source of drinking water during the dry season is a good proxy of general population welfare of the country, particularly given Malawi's recent history with drought. Nationally, of those with access to improved water sources, 61.7% used boreholes, 8.1% used community standpipes, and 10.3% used piped water into dwelling or plot as the main sources of drinking water in the dry season (2018 Population and Housing Census).

*Table 2.1: Source of water, urban residents*

| Source                                   | % of urban households |
|--|-----------------------|
| Piped into dwelling                      | 12.0%                 |
| Piped into yard or community stand pipes | 64.9%                 |
| Borehole                                 | 16.0%                 |
| Protected well                           | 4.2%                  |
| <b>Total improved</b>                    | <b>97.1%</b>          |
| Open well                                | 2.1%                  |
| Spring, river, etc.                      | 0.7%                  |
| <b>Total unimproved</b>                  | <b>2.8%</b>           |

Source: IHS5

However, the principal sources of water for urban residents differ considerably (Table 2.1). The main source of improved water in urban areas were community stand pipes or piped into yards: 64.9% of households use them (Government of Malawi, 2020). This source of water is symptomatic of the general condition of urban dwellers. With the palpable demographic shift to towns, most migrants find themselves in informal settlements. Sixteen percent of Malawi's population live in urban areas, roughly 3.3 million people, and non-trivial percentages live in either semi-permanent (23%) or traditional (35.9%) housing (2018 Population and Housing Census).

Essential service provision typically does not reach informal settlements, which tend to grow spontaneously, in response to some economic stimulus and, more importantly, in an unregulated fashion. The latter makes it challenging for local governments to plan, invest and develop infrastructure for these informal settlements. Thus, informal settlements are also focal points for illegal connections, and lower willingness to pay for water and other services, because these are largely functions of income, and the residents in these settlements are typically low-income households. This, in turn, makes investment in water infrastructure commercially unattractive, particularly for utility companies pricing on a cost recovery principle (Boake-Ansah et al., 2019).

An example of the inferior service of low-income areas is documented by Boakye Ansah et al. (2016) in Lilongwe. They discovered that the more densely populated (also low-income) areas are supplied with a rather scattered network, composed of a lower number of smaller pipes of lesser quality. Whilst 90% of households in the planned areas are connected with high quality pipes, kiosks in low-income areas (LIA) are connected with galvanized iron pipes, which are susceptible to corrosion. In addition, everyday operation of the network determines a situation in which high-income areas enjoy semi-continuous supply, while low-income areas experience highly intermittent supply. As a result the network is operated in such a way that supply to planned areas is continuous with high pressure (minimum flow of 13.3 L/min; maximum flow of 24 L/min) whilst LIAs experience intermittent flows with regular cut-offs and low pressure (minimum flow of 2.5 L/m and maximum flow of 7.6 L/min). Maintenance practices of the Lilongwe Water Board also indicate some form of prioritization, which further deteriorates the quality of water supplied to the low-income areas. While it takes a maximum of three days for maintenance activities to be carried out in high-income areas, it takes up to 3 months or more in the low-income areas.

Despite this, coverage (connections) in Malawi has improved: between 2016/17 and 2017/18, water boards installed over 28,000 connections, representing a 13% year-on-year increase in active users. However, the expansion in the number of household connections has not directly translated into consistent access to improved drinking water as even households who have water piped into their dwelling space often face prolonged water cuts (Government of Malawi, 2020). The system continues to be hampered by service interruptions, questionable quality and unaffordability, insufficient maintenance and operations, and political interference.

<sup>1</sup> The proportion of households with access to improved water sources was higher (97.1 percent) in urban areas than in rural areas at 86.5 percent.

## 2.1 Challenges within water sector

### 2.1.1 Water shortage

Water provision in Malawi is characterized by frequent breakdowns and supply disruptions (Adams and Zulu, 2015). Without taking technical or commercial losses into consideration, one of the reasons is that supply simply does not meet demand. Water resources are under threat from severe watershed degradation and climate change. The total renewable water resource available in Malawi is estimated to be 927 m<sup>3</sup> per capita per year, which is very close to water scarcity. The World Bank (2020) estimates that, aggravated by population growth, per capita water availability has declined by 44% in the last 20 years. Further, lack of water storage infrastructure limits Malawi's ability to sustainably explore its natural resources for economic growth, regulating unpredictable hydrological variability, and mitigating the effects of floods and droughts. The country's dam storage capacity is the lowest in the Southern Africa region (World Bank, 2020).

For example, the projected water demand for Mzimba Boma by 2020 and 2025 is 5,000m<sup>3</sup> and 7,000m<sup>3</sup> per day, respectively. Yet the current average water treatment capacity for the Mzimba Water Supply Scheme is 1,700m<sup>3</sup> per day (AFDB, 2015).

Adams and Smiley (2018) observe that the vast majority of peri-urban households (77%) do not have 24-hour a day access to water. Of the households without daily access, 20% have water available for up to five hours a day; 56% have water available for up to 10 hours a day. Only 40% of the households say that water is available to them seven days a week, while 26% have availability for less than five days a week, and a rather non-trivial 9% have availability for just one or two days a week.

### 2.1.2 Quality

Coverage or connection also does not guarantee quality. Boakye-Ansah et al (2016) undertake comparative analysis of water quality distributed through the centralized water supply network to low-income unplanned areas (LIAs) and higher-income planned areas (HIAs) in Lilongwe, Malawi. The concentration of E. coli and total coliforms was low at the outlet treatment works and reservoirs, but increased as the water flowed to the informal settlements. The mean E. coli and total coliforms detected in all samples for both kiosk and household-stored water were statistically significantly higher than the counts at the outlet treatment works, reservoirs and planned areas (piped into dwellings), which suggests contamination before or at the kiosks and at household level. Price et al. (2021) undertook a similar study for Blantyre and found similar results. While household drinking water samples from tap water (public and private taps) were more likely to be perceived by households as 'safe' compared to other sources, the water they provided was often found to be unsafe for consumption; 8% of drinking water samples from public taps and 12% of drinking water samples from private taps were in the 'high risk' category for E. coli.

### 2.1.3 Water demand management

Water demand management is the adoption of a strategy, policy or program that promotes a more efficient use of water, either within the water supply system or by the end-user. Typical water demand management activities may include customer/water user efficiency behavior change campaigns; reducing physical losses, including leakage in networks; reducing illegal connections; improving tariff modalities (while balancing equity with a sense of resource valuation); water reuse; and implementing water use restrictions (UNICEF, 2021).

Several studies (Jimu, 2008; WaterAid, 2008; Manda, 2009) indicate that water-kiosk operations in Malawi are characterized by poor management, vandalism, lack of community coherence and poor responsiveness to faults and community complaints. Furthermore, lack of transparency in water billing, overcharging by private kiosk operators, and lack of accountability, financial embezzlement and inefficiencies have led to frequent water-supply disconnections.

Political interference compounds the inefficiencies and mismanagement (Adams and Zulu, 2015). Magoya (2019) recounts several failed attempts to form a Water User Association (WUA) in Ndirande-Malabada (Blantyre) from 2009 till 2016 due to heavy political interference and strong resistance from the grassroots party leaders. Water tariffs at communal water kiosks as kiosks were being managed by different operators (political party committees/traditional local leader committees), resulting in different prices. An increasing number of communal water kiosks were non-functional due to non-payment of water bills to the service authority Blantyre Water Board (BWB), which amounted to more than \$ 18,000 between 2009 to 2015. There was also vandalism of communal water kiosks due to poor community participation in kiosk management. Interventions to address this problem included mass communication on the water value chain and the importance of water in maintaining good health; the support and facilitation of investigative journalism; continuous engagement of local politicians. Within 3 years (2014-2017), water points found in Ndirande-Malabada were in good physical condition increased from 49% to 97 % because the WUA prioritized maintenance of the system using the funds realized from water sales, and all water points met government standards. This was not just a localized anomaly, Coulson et al. (2021) examine the operations of several Water User Associations in Blantyre, all had arrears, and some use revenues from kiosks to pay honorariums to political leaders.

### 2.1.4 Affordability

According to Mitlin and Walnycki (2019), in 2013 residents in Blantyre's informal settlements required 13% of income just to meet the WHO's minimum needs of 20 L per person per day. This implies that residents either seek sources of water that do not attract fees – typically unimproved sources such as surface water or rivers – or have a large portion of their demand unmet. Additionally, because water is not piped into the home in informal areas, households have to spend some time per day fetching water. Fortunately, the latest IHS5 notes that 93% of urban households have a water source less than 30 minutes' walk away.

An element of inequality of access emerges where it relates to water consumption. Households in planned areas (where there are piped

connections into the dwelling) have an average monthly bill of MWK 1,121, markedly less per litre than that paid by those accessing their water through kiosks (Cassivi et al 2020). Residents in formal housing are presumably wealthier and hence spend a smaller proportion of their monthly incomes on water.

*Table 2.2: Household expenditures on water*

| Year | MWK, billion |
|------|--------------|
| 2015 | 28.8         |
| 2016 | 35.1         |
| 2017 | 42.7         |
| 2018 | 48.8         |
| 2019 | 54.4         |

Source: GoM (2020); IHS5 (19/20)

Household expenditure on water has policy significance as it is largely linked to expenditures by water boards. In 2016 households were estimated to spend MKW 35 billion (2016 prices) on water – 36% of which was directed to water boards. As such, 64% of household expenditure on water is spent on other providers. The expenditure per household per year on water in urban areas was over MWK 35,000 (Government of Malawi, 2020). This is likely to include: fees paid to WUAs; expenditure on self-supply; purchasing water from informal providers (non-water board); and bottled water. This ‘non-water board household expenditure’ represents a large portion of funding to the sector, though it is potentially a ‘blind spot’ in policymaking as these expenditures are not regularly tracked.

Coulson et al (2021) examine the costs of the operating network of water kiosks in peri-urban Blantyre, Malawi. They demonstrate that using the cost-recovery principle to set end-user tariffs renders the price of water unaffordable. Since the bulk water (Blantyre Water Board to WUAs) tariff is MWK 2.46, the price of the 20-litre bucket to consumers should be MWK 10, which is intended to cover the operating and administration costs of the WUA. However, there are other payments such as honoraria paid by WUAs to traditional leaders and arrears, for which end-users bear the burden. In one WUA, the honorarium amounted to 11% of the cash collected. Coulson et al. (2020) also found a wide variety of bookkeeping skills demonstrated in the field, with record keeping ranging from simple pencil-written receipts and payments to detailed computerized spreadsheets, the source of leakages typically associated with cash businesses. Payments made in arrears were also visible across five WUAs. They included both payment of debts to BWB which had been inherited by WUAs when taking over kiosks and delays in payment such as salaries. The WUAs inherit the outstanding debts at the kiosks from previous ‘managers’, and the arrears ranged from MK 500,000 to MK 9.7 million in the WUAs sampled. Coulson et al. (2020) calculate that although the WUAs should breakeven at the MWK 10 MK (four WUAs had break-even points below this), three WUAs in the sample had break-even points at MWK 12.35, 14.62 and 15.03.

This inequality of access extends to maintenance operations as well. Alda et al (2017), over a period of four months, follow the everyday practices of the engineers and water utility staff as they do daily maintenance and operational work in Lilongwe. They find that, depending on the community served, different technologies and management models are used. This, in turn, affects the continuity of water supply and differs from area to area. The low-income (LIA) areas of Lilongwe include both traditional Housing and unplanned/informal settlements, which host 76% of the population. They find that water supply is re-directed towards consumers that are more able to negotiate their access and avoid discontinuity; that during maintenance and repair, valves are operated to redirect the flow and benefit specific critical customers like, for example, big hotels; that everyday operation of the valves also encompasses informal or illegal manipulation by customers or informal plumbers, who tamper with valves to get a better supply for them or for specific areas and contribute to the confusion in the network. Furthermore, Boakye-Ansah (2015) documents that while maintenance in LIAs can take up to three months, in higher-income areas response takes a maximum of three days.

Tiwale et al (2018) find similar results: technical properties of the water supply network that appear fixed and unchangeable instead turn out to change according to political decisions on the distribution of water in the city, which systematically prioritise the demands of the economic and political elites over the basic needs of those living in growing low-income and high-density neighbourhoods. While the past five decades saw a production of extra water of 92,500 m<sup>3</sup> /day (from 2,500 m<sup>3</sup> /day to 95,000 m<sup>3</sup> /day), much of this extra water has benefited the places and people that were already receiving relatively good services. Those without satisfactory conditions of access remain underserved. Furthermore, during operations, field-level engineers comply with the orders of their superiors and divert more water to the better-served areas.

Another operating assumption observed by Alda-Vidal et al. (2017) is that residents of LIAs have different water needs and are better able to cope with discontinuous supply. Most customers purchase water from kiosks and store it in the home. However, kiosks operating on average six hours daily means that consumption is limited by availability, affordability and the amount that can be physically-carried and stored. A similar observation was made by Coulson et al. (2020). Daily per capita water consumption from the kiosk is shockingly low, ranging from 4.67 L at best, down to 0.53 L, well below minimum World Health Organization guidelines on consumption of 20 L per person per day. Given these low levels, it is unlikely that the amount of bulk water drawn at the kiosk reflects demand. They authors believe that it is more reflective of the price of water at the kiosks and/or its non-availability.

### 2.1.5 Non-revenue water reduction

Non-revenue water (NRW) is water that has been produced and is lost before it reaches the customer either through leaks, theft or metering inaccuracies. The rate of NRW in Malawi is high, ranging between 30-54% due to water leakages as a result of old distribution pipes, etc.

The LWB's annual NRW is estimated at 42% as of February 2021 (LWB website, accessed June 2021). The LWB attributes this to physical loss due to leakage, pipe bursts, and reservoir overflow. It also includes commercial loss from meter reading errors, illegal connections and water theft and unbilled water consumption (operational use such as firefighting). To understand the importance of NRW, it is necessary to look at the supply shortfall: the demand in Lilongwe and the surrounding region is about 135,000 m<sup>3</sup>/day whereas the current water production volume is 92,441 m<sup>3</sup>/day, 42% of which is lost before it reaches the customer. As a consequence, the period of water supply has been decreasing over the past few years. There were 24 hours of water supply in 2010; 20 hours in 2012; 10 hours in 2016; and, in 2018, the water supply was suspended three days a week. JICA is and has been working with the LWB to address the infrastructural constraints (JICA, 2018)

Similarly in Blantyre, the BWB has struggled with NRW, which fluctuated between 36% and 47% over the years (Kalulu and Hoko, 2010) and has recently increased to 54% in 2019/20, causing a MWK 8.9 billion loss in the 2019/20 financial year (Mkandawire, 2020).

There is some indication that the main source of non-revenue water in Blantyre is technical. According to a JICA report (2018), the BWB loses water from leakage from distribution pipes. This is a challenge that is closely related to public works for water facilities in the city. In Blantyre, some water distribution pipes are inappropriately buried and there is no standardized depth of trenches in which the pipes are buried. Consultations with the Blantyre Water Board noted that the 460km of pipes distributing water are decades old and have outlived their design lifespan. As such, they are subject to significant leaks.

## 2.2 Policy and regulatory framework around water provision

Urban water supply in Malawi is managed by five parastatal water boards. The Local Government Act (1998) decentralized some WASH sector functions to the district councils, and the Waterworks Act (1995) created the water boards and defines their responsibilities with regards to urban service delivery (Government of Malawi, 2020). The Blantyre and Lilongwe Water Boards oversee water supply to the two largest cities in Malawi. The three remaining water boards are responsible for urban water supply in the Northern, Central, and Southern regions. In 2006, the Lilongwe and Blantyre Water Boards (LWB and BWB) began partnerships with community-elected Water User Associations (WUA) to extend water services to underserved urban and peri-urban areas (Adams and Smiley, 2018). The Ministry of Agriculture, Irrigation and Water Development adopted the concept of the WUA to 'empower the communities to own and manage the piped water supply systems in the market centres and rural areas on their own with minimum support from outside'. These community-based WUAs are intended to act as 'mini water boards' – though they do not receive any financial support from central government sources and are expected to collect the funds for running the systems from the communities they serve, primarily through water kiosks (Government of Malawi, 2020). The Water Boards supply and treat the piped water to kiosks, and the WUAs manage the water kiosks. (Adams and Zulu, 2015).

Overall, policy objectives aim to reduce non-revenue water (discussed below) and to identify sources of financing for large-scale investments in infrastructure with a view to expanding supply. For this reason, funding to the District Development Fund has declined in recent years. In 2016/17, 98% of resources approved were funded; in 2017/18, this had dropped to 58.4%; in 2018/19, 40%. Front line service providers (i.e. the WUAs) are meant to be financially viable. Invoiced sales in Table 2.4 reveal domestic connections and institutions as high value customers. Both commercial and water kiosk sales are comparably unimpressive.

The World Bank (2020), in a performance evaluation of Malawi's state-owned enterprises in both the power and water sectors, conclude that the Water Boards suffer from operational challenges and limited financial resources. Out of the three utilities reviewed, Lilongwe Water Board (LWB) is the only utility that has consistently improved profitability in the past four to five years, largely due to increases in tariff rather than improvement in performance. Between financial years 2014 and 2018, LWB's tariff grew at a compounded annual growth rate (CAGR) of 38.8 percent from MWK 151 million to MWK 778 million. At the same time, however, water losses (non-revenue water (NRW) increased from 34.5 percent to 39.6 percent, commercial losses increased from 12.1 percent to 13.7 percent, and average hours of service decreased from 18 hours to 7.3 hours. Both the LWB and Northern Region Water Board (NRWB) can cover operational costs from internally generated revenues and tariffs and service long-term concessionary loans. However, tariffs are not adequate to contribute to capital expenditure needs. The Blantyre Water Board (BWB), on the other hand, is technically insolvent with negative equity and displays all the symptoms of a cash-strapped utility struggling to make ends meet. It should be noted that BWB's biggest challenge is the high cost of pumping water from the current water source (Walker Ferry) on the Shire Valley, translating into a high energy cost of about 41 percent of BWB's gross revenue in 2017/18. With staff costs and debt servicing costs amounting to 45.5% and 13.8% of gross revenue, respectively, BWB is in a loss-making position (World Bank, 2020).

Owing to the World Bank's evaluation of the BWB, along with the accompanying academic literature regarding its challenges with non-revenue water loss and political interference, this paper focuses on interventions to improve the reliability of service provision of the BWB.

Table 2.3: Water sector architecture

| Policy  | Details  |
|---|--|
| <b>National Decentralisation Policy 1998</b>                | <ul style="list-style-type: none"> <li>MoAIWD to supply safe water</li> <li>MoHP to coordinate and manage environmental sanitation</li> <li>MoLGRD to provide oversight of WASH services through Health and Services Committee</li> </ul>  |
| <b>MGDS III (2017–2022)</b>                                 | <p>Under Priority 6, clarifies roles of MoAIWD and MoHP:</p> <ul style="list-style-type: none"> <li>MoAIWD is to supply safe water and manage water sources</li> <li>MoHP promotion of sanitation and hygiene, enforcement of sanitation laws</li> </ul>   |
| <b>National Environmental Health Policy 2018</b>            | <p>Gives roles and responsibility of MoAIWD and MoHP as:</p> <ul style="list-style-type: none"> <li>MoAIWD – supply of safe water</li> <li>MoHP – promotion of sanitation and hygiene, conducting water quality surveillance, and enforcement of sanitation and hygiene laws (Public Health Act CAP 34:01 section 59-114)</li> </ul> |
| <b>National Sanitation and Hygiene Strategy (2018–2024)</b> | <ul style="list-style-type: none"> <li>Gives leadership of sanitation and hygiene to MoHP, in line with Public Health Act CAP 34:01, National Decentralisation Policy 1995, and MGDS III Priority Area 6</li> </ul>  |

Table 2.4: Invoiced sales of five water boards, Government of Malawi (2020)

**(MWK million – 2014/15 prices)**

|                     | 14/15         | 15/16         | 16/17         | 17/18         | 18/19         |
|---------------------|---------------|---------------|---------------|---------------|---------------|
| <b>Domestic</b>     | 8,967         | 10,732        | 12,147        | 12,557        | 13,264        |
| <b>Kiosks</b>       | 286           | 369           | 368           | 358           | 347           |
| <b>Institutions</b> | 8,478         | 9,549         | 10,889        | 12,719        | 12,473        |
| <b>Commercial</b>   | 6,298         | 6,201         | 7,603         | 8,233         | 8,589         |
| <b>Total</b>        | <b>24,030</b> | <b>26,851</b> | <b>31,008</b> | <b>33,866</b> | <b>34,672</b> |

**Sources:** Authors' analysis of financial reports received from each water board

### 3. Blantyre Water Board

The Blantyre Water Board (BWB) was established in 1929 and reconstituted under the Water Works Act No. 17 of 1995, with a mandate to provide reliable and affordable water supply services to the population of Blantyre City and its surrounding areas, a total area of 83,000 hectares (BWB Annual Report 2017). The BWB estimates that it is supplying water to about 1.4 million people within its supply area, which includes the City and other areas such as Bvumbwe, Chileka, Lunzu, Chiradzulu, Limbe and Mapanga, approximately 60,000 customers. BWB registers an average of 300 connections every month.

Blantyre's geographic location, in the Shire-Zambezi river basin, means that freshwater is relatively abundant in comparison to some parts of southern Africa (Price et al., 2021). BWB extracts its water from Shire River (an outlet of Lake Malawi) at Walker's Ferry about 40 kilometres away and 800m below Blantyre City. Approximately 96,000 cubic metres/day are pumped uphill through a 48-km pipeline to the city overcoming the elevation of 800 m, with additional booster stations necessary to distribute water throughout the hilly city terrain, leading to 40% of operating costs being consumed by electricity (Coulson et al., 2021).

The BWB has a capacity to deliver 122 million L per day, from sources at Walker's Ferry (96 million L), Mudi Dam (6 million L) and the Likhubula (20 million L). Water is not available for 24 hours per day, and most residents (85%) utilized a secondary source of water when their main source of water was unavailable. On average, public taps, boreholes, and protected springs were only available for 12 h per day, due to limited opening hours and irregular supply. According to Price et al. (2021), there is a difference in availability for piped water from different sources: whereas drinking water from public taps is available for 12 h per day, drinking water from a private tap is available for 21 h per day, on average.

*Table 3.1: Availability of water, by source*

| Drinking water source | Average availability (hours/day) |
|-----------------------|----------------------------------|
| Piped to dwelling     | 21                               |
| Piped to public tap   | 12                               |
| Borehole              | 12                               |
| Protected well        | 15                               |
| Protected spring      | 12                               |

*Source: Price et al (2021)*

Well aware that water coverage falls short of population growth, the Malawi Water Sector Investment Plan (2012) estimated that access as a percent of the population in urban areas is likely to decline from close to 90 percent in 2015 to 70 percent by 2030.

The BWB has additional challenges:

- Revenue collection. Seventy per cent of all the invoiced bills were collected in a maximum of 340 days against an ideal target of 90 days (Kalulu and Hoko, 2010). To meet their collections targets, the BWB has partnered with TNM, a local mobile network, to facilitate secure payments via mobile phone. As of May 2021, Blantyre Water Board (BWB) has migrated two thirds of its customers in its jurisdiction from post-paid to prepaid billing system, approximately 28,000 out of 60,000 (Ikiloni, 2021).
- Inefficient administration. The staff per thousand connections value was found to be 18 compared to an ideal value of five. (Kalulu and Hoko, 2010)
- Indebtedness. The BWB's profit after tax was negative, -2.38 MWK billions in 2018, with MKW 20.4 billion in long-term debt (World Bank, 2021).
- Unaffordability of water. Focused on cost recovery, the tariffs of the BWB are actually out of reach of targeted customers, the residents of informal settlements. Mitlin and Walnycki (2020), undertook a review of water utilities in four African cities (Dar es Salaam, Harare, Windhoek, Blantyre) to better understand the challenges for residents of informal settlements here in respect to water access and affordability. As calculated above, the authors also find that water costs as a percentage of household income is not insignificant, and consequently kiosks are not able to generate sufficient demand to make kiosks viable. Kiosks have to sell nine cubic meters a month; or fifteen 20-litres cans per day to be financially viable. The authors conclude that even this small amount is not possible in some localities due to the lack of effective demand.

#### 3.1 The Malawi Priorities Project

The National Planning Commission (NPC), with technical assistance from AFIDEP and the Copenhagen Consensus Center (CCC) are conducting the Malawi Priorities project across 2020 and 2021. The project is a research and advocacy exercise to identify the most effective ways to address the nation's challenges using the framework of cost-benefit analysis. The aim is to inform both short and long term development priorities for the country, acknowledging that there are insufficient resources to address all of Malawi's challenges and that maximizing outcomes requires careful, evidence-based consideration of the costs and benefits of all policies.

The starting point of all research questions is the NPC's existing research agenda, structured around the six thematic areas of Sustainable Agriculture, Sustainable Economic Development, Human Capital and Social Development, Sustainable Environment, Demography, Governance, Peace, and Security, and Human Capital and Social Development. It was developed by the Commission in September 2019 after extensive consultation with academics, think tanks, the private sector and government. Consequently, the Commission's research agenda, *prima facie*, contains questions of national importance.

This paper seeks to address the question:

**What are effective strategies for managing urban population growth so that it is a catalyst for sustained economic growth, is at pace with growth of basic and social services and ensures rural areas are not left behind in economic transformation?**

Recently, the Malawi Vision 2063 was unveiled, with Urbanization, Industrialization and Agriculture as its central pillars. Secondary cities, urban centers which have as their focal point an activity, such as tourism or mining, have the catalytic potential to create both downstream and upstream industries. One of the main challenges also mentioned in the Vision 2063, as well as other sectoral strategies, is the need to assure the reliability of essential service provision.

As a first step, Malawi Priorities drew questions from the NPC research agenda that could be answered using a cost-benefit methodology. Then, additional research questions were added based on input from NPC, an Academic Advisory Group (AAG) of leading scholars within Malawi, and existing literature, particularly previous cost-benefit analyses conducted by the Copenhagen Consensus Center. This process of identifying research questions for investigation generated a total of 38 potential research questions across all 6 thematic areas.

The research agenda was validated and prioritized by a Reference Group of 25 prominent, senior stakeholders from government, civil society and the private sector. The outcomes of the Reference Group exercise were used to inform which research questions to prioritize and which interventions to focus on within those 38 potential research questions. The validation process was completed in July 2020.

The universe of interventions to tackle the challenges of administrative and management inefficiency, technical losses, and commercial losses at the BWB include the following:

**Table 3.2: Interventions considered**

| Intervention                                    | Objective  | Comments  | Evidence of effectiveness  |
|---|--|---|--|
| Construction of new water source                | To meet forecasted demand  | Among BWB's future projects   |  |
| Construction of power generation plant          | To construct an independent power plant to relieve the Board from the burden of paying unsustainable electricity bills | Among BWB's future projects   |  |
| Establishment of an independent water regulator | To ensure quality; to adjust tariffs; to coordinate and house relevant data  | There is no independent surveillance agency. Water quality provision and monitoring are, therefore, carried out by each of the five water boards in urban areas or the district assemblies in rural water; however, there are not sufficient resources to monitor water quality. World Bank (2020): there is an ongoing review of the National Water Policy proposes the establishment of an independent water sector regulator, by expanding the roles of the existing National Water Resources Authority. | Hepworth et al (2020)'s review of the literature suggests that accountability and advocacy interventions have an overwhelmingly positive influence on water governance and service delivery in the water sector  |
| Community-state co-production                   | To improve water access in urban informal settlements  | Adams and Zulu (2015); Adams and Boateng (2018) evaluation of a pilot: a form of service co-production in which state water utilities work together with community-elected water user associations (WUAs), who manage revenue from water sales, oversee community water points (or kiosks), organize community elections to appoint representatives, and report community complaints about service delivery to the Lilongwe Water Board (LWB)   | In Kauma, most residents observed that access to water had improved in terms of kiosk operating hours (43.8 per cent), cost of water (49 per cent), and proximity to the nearest water kiosk (53 per cent). In Mtandire, about 30 per cent thought the price of water was lower, 58 per cent saw an increase in the number of community water kiosks, and 49 per cent indicated shorter distances from their households to the nearest water kiosks. In both areas, half the residents observed worsening interruptions in supply. |

|  |  |   |   |
|--|--|---|---|
| Establishment of a kiosk management unit within water boards   | To improve financial management: billing, collections, debt management   | The BWB has a Kiosk Manager.  | Evidence was visible in Stakeholder Minutes and WUA Board Minutes of some agreement between the BWB Kiosk Manager and WUA Secretariats on how to prioritize costs and “chip away at arrears”. Engagement between the BWB Kiosk Manager and WUAs helped to increase BWB’s knowledge of local conditions and associated financial position, which, in turn, supported informed decision-making across WUAs and, ideally, reduced costs and the tariff. (Coulson et al., 2021) |
| e-Madzi kiosks, a fully-automated system allowing users to draw water using an e-card.   | To reduce non-revenue water loss and operating costs of kiosks   | World Bank (2020): The E-Madzi system is comprised of three main elements - a smartcard, a dispenser unit and a water management system. The system is installed at a kiosk and is operated through an electronic water management device. The card uses Radio-Frequency Identification (RFID) technology to allow users to draw water by tapping on the dispenser unit. Consumers with a prepaid smartcard only tap the water dispenser, and credit is deducted from the smartcard balance to the exact amount of water collected. | The system gives access to water at any time. The system has also enabled a 65% reduction in water costs, because there is no longer need for an attendant, and no waste.   |
| Pre-paid metering  | To improve revenue collection  | As of May 2021, Blantyre Water Board (BWB) has migrated two thirds of its customers in its jurisdiction from post-paid to prepaid billing system, approximately 28,000 out of 60,000 (Ikiloni, 2021).   |   |
| GIS mapping of water kiosks  | To help provide accurate information about population density around kiosks of served and unserved communities |   |   |
| Water infrastructure Development: Rehabilitation, upgrade, and expansion of water treatment plant; transmission pipelines; distribution system (pipelines, pumping stations and service reservoirs); river gauging stations; - Service connections; - Design and Supervision Services. | To increase access to reliable and sustainable potable water supply  | AFDB (2015) for Mzimba Town: The water system was only able to provide 12 hours (some less than 6 hours) of service with only 65% coverage. The capacity of the water treatment plant at 1,500m <sup>3</sup> /day is far less than the current demand of 2,600m <sup>3</sup> /day. Non-revenue water is estimated at 25% mainly due to physical water losses resulting from dilapidated water supply systems.   | BCR = 1.75  |

Irregular water supply merges as the BWB’s biggest problem. One of the causes of service interruptions is that demand far exceeds supply. The intervention selected to address this is what the BWB has proposed and costed as a project to be undertaken in the near future: **the construction of a new water source from the Shire River to deliver 230 million L of water per day.**

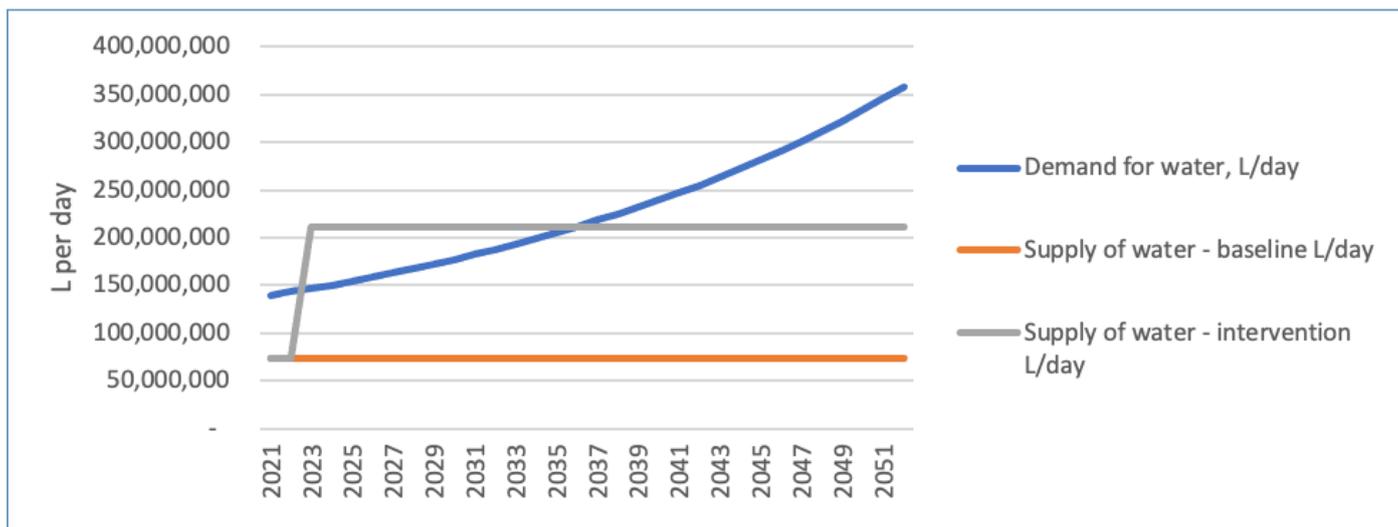
To the extent that manual water kiosks contribute to NRW, **the adoption of automated kiosks is analyzed as the second intervention.** It is also expected to lower the cost of water by 65% as per the experience in Lilongwe.

## 4. Cost Benefit Analysis

### 4.1. Intervention 1: Construction of a new water source from the Shire River

The Malawi Water Sector Investment Plan (2012) had already identified Blantyre as being in a precarious position of beginning to run out of water vis-a-vis its growing population. With the supply of water evidently falling short of demand, the BWB has plans to invest in a new water source from the Shire River. The plans include a water treatment plant, pumping stations, water tanks and pipelines to produce 230 million litres per day in 2023. The intervention is expected to directly address the interruptions in service owing to inadequate supply, which is struggling to keep up with the number of inhabitants.

Figure 1: Estimated demand and supply of water with and without the intervention



According to the BWB itself, the board serves around 1,400,000 customers. With a daily demand equivalent to 140 million L (private correspondence, Blantyre Water Board), demand already exceeds supply. Additionally, there are still substantial outages and limitations to continuous service, predominantly driven by losses in the system. Following Magambo and Ksumu (2016) and in line with historical estimates we assume that the physical loss component of non-revenue water at 40%. This suggests an effective water supply only 60% as large as capacity, or 73million L per day (see Figure 1).

The construction of an additional water source from Shire River is expected to deliver extra capacity of 230 million L per day. Once this is operational, and assuming this also experiences physical loss of 40%, then the effective supply after the intervention will be 211 million L per day. This would be sufficient to meet demand for water in Blantyre until 2036, assuming annual population growth of 2.0% as forecast by the BWB. We treat the intervention as being able to effectively eliminate the shortfall from insufficient water supply until this point in time. Thereafter, for the remainder of the project's assumed 30-year life, supply is capped at 211 million L per day which obviously meets more demand than a counterfactual of no intervention, but is insufficient for all demand beyond 2036.

#### Who receives the extra water?

The above shows that the current demand shortfall is 50% in 2021 – i.e. the amount of shortfall is 50% of total demand. In the absence of the intervention this rises to 80% by 2052. However, with the extra water and even accounting for large 40% physical losses, there is sufficient water to meet all demand until 2036 and then some substantial fraction of demand thereafter. How would this extra water be distributed? A simple assumption would be to assume that new water would be distributed proportional to existing consumption. According to Maouldi (2012), 51% of water is used by domestic customers (i.e. mostly for those living in permanent housing areas), 4% by kiosks for those living in informal settlements, 22% for commerce and industrial use, and 23% for institutions. However, this fails to acknowledge that the demand gap is much larger for those living in informal settlements (kiosks) than those in permanent housing areas. According to IHS5, 60% of urban residents live in informal settlements compared to 40% in permanent housing areas. In other words, informal settlements have about 150% the number of people as domestic consumers but only receive less than 5% of supplied water.

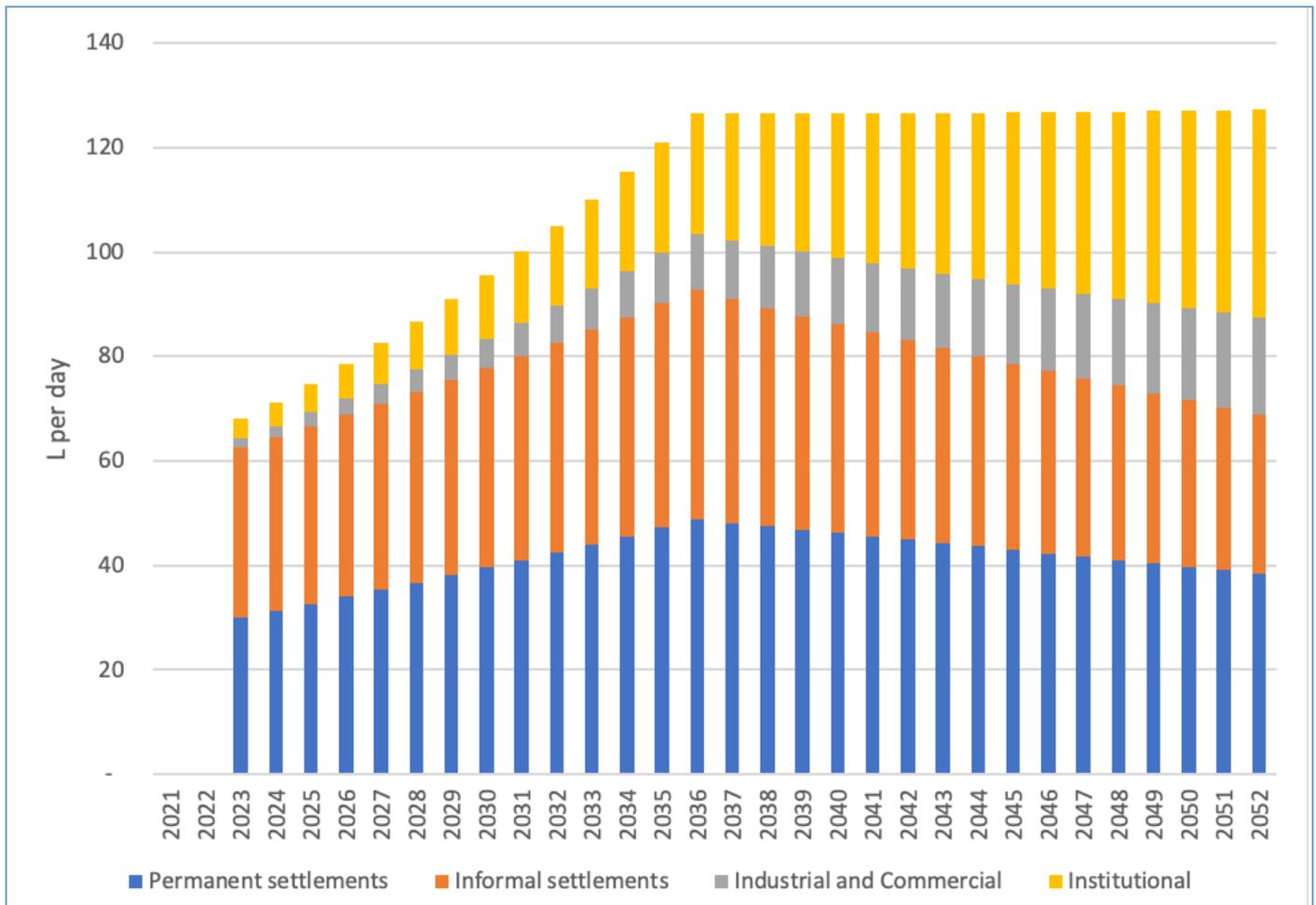
Given that the new facility would be able to eliminate the demand gap across the city, even after taking into account physical losses, we have to therefore estimate demand gaps specific to each consumer group for accurate estimation of benefits. There is unfortunately limited data to precisely estimate these figures and therefore we have to infer figures from reports, literature and consultations with BWB.

To estimate this, we first make the simplifying assumption that commercial, industrial and institutional users have a demand gap equivalent to around 20% - i.e. these users only receive 80% of their demand from the BWB. While this is large, it is smaller than the average demand gap of 50%. This is based on conversations with the BWB who indicated that these users are prioritized in terms of water supply.

For residents in permanent and informal settlements we estimate each group’s daily average demand. From the total demand equivalent to 100 L per capita we subtract the share for commercial, industrial and institutional users. This leaves 71 L per capita per day for residential users. Following Mitlin and Walynicki (2019) we assume households in informal settlements have a yearly income of MWK 494,000. Our calculations put households in permanent settlements at a yearly income of MWK 2,869,000. Using an income price elasticity of water of 0.3 (Nauges and Whittington, 2010), households in permanent settlements demand 2.4 times as much water as those in informal settlements, a ratio consistent with figures presented in Maloudli (2012). Therefore, water demanded is 109 L per capita for residents in permanent settlements, and 45 L per capita for those living in informal settlements.

This allows for an estimation of demand shortfall avoided by the intervention stratified by user group – see Figure 2 below. Water demand is assumed to follow population growth for residential users, and institutional users. For industry and commerce water demand is assumed to follow GDP growth, since the driver of water use is economic activity. Overall, residential users (residents of permanent and informal settlements) receive the largest share of the new water over the life of the project, since they have the largest demand gap currently. As a percentage of current demand, users in informal settlements have the largest gain. However, after 2036, and in the absence of further supply, there is again a shortfall (see Figure 1). Here, we assume that institutional, industrial and commercial customers take on an increasingly greater share in line with BWB’s policy of prioritizing these users.

Figure 2: The daily water demand shortfall avoided by increasing the supply of the intervention



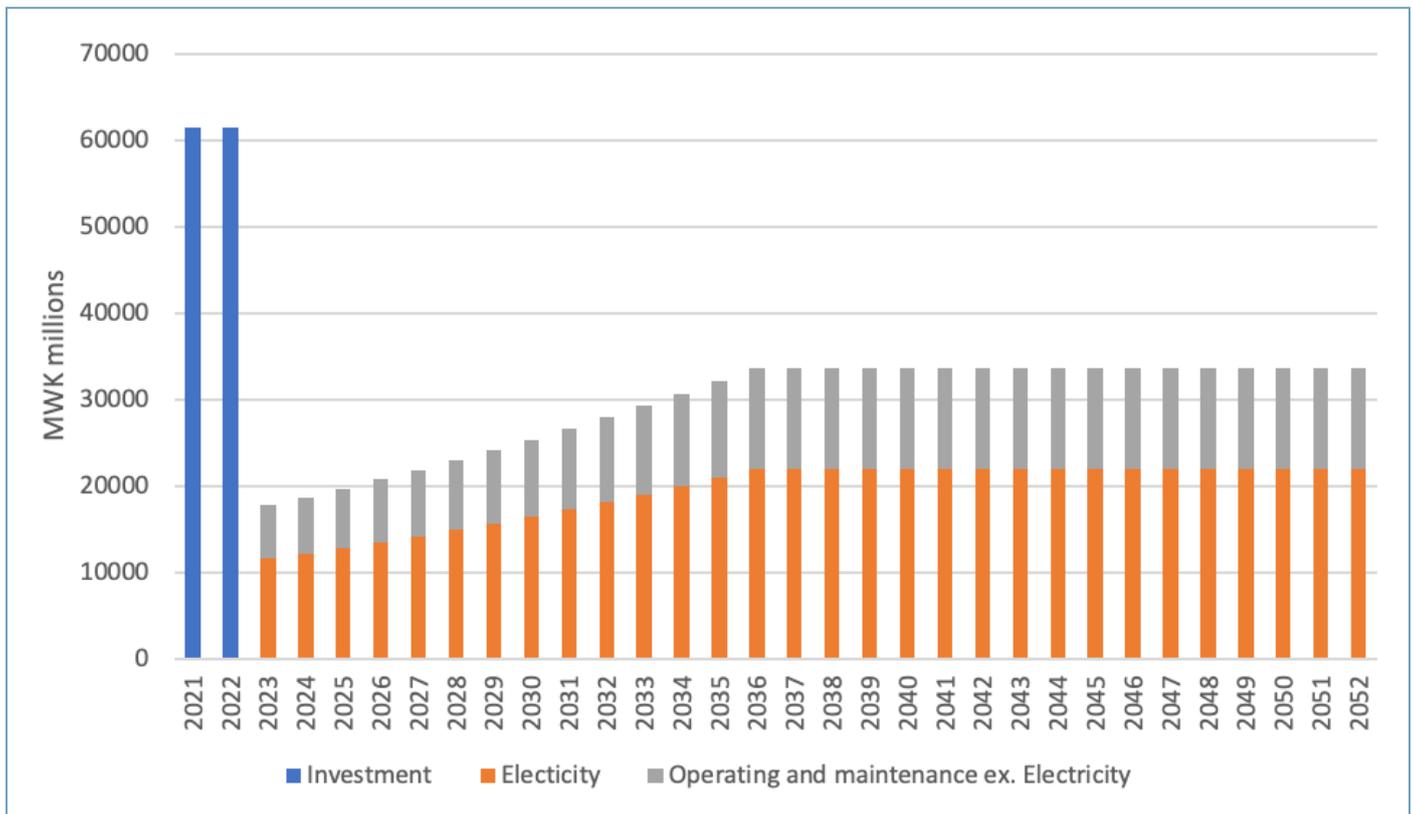
#### 4.1.1 Costs

The BWB has costed the project at a net present value of US\$ 165 million or MWK 122,925 million. We treat this as the investment cost of the project and spread over two years. Based on electricity bills provided by BWB we estimate that future electricity costs will rise from MWK 11,612 million in 2023 peaking at MWK 21,910 million in 2036 when total supply is required. Operating and maintenance costs are assumed to be 54% of electricity costs, following the current BWB’s annual expenditure profile. Annual recurrent costs are presented in Figure 3.

#### 4.1.2 Benefits – avoided coping costs

The main benefit of an increased water supply is that users of water no longer have to engage in costly coping strategies. Mpakati-Gama and Mkandire (2015) present findings of a feasibility study to explore and compare mechanisms that people use to cope with water shortages and water supply disruptions in 3 major cities of Malawi, namely Blantyre, Lilongwe and Mzuzu. They found that water supply was inconsistent across the sample, varying from 0.27 to 13 hours of water shortage daily. Coping strategies included water storage (by bucket), purchasing water from nearby sources which were still functioning, using streams for washing and laundry, and using a private borehole; the first two being the more prevalent strategies. In terms of commerce and industry, we note that firms’ experience output losses associated with lack of reliable water (Rentschler et al. 2018). In equilibrium, this output loss should equal the

Figure 3: Costs of additional water supply



cost of the cheapest coping cost, which we assume as a private borehole with storage. Based on these studies we assume the following coping strategies and associated costs for the different categories of customers currently receiving water from BWB.

Table 4.1: Summary of coping costs

| Customer Class                    | Coping Strategy  | Coping cost per L of water, 2020 |
|-----------------------------------|--|----------------------------------|
| Residents of permanent settlement | Store water (60%), borehole (20%), purchase water (20%)  | MWK 1.0                          |
| Residents of informal settlement  | Travel to next closest available source of water (20%), source water from private boreholes (30%), source water from unprotected sources or demand unmet (50%) | MWK 2.4                          |
| Industry and Commercial           | Extract water from private borehole or output loss   | MWK 1.1                          |
| Institutional                     | Extract water from private borehole  | MWK 1.1                          |

### Permanent settlements

Based on the discussion by Mpakati-Gama and Mkandire (2015) we assume that residents of permanent settlements store water, use boreholes or are forced to purchase water, if their needs are acute and water is not available. Water stored is assumed to be relatively inexpensive, since they are filled when water is available in the home, and therefore require no travel time. The only costs are the costs of the storage unit (buckets or steel tank) which is relatively small on a per L basis. For example, a typical 1000 L steel water tank costs MWK 111,750 (\$150) and could last as long as 10 years. A normal, 4 person urban household would demand around 440 L per day and suffer 3 hours of outages daily. This means that over a year around 26,000 L would be drawn from storage, for a per L cost of approximately MWK 0.4. Similarly, a borehole plus pump costs MWK 149,000 (\$200), implying a per L cost of MWK 0.7 per year including 20% markup for electricity and maintenance.

However, not all domestic connections have options for bulk storage or boreholes. For these residents, we assume that they purchase water from nearby sources of water such as private boreholes or available kiosks. To estimate this cost, we assume a 20L bucket of water is priced at 15 MWK and it takes 30 min to source this water (20 min travel, and 10 minutes waiting). We value time at 50% of the urban hourly rate, as per Whittington and Cook (2019) for a value of MWK 94 per hour. The sum of the price of water and time required to collect it equals MWK 2.3 per L. Lastly, we assume 60% of those in permanent settlements use storage (since it is cheaper), 20% use boreholes in line with IHS5, while the remainder purchase water. This leads to an average coping cost for domestic users around MWK 1.0 per L.

<sup>1</sup> The BWB uses the Preliminary Bulk Meter Tariff Calculation (PBTC), a full-cost pricing method, to establish the retail cost of water at the kiosks. Kiosks, and consequently WUAs are expected to, at worst, break-even at MWK 10 per 20-litre bucket. However, in a survey of seven WUAs, Coulson et al. (2021) found that, while four WUAs broke even within the price range of MWK 8.1 – 9.8, three WUAs had a break even point between the ranges of MWK 12.3 and 15.0. The latter, a similar finding in Adams and Zulu (2015) who survey that the cost per bucket was 12–15 Malawi Kwacha in 2013, and, more recently, Water Aid (2016) found that the price for 20 L buckets was MWK 15 in Blantyre and Lilongwe. For this analysis, the mid-point of MWK 15 is used.

### Informal Settlements

Only 4% of water delivered goes to kiosk users, who are residents in informal settlements. Mpakati-Gama and Mkandire (2015) note that most residents of informal settlements store water in buckets or travel to collect / use water from the next nearest source as a coping strategy for unreliability. The cost of this coping strategy is the 30 min of collection time required to get the spare buckets of water when water is available for storage in the home or to move to the next nearest source when water is unavailable. This 30 min to collect a 20L bucket implies a cost per L of MWK 2.4. For the % of water that is sourced from unimproved sources or represents unmet demand, the coping cost is estimated by the willingness-to-pay for kiosk water which is a sum of the price plus travel time and equals MWK 3.8 per L. For the % of water that is currently sourced from boreholes this will be unaffected by increased supply and so there is no coping cost for this fraction of water consumption. The average coping cost is therefore MWK 2.4 per L for those living in informal settlements.

### Commercial and Industrial Users

From Maouli (2012), 22% of water delivered is used by commercial and industry. As noted above, commercial and industrial users suffer productivity losses without water (Rentschler et al. 2018). In equilibrium the magnitude of this output loss should equal the cheapest coping cost – otherwise there is an incentive to switch strategies. The assumed cheapest coping strategy is the use of a borehole plus tank for storage which was calculated above at MWK 1.1 per L.

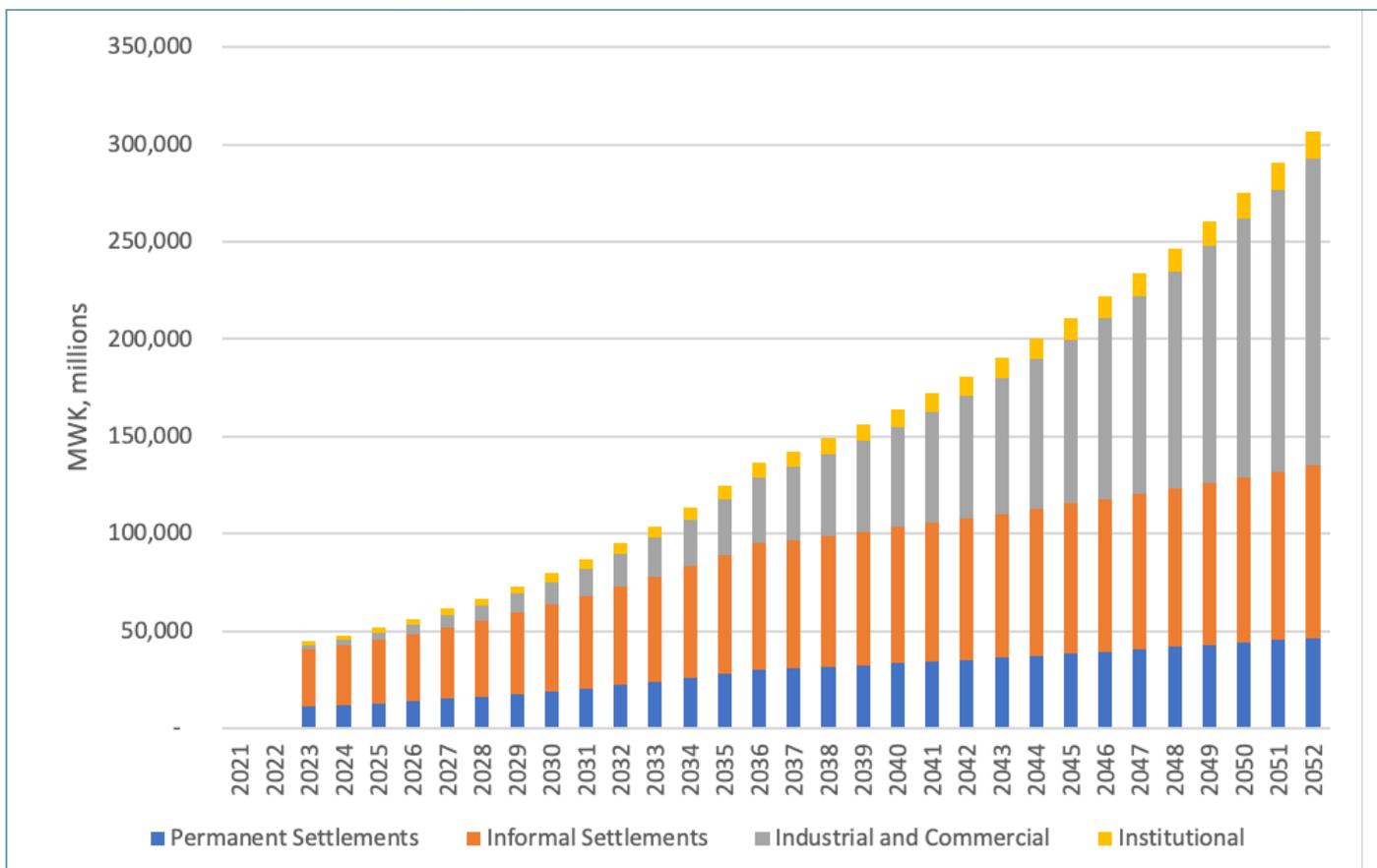
### Institutional Users

There is limited evidence on the coping costs of institutional users. We assume that institutions (governments, universities etc...) are able to construct large water storage technologies that deliver low coping costs at scale. This is equal to MWK 1.1 per L.

### Overall benefits

The above coping costs are assumed to increase with projected income per capita growth over time, except for coping costs of commercial and industry which grows with overall GDP growth. Applied to the time series of avoided demand shortfall presented in Figure 2, the total benefits of the intervention start at MWK 44,770 million in 2023 rising to MWK 306,887 million by 2052. The absolute magnitude of benefits is substantial, around 0.6 to 0.7% of GDP. In the initial years, the benefits are largest for residents in both permanent and informal settlements. However, towards the end of the period, the benefits are largest for industrial and commercial users. This predominantly reflects the increasingly larger share of demand from industrial and commercial users, and the value of output as Malawi’s economy grows.

Figure 4: Avoided coping costs from the intervention



### 4.1.3 Results

The costs, benefits and benefit-cost ratio of the intervention are summarized in the table below across various discount rates. At an 8% discount rate, the intervention costs MWK 393,001 million until 2052. The benefits are MWK 1,105,075 million and the BCR is 2.8.

Table 4.2: Benefits, Costs and BCR from water supply intervention

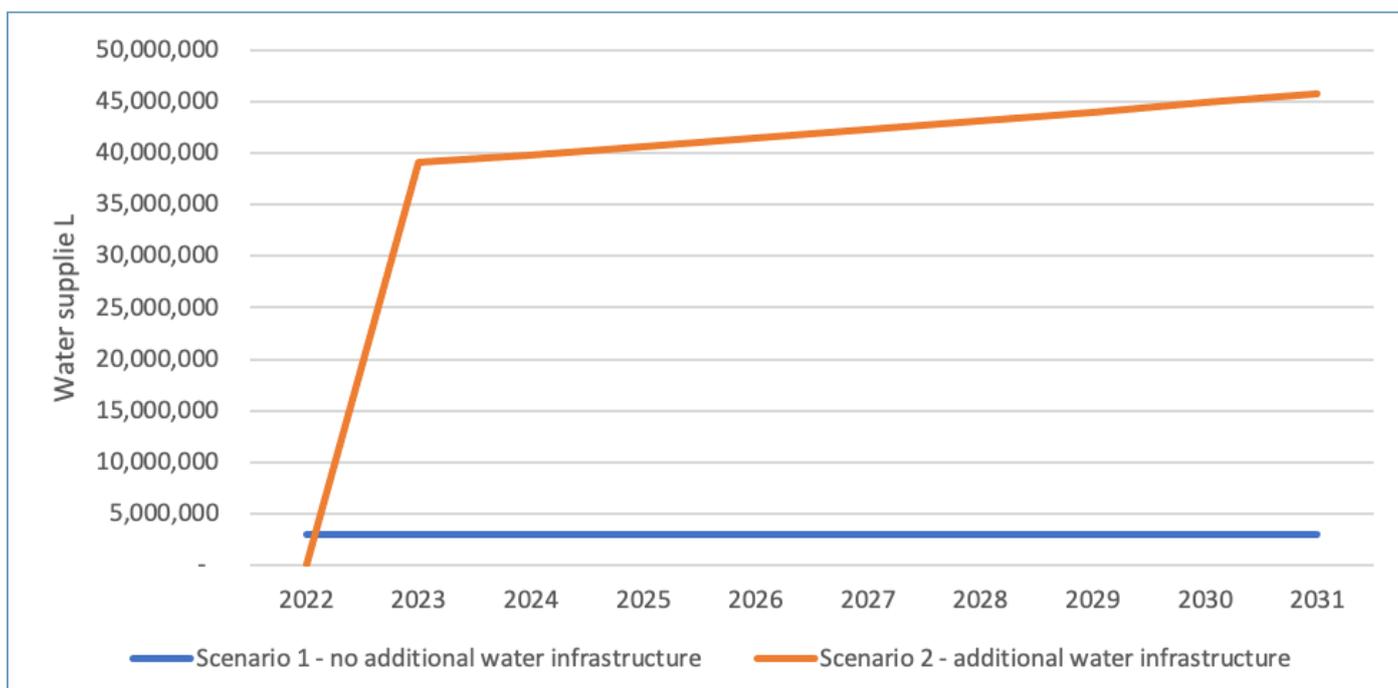
| Discount rate | Costs MWK, millions | Benefits MWK, millions | BCR |
|---------------|---------------------|------------------------|-----|
| 5%            | 523,709             | 1,769,299              | 3.4 |
| 8%            | 393,001             | 1,105,075              | 2.8 |
| 14%           | 264,560             | 521,243                | 2.0 |

## 4.2 Intervention 2: Roll-out of e-Madzi kiosks across Blantyre

In Malawi, the WUA, as intended by the Water Resources Act of 2013, is a not-for-profit legal entity established to manage kiosks (sales, cash management, book-keeping, reporting faults and reporting to the Water Board (Coulson et al., 2021). With residents in informal settlements unable to pay for connection fees and water authorities unwilling to extend the piped network to environmentally sensitive areas, the water kiosks are considered critical to providing and maintaining water-supply to low-income areas. With assistance from the World Bank, the Lilongwe Water Board (LWB) piloted four E-Madzi kiosks in 2019 and rolled out an additional 35, primarily in response to Covid-19. The E-Madzi kiosks respond directly to the problems of NRW, inconsistent access, and unaffordability. Residents can also access water at any time, as the traditional kiosks were only open for about 6 hours/day. Finally, the technology helps to reduce water wastage due to spillage and non-revenue water because the release of water is automated, accessible through a smart card.

The intervention proposed is to replace traditional (manual) water kiosks with e-Madzi kiosks across all 730 functional kiosks in Blantyre (Mitlin and Walnycki 2019). We consider two scenarios in the cost-benefit analysis. In the first scenario, the intervention assumes that the current level of water supplied to informal settlements remains constant, i.e. there is no additional water infrastructure to boost supply, and no redirection of water to informal settlements. Based on the figures reported in Section 4.1.2 informal settlements receive 2,982,000 L per day. In the second scenario, we assume that water supply intervention noted in Section 4.1. has already been implemented, and that latent water demand in informal settlements is fully met. The two scenarios are depicted in Figure 4. In the second scenario, with benefits starting in 2023 after the water infrastructure project is complete, substantially more water is provided to informal settlements both initially and over time as population grows. In the first scenario, with benefits starting in 2022, whatever supply is capped at 2,982,000 L per day.

Figure 5: Water supplied to informal settlements under scenarios with and without additional water infrastructure



### 4.2.1 Costs

The E-Madzi system is comprised of three main elements - a smartcard, a dispenser unit and a water management system. The system is installed at a kiosk and is operated through an electronic water management device. The card uses Radio-Frequency Identification (RFID) technology to allow users to draw water by tapping on the dispenser unit. The E-Madzi kiosk has been costed at (MWK 409,000 or \$5,500 plus associated costs of overhead and management assumed at 10%) including supply and installation work (private correspondence, Lilongwe Water Board). Operations costs are MWK 223,500 (\$300) per year per kiosk (private correspondence, Lilongwe Water Board). Lastly, the costs of smartcards are assumed to be MWK 400, and are replaced every five years. The E-Madzi kiosks will need to be replaced after 10 years.

### 4.2.2 Benefits

The first benefit observed by the World Bank (2020b) is the reduction in the cost of water by 65%, owing to the elimination of kiosk attendants, increased efficiency and reduction in physical losses. The calculation of the benefit assumes bucket rate tariffs decrease by 65% - i.e. from MWK 15 per 20L bucket to MWK 5.25 per 20L bucket. To estimate the total benefits, the number of buckets bought by kiosk users is first estimated, and savings of MWK 9.75 per bucket is applied.

The second benefit category is the time savings from avoided queuing. In the case of Lilongwe, kiosks were only operational six hours per day prior to the e-madzi rollout. This caused congestion during working hours. Because they do not require the physical presence of a person, E-madzis are theoretically available 24 hours per day. While we do not have data on avoided queuing times, common sense suggests that some time savings should be realized. Based on figures in the IHS5, we assume that collecting water in urban environments takes 30min round trip. We assume 10 min each way for walking, with 10 min queuing time at the kiosk. E-madzis increase water availability by 4x, from 6 hours to 24 hours. We conservatively assume that queuing time is reduced by half, i.e. from 10 min to 5 min per trip. The value of this 5 min is assumed to be 50% of the urban wage rate in informal settlements, noted as MWK 140 per hour in 2021.

In Lilongwe, one of the main rationales for the intervention was to reduce the spread of COVID-19. In this analysis we do not include this benefit, due to lack of data on the exact impact of the intervention on COVID-19 transmission, the complexities in predicting the future pathway of the pandemic and the uncertainties in responses by governments to growing or shrinking caseloads. We only note that if this were to be included the BCR would increase though we are unable to estimate the magnitude.

The benefits of the intervention are presented below for the two scenarios, using the same axis for comparability. Clearly, the benefits from the first intervention are much lower than the benefits of the second, due to the vast differences in water supplied to informal settlements under the two scenarios. In the first scenario, the benefits are MWK 938 million in 2022 rising to MWK 1,073 million in 2023. In the second scenario, the benefits start at MWK 12,613 million and rise to MWK 17,439 million by the time the E-Madzi unit needs to be replaced. In both scenarios time savings make up 45-50% of the benefits.

Figure 6: Benefits of E-Madzis under two scenarios, scenario 1 assumes no new water infrastructure is provided. Scenario 2 assumes the 230 million L supply facility is operational in 2023.



### 4.2.3 Results

The costs, benefits and benefit-cost ratio of the intervention are summarized in the table below across various discount rates and scenarios. At an 8% discount rate, the BCR under the first scenario is 1.5. For the second scenario, the BCR is 22, a substantial jump in effectiveness. The economic logic of these different results is simple: improving the efficiency of kiosks in informal settlements is only economically justified when a sufficient amount of water is supplied to these residents – otherwise the potential benefits only modestly exceed the costs of installing the systems.

Table 4.3: Benefits, Costs and BCR of E-Madzi intervention

| Discount rate  | Costs MWK, millions | Benefits MWK, millions | BCR  |
|--|---------------------|------------------------|------|
| <b>Scenario 1: No additional water infrastructure</b>                  |                     |                        |      |
| 5%   | 4,670               | 7,671                  | 1.6  |
| 8%   | 4,498               | 6,643                  | 1.5  |
| 14%  | 4,243               | 5,131                  | 1.2  |
| <b>Scenario 2: Additional water infrastructure already implemented</b> |                     |                        |      |
| 5%   | 4,448               | 107,873                | 24.3 |
| 8%   | 4,165               | 90,389                 | 21.7 |
| 14%  | 3,722               | 65,553                 | 17.6 |

**Notes:** Costs and benefits are present values at various discount rates. Scenario 1 timeline is 2021 to 2031 (benefits begin in 2022), while Scenario 2 timeline is from 2021 to 2032 (benefits begin in 2023). This slight phasing difference explains the slight differences in costs for the intervention under the two scenarios.

## 5. Conclusion

This report conducted cost-benefit analyses of two interventions to improve water provision in Blantyre. The first intervention, the construction of new supply from the Shire Valley capable of providing 230 million L per day, would require an upfront cost of MWK 122,925 million and recurrent costs of MWK 17,865 million rising to MWK 33,708 million, the new supply of 230 million L per day would likely be sufficient to meet demand in Blantyre until 2036, even after accounting for 40% physical losses. This would generate benefits worth MWK 44,770 million in 2023, the assumed first year of operations, rising to MWK 306,887 million by 2052. These figures are around 0.6% of projected GDP. Being the commercial center of Malawi, ensuring Blantyre has sufficient water is essential for both the city and the country's economic growth. The return-on-investment from the intervention is 2.8, meaning that for every kwacha spent on the project, Blantyre receives 2.8 kwacha in economic benefits. This finding provides economic justification for increasing the water supply in Blantyre.

The results from the cost-benefit analysis of the second intervention show that E-Madzis have a modest return on investment of 1.5, under the situation where kiosks only receive 4% of current supplied water. However, in a scenario where residents of informal settlements are receiving increased supply – after the installation of the new supply station mentioned above – the BCR of E-Madzis jumps to 22, meaning that every kwacha invested yields 22 kwacha in benefits. The main policy implication is that BWB should wait until the new supply is provided, and that a sufficient proportion goes to informal settlements, before considering any rollout of E-Madzis.

When considering the interventions together, compared to a counterfactual of neither intervention, the BCR is 3.2. This is based on a thirty-year water supply project and E-madzis installed in 2022 and replaced in 2032 and 2042. The combined intervention has a cost of MWK 399,884 million and benefits of MWK 1,277,453 million at an 8% discount rate. This is larger than the BCR of either intervention alone, indicating that the two interventions are synergistic.

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A COST-BENEFIT ANALYSIS OF INTERVENTIONS TO IMPROVE WATER SERVICE RELIABILITY IN BLANTYRE MALAWI