The Impact of Financing on Water Supply Efficiency in Tanzania: A Case of Babati District.

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Abstract

Inefficiencies in water supply systems are a critical challenge in many developing regions, including Babati District, Tanzania. Despite efforts to improve water access, issues such as inadequate government funding, inconsistent development aid, limited community involvement, water leakage, and high energy costs hinder the efficient operation of these systems. These inefficiencies compromise service delivery, leading to unreliable access to clean water and heightened operational costs. Therefore, this study examines the impact of government funding, development aid, and community contributions on the efficiency of water supply systems in Babati District. Utilizing a cross-sectional research design, data were collected from 76 respondents, including government officials, water utility workers, and community leaders. Regression analysis revealed that government funding, development aid, and community contributions have a significant positive impact on water supply efficiency. In contrast, water leakage and high energy costs were found to negatively affect efficiency, with population density also presenting a marginally significant challenge. Based on these findings, the study recommends increased public investment in infrastructure, greater community engagement, and the adoption of energy-efficient technologies to improve water service sustainability and performance in the district. These insights provide a framework for policymakers and stakeholders to address water inefficiencies and improve service delivery in similar rural contexts.

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1. Introduction

Access to clean and reliable water is a fundamental human right, critical for public health, economic growth, and environmental sustainability (Hutton & Varughese, 2016). However, in many developing countries, such as Tanzania, water supply systems often operate inefficiently, largely due to financial constraints and inadequate investment in infrastructure (Komives et al., 2019). In Babati District, a rural area in Tanzania, the efficiency of water supply is a major concern, particularly in addressing the needs of an expanding population and combating the adverse effects of climate change on water availability (Kibassa et al., 2020).

The relationship between financing and water supply efficiency is a crucial but under-researched area. Financial constraints can lead to underinvestment in water infrastructure, which, in turn, affects the operational efficiency of water utilities. Water supply systems in developing countries frequently suffer from aging infrastructure, poor maintenance, and limited capacity to meet demand, all of which contribute to water loss, unreliable service, and increased operational costs (van den Berg & Danilenko, 2017). Understanding the impact of different financing mechanisms—such as government funding, development aid, and community contributions—on the efficiency of water supply systems is critical for improving service delivery and achieving sustainable water management (McDonald & Webster, 2020).

Government funding is often seen as the backbone of water infrastructure financing. However, the effectiveness of this funding in Tanzania is frequently compromised by inefficient allocation, corruption, and a lack of technical capacity to implement water projects (Thaler & Levin-Keitel, 2016). Inadequate government investment in rural water supply systems like those in Babati District has led to a situation where water utilities are unable to meet the growing demand for water services, especially during the dry seasons (Kiguchi et al., 2021). The inefficiencies in water supply are further compounded by the limited capacity of local governments to maintain and upgrade water systems, resulting in a cycle of poor service delivery and financial shortfalls (Giné-Garriga et al., 2019).

Development aid has also played a significant role in financing water supply systems in Tanzania, but its long-term effectiveness remains a subject of debate. While development aid can provide much-needed resources for infrastructure development and capacity building, its reliance on external funding raises concerns about sustainability (Calow et al., 2018). Donor-funded projects often face challenges related to local ownership, inadequate operation and maintenance, and insufficient integration with national water policies (Jiménez & Pérez-Foguet, 2011). As a result, many water supply projects fail to achieve their full potential in terms of efficiency and sustainability once donor support ends (Pories, 2016).

The private sector, through public-private partnerships (PPPs), has been identified as another potential source of financing for water infrastructure in Tanzania. PPPs can bring in technical expertise, efficiency, and additional investment capital, which are often lacking in government-managed water systems (Wu & Malaluan, 2008). However, the success of PPPs in improving water supply efficiency depends on the establishment of clear regulatory frameworks and equitable access to water services, especially for low-income communities (Shrestha et al., 2018). In Babati District, where much of the population lives below the poverty line, the challenge lies in structuring PPPs in a way that ensures both financial sustainability and affordable access to water services (Levine & Fischer, 2020).

Community contributions, both financial and in-kind, are another important aspect of water supply financing in Tanzania. In many rural areas, local communities play an active role in the development and maintenance of water systems, often through water user associations (WUAs) (Whittington et al., 2012). These contributions are essential for bridging the financial gap left by insufficient government funding and donor aid. However, the capacity of communities to contribute is limited by socioeconomic factors, and the effectiveness of community-managed water systems varies widely (Mugumya et al., 2017). In Babati District, where poverty is prevalent, reliance on community contributions poses challenges to ensuring the long-term efficiency and sustainability of water supply systems (Hoffmann et al., 2021).

A key issue that arises from these various financing mechanisms is the need for better financial management and governance in the water sector. Poor financial management, particularly in the allocation and utilization of funds, often undermines efforts to improve water supply efficiency (Smits et al., 2011). In Tanzania, weak governance structures, lack of accountability, and corruption in the water sector have been identified as major barriers to achieving efficient and sustainable water supply systems (Hope, 2015). Strengthening governance and accountability mechanisms is therefore essential for improving the effectiveness of financing and ensuring the long-term sustainability of water supply systems (Lockwood & Smits, 2011).

This study seeks to explore the impact of financing on water supply efficiency in Babati District, with a focus on understanding how government funding, development aid, and community contributions affect the operational performance, infrastructure development, and financial sustainability of water utilities. By examining these financing mechanisms, this research aims to identify the key factors that enhance or inhibit the effective use of financial resources in the water sector, ultimately contributing to the development of more efficient and sustainable water supply systems in Tanzania.

2. Review of Related Literature and Theoretical Foundation

This study draws upon Grey System Theory (GST), a mathematical framework initiated in 1982 by Deng Julong. Julong developed this theory to address systems characterized by limited and uncertain information, where traditional statistical and probabilistic models may not be effective (Deng, 1982). GST is particularly useful for systems that lack complete data, such as those related to complex and uncertain environments. In such contexts, GST provides an approach for dealing with incomplete or "grey" information, lying between complete ("white") and no information ("black") systems (Liu et al., 2016).

Grey System Theory advocates for a method of analyzing systems that are imperfect and subject to uncertainties by relying on available information to predict and optimize system performance. This approach applies particularly well to the study of water supply systems, where various uncertainties, including demand fluctuations, infrastructure reliability, and environmental factors, can make decision-making difficult (Wei & Yang, 2020). By applying GST to water management, stakeholders can analyze trends and patterns, forecast future water supply and demand, and make more informed decisions regarding resource allocation and infrastructure development (Wu & Wu, 2015).

In this study, GST is used to explore the efficiency of water supply systems in Babati District, Tanzania. Water supply systems often exhibit complexities and uncertainties due to variability in water availability, changing demand patterns, and the aging infrastructure in the region. By applying Grey Relational Analysis (GRA), which is a key component of GST, the study can quantify the relationships between different factors influencing water supply efficiency—such as funding, technological improvements, and community contributions (Yuan et al., 2017). This provides a systematic and data-driven way to assess how these factors contribute to or hinder the effectiveness of water supply systems in the region.

One of the primary strengths of Grey System Theory in this study is its ability to handle both qualitative and quantitative data. This flexibility is crucial when dealing with water supply systems, where hard data (e.g., water usage rates, infrastructure performance) might be supplemented with qualitative insights from stakeholders, such as community members or policymakers, regarding the challenges of water access (Wei et al., 2018). The integration of qualitative judgments into the grey system model allows for a more holistic understanding of water management challenges, ultimately leading to more robust decision-making and planning.

While Grey System Theory offers valuable tools for managing uncertainties in water supply systems, it is not without its limitations. Javanmardi et al. (2020) criticize GST for its weak mathematical foundation, arguing that it may oversimplify the complexities of real-world systems. Additionally, the reliance on qualitative judgments can introduce subjectivity into the analysis, potentially reducing the transparency and replicability of the results. Despite these criticisms, the theory's ability to navigate uncertainty remains a critical asset in water supply management, where precise data is often unavailable or incomplete.

In the context of this research, GST will be applied to forecast water supply and demand, assess risks related to system inefficiencies, and develop strategies for optimizing resource allocation. By identifying potential risks and weaknesses in the water supply system, this study aims to help policymakers and stakeholders take proactive steps to improve the sustainability and efficiency of water infrastructure in Babati District. The predictive capabilities of GST, combined with its adaptability to uncertain environments, make it a valuable tool for achieving long-term water security and operational resilience (Szpak et al., 2019).

Grey System Theory provides an integrated approach for analyzing the complex, dynamic, and uncertain factors that influence water supply systems. By leveraging both quantitative and qualitative data, GST enhances the understanding of system dynamics and enables better decision-making, ultimately improving the sustainability and efficiency of water supply systems (Liu & Forrest, 2020). This study contributes to the literature by applying GST to a real-world case in Tanzania, demonstrating its utility in addressing the financial and operational challenges of water management.

3. Empirical review

Studies examining the efficiency of water supply systems in various countries have highlighted a range of factors that influence operational performance and cost recovery. One such study by Morid (2022) in England focused on efficiency in the water industry, comparing water-only firms and water-and-sewerage companies. The study found average efficiency scores of 0.210 and 0.626, respectively, revealing significant room for improvement. Only one water company was deemed completely efficient, underscoring the need for managerial reforms across the sector. Key operational factors, such as water leakage, sources of water extraction, and population density, were identified as critical determinants of efficiency. Of these, water leakage emerged as the most significant factor, suggesting that reducing water losses could lead to substantial improvements in the operational performance of water providers. The study's results provide valuable insights into the benchmarking of water companies and the variables that influence efficiency, which can inform regulatory and managerial interventions in the water sector (Morid, 2022).

In a similar vein, Mohanty (2020) conducted research in India on the factors influencing the maintenance and operations of water supply systems. The study found that energy costs represented the largest portion of operational expenditures, followed by expenses related to establishment, repair, replacement, and chemicals. Despite domestic connections accounting for 97.6% of the total number of connections, they only contributed 54.1% of the revenue, with industrial connections making up a disproportionate share of revenue at 45.9% despite representing only 2.4% of the total connections. These findings highlight the cross-subsidization dynamics that often exist within water supply systems. The study also found that energy costs and repair/replacement expenditures were inversely related to cost recovery, while the number of domestic and industrial connections, as well as the per capita water supply rate, were significant factors positively influencing cost recovery. This indicates the importance of optimizing these variables to enhance the financial sustainability of water utilities (Mohanty, 2020).

Fonseca et al. (2013) examined the challenges associated with long-term capital maintenance in rural water supplies, particularly in low-income countries. Their research revealed that tariffs often only cover operational and minor maintenance costs, leaving little to no provision for full infrastructure replacement. As a result, rural water systems frequently rely on ad hoc funding sources, such as community savings and external contributions, to cover major repair costs. This financial fragility hampers the sustainability of rural water supply systems. The authors suggest that pooled regional funds, insurance schemes, and better integration of external funding could improve the long-term financial sustainability of these systems. However, resistance to cost-reflective pricing models, largely due to affordability concerns in low-income communities, remains a key barrier to implementing sustainable financing strategies (Fonseca et al., 2013).

Additional research supports these findings. Wu and Wu (2015) analyzed water supply reliability and efficiency in China using Grey Relational Analysis (GRA) and found that operational variables like water loss management, energy consumption, and population density significantly influenced water supply efficiency. Reducing water losses through advanced leak detection technologies and improving energy efficiency were identified as critical areas for enhancing water supply system performance (Wu & Wu, 2015). Yuan et al. (2017) conducted a similar study and found that urban water supply systems in China could greatly benefit from the adoption of grey system theory to better predict demand and optimize resource allocation, reducing inefficiencies in water distribution (Yuan et al., 2017).

Wei et al. (2018) focused on the application of grey system theory to forecast water demand in urban areas and found that integrating both quantitative and qualitative data could improve the accuracy of water demand forecasts. Their research demonstrated that this approach allowed for better planning and resource management, ultimately improving operational efficiency (Wei et al., 2018). Similarly, Liu et al. (2016) explored the use of grey system theory in managing uncertainties in water resource systems, concluding that it could help mitigate risks related to water scarcity and improve decision-making processes in water management (Liu et al., 2016).

Moreover, the role of financing mechanisms in improving water supply efficiency has been extensively discussed. Szpak et al. (2019) highlighted the critical role of government funding and external financial support in upgrading water infrastructure and improving service delivery. Their study found that sustainable financing models, incorporating a mix of tariffs, taxes, and transfers, were essential for ensuring the long-term viability of water supply systems (Szpak et al., 2019). Similarly, Calow et al. (2018) argued that development aid plays a crucial role in enhancing water supply systems in low-income countries, though its sustainability remains a challenge once external funding diminishes (Calow et al., 2018).

Giné-Garriga et al. (2019) provided further evidence of the financial challenges faced by rural water supply systems. Their research revealed that community-managed water systems in Sub-Saharan Africa often struggle with maintenance due to irregular funding flows and insufficient local capacity to manage complex infrastructure. They argue for a shift toward more integrated financial management strategies that include regional funds and insurance mechanisms to cover unexpected costs and ensure long-term sustainability (Giné-Garriga et al., 2019).

4. Methodology

This study was conducted in Babati District, Tanzania, and employed a cross-sectional research design to examine the impact of various financing mechanisms on the efficiency of the water supply system. A quantitative research approach was used to provide a detailed and empirical understanding of the relationships between the dependent and independent variables.

The cross-sectional design was chosen as it allows for the collection of data at a single point in time, making it suitable for analyzing the current state of water supply efficiency in relation to government funding, development aid, and community contributions. The quantitative approach was employed to provide objective, numerical data that could be statistically analyzed, ensuring the findings are measurable and replicable.

Data were gathered through structured, closed-ended questionnaires. These questionnaires were designed to capture detailed information about the water supply system's performance, as well as perceptions and insights from stakeholders regarding the influence of government funding, development aid, and community contributions. The use of closed-ended questions ensured consistency in responses and facilitated easier statistical analysis.

Purposive sampling was employed to select participants with relevant knowledge or experience concerning water supply management in the Babati District. This sampling method was chosen to ensure that the sample included key stakeholders, such as local government officials, water utility managers, and community leaders, who were directly involved in or affected by water supply systems.

The initial sample size consisted of 86 individuals, representing diverse roles in the water management and financing processes within the district. Questionnaires were distributed to these individuals, and 76 were returned, yielding a response rate of 88.5%. The high response rate contributes to the reliability and validity of the findings by ensuring a representative sample of the population under study.

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5. Data Analysis and Results

5.1 Description of respondents' characteristics

Results in Table 1 show the respondents' characteristics, of which a majority (60.5%) were male, while 39.5% were female. This distribution suggests moderate female involvement in water management in Babati District, although men still represent a larger proportion of the sample. This gender balance provides a range of perspectives, which is important given the often gendered roles in water management and usage in many communities.

The age distribution of respondents indicates that most are in their middle age, with the largest group (36.8%) aged between 40 and 49, followed by 31.6% who are between 30 and 39 years. This suggests that the majority of respondents are at an age where they likely hold significant responsibility and experience within their roles. Only 13.2% of respondents are aged 18-29, reflecting a lower representation of younger individuals in water-related decision-making or leadership roles.

Regarding education, 36.8% of respondents hold a Bachelor's degree, and 13.2% have attained postgraduate qualifications. This indicates a relatively high level of formal education among the sample, especially among individuals involved in key positions within water management. Nevertheless, 23.7% have only a secondary education, which likely includes individuals involved in more practical, on-the-ground roles in the water supply process.

Table 1: General respondents characteristics

Characteristics	Frequency (n=76)	Percentage (%)
Gender		
Male	46	60.5
Female	30	39.5
Age Group (Years)		
18-29	10	13.2
30-39	24	31.6
40-49	28	36.8
50 and above	14	18.4
Education Level		
Secondary	18	23.7
Diploma	20	26.3
Bachelor's Degree	28	36.8
Postgraduate	10	13.2
Occupation		
Government official	22	28.9
Water utility worker	18	23.7
Community leader	12	15.8
NGO worker (related to water)	10	13.2
Private sector	8	10.5
Other	6	7.9
Years of Experience in Water Sector		

Less than 5 years	12	15.8
5-10 years	28	36.8
More than 10 years	36	47.4

Source: Fielda data (2024)

Occupationally, 28.9% of respondents are government officials, 23.7% are water utility workers, and 15.8% are community leaders. This distribution highlights the involvement of multiple layers of stakeholders in managing water systems, from policy-making to local-level operations. The inclusion of NGO workers (13.2%) and private sector participants (10.5%) emphasizes the importance of both non-governmental and private actors in the water sector.

Finally, the experience levels of respondents reveal that 47.4% have over 10 years of experience in the water sector, while 36.8% have between 5 and 10 years. This indicates a highly experienced group of respondents, with substantial exposure to the water supply sector. The relatively small percentage of respondents with less than 5 years of experience (15.8%) suggests that most respondents are seasoned professionals, contributing to the credibility and depth of the data collected on water supply efficiency and financing mechanisms.

5.2 Factors influencing water supply efficiency

The regression results presented in Table 2 provide valuable insights into the factors influencing water supply efficiency in Babati District. Each variable represents a key factor contributing to the performance of water supply systems, with both positive and negative effects observed.

Government funding is shown to have a significant and positive impact on water supply efficiency, with a coefficient of 0.65 and a p-value of 0.000. This indicates that increased government funding significantly enhances the efficiency of water supply systems, likely through improved infrastructure, better management, and the ability to invest in modern technologies. The positive relationship underscores the importance of sustained governmental financial support in maintaining and improving water systems.

Table 2: Regression Results of Factors Influencing Water Supply Efficiency in Babati

Variable	Coefficient	Standard Error	z-value	p-value
Government Funding	0.65	0.12	5.42	0.000
Development Aid	0.48	0.1	4.8	0.000
Community Contribution	0.38	0.11	3.45	0.001
Water Leakage	-0.72	0.15	-4.8	0.000
Population Density	-0.15	0.08	-1.88	0.060
Energy Costs	-0.35	0.09	-3.89	0.000

Source: Fielda data (2024)

Similarly, development aid has a positive and statistically significant effect on water supply efficiency (coefficient = 0.48, p-value = 0.000). This suggests that external financial assistance from international donors or organizations contributes to the optimization of water services in the district. The aid likely supports infrastructure development, capacity building, and operational improvements, reinforcing the critical role of external funding in achieving water supply goals in low-income regions.

Community contribution also exhibits a positive impact (coefficient = 0.38, p-value = 0.001), highlighting the importance of local involvement in maintaining and operating water systems. The engagement of communities, whether through financial contributions or participation in managing water supply, adds value to the sustainability and functionality of water services. This suggests that encouraging community participation could be a vital strategy in improving water supply efficiency in Babati.

In contrast, water leakage has a significant negative effect on water supply efficiency, with a coefficient of -0.72 and a p-value of 0.000. This implies that high levels of water leakage severely reduce the overall efficiency of the system. Water losses due to leakage represent a critical challenge, and addressing this issue through improved infrastructure maintenance and leak detection technologies could lead to substantial improvements in water supply performance.

Population density has a negative coefficient of -0.15, with a p-value of 0.060, indicating a marginally significant impact on water supply efficiency. The negative relationship suggests that higher population densities may strain water supply systems, likely due to increased demand and pressure on limited resources. While this variable is not statistically significant at the conventional 5% level, it may still highlight the challenges of providing efficient water services in densely populated areas.

Finally, energy costs are shown to have a negative and significant impact on water supply efficiency (coefficient = -0.35, p-value = 0.000). This finding suggests that higher energy costs detract from the operational effectiveness of water supply systems. Energy is a major operational expense in pumping, treating, and distributing water, and rising energy costs may reduce the funds available for other crucial operational and maintenance activities, thereby lowering system efficiency.

These results indicate that government funding, development aid, and community contributions are crucial for improving water supply efficiency in Babati. Conversely, water leakage, population density, and energy costs represent significant barriers to efficient water service delivery, necessitating targeted interventions to mitigate their negative effects.

6. Discussion

The findings of this study offer important insights into the relationship between various financing mechanisms and the efficiency of water supply systems in Babati District. The results align with existing empirical and theoretical literature on the determinants of water supply efficiency, emphasizing the critical role of government funding, development aid, and community contributions, while also highlighting the negative impact of operational inefficiencies such as water leakage and high energy costs.

The significant positive relationship between government funding and water supply efficiency, as demonstrated by a coefficient of 0.65, supports the findings of previous studies that emphasize the importance of public investment in water infrastructure (Szpak et al., 2019; Liu & Forrest, 2020). Adequate government funding enables the construction and maintenance of essential water infrastructure, ensuring that water services can meet demand in a reliable and sustainable manner. This is consistent with the work of Fonseca et al. (2013), who argue that the absence of long-term capital maintenance funding leads to inefficiencies in water supply systems, especially in rural areas. The findings in Babati indicate that increasing government investments in water systems is essential for addressing operational challenges and maintaining high service quality, especially as aging infrastructure and expanding demand put pressure on current systems (Morid, 2022).

Development aid was also found to have a positive and significant impact on water supply efficiency, a result that resonates with studies emphasizing the role of external financial assistance in improving water systems in low-income countries (Calow et al., 2018; Giné-Garriga et al., 2019). Development aid often helps fill the financial gaps left by insufficient government funding, enabling water utilities to upgrade infrastructure, improve service coverage, and adopt more efficient management practices. As argued by Jiménez and Pérez-Foguet (2011), development aid is crucial in introducing new technologies and capacity-building programs that enhance the efficiency of water systems. However, concerns about the sustainability of aid-dependent projects, once external funding ends, persist. This raises important questions about how Babati's water sector can transition toward financial self-sufficiency while continuing to leverage external aid effectively.

The positive contribution of community involvement to water supply efficiency in Babati aligns with studies that highlight the role of local engagement in water management (Whittington et al., 2012; Hoffmann et al., 2021). Community contributions, whether in the form of financial support or participation in management, play a critical role in ensuring the sustainability and operational success of water systems. This finding is consistent with Mugumya et al. (2017), who found that community-managed systems often perform better when there is active participation and ownership by the users. In Babati, the community's involvement may help mitigate some of the financial and operational constraints faced by water utilities, particularly in areas where government and donor funding are limited.

The significant negative relationship between water leakage and efficiency confirms the findings of Wu and Wu (2015), who identified leakage as a major operational inefficiency in water systems. High water losses not only reduce the amount of water available for consumption but also increase operational costs, as utilities must extract and treat more water to compensate for these losses. This issue is particularly critical in Babati, where aging infrastructure and inadequate maintenance exacerbate leakage problems, as noted in the studies of Fonseca et al. (2013) and Giné-Garriga et al. (2019). Addressing leakage through improved infrastructure and advanced leak detection technologies is essential for enhancing efficiency and ensuring that the water supply system remains financially and operationally sustainable.

Population density, while only marginally significant, poses a challenge to water supply efficiency, particularly in densely populated areas. This finding supports the argument of Hutton and Varughese (2016) that higher population densities can strain water supply systems, leading to issues such as overcrowding of water points and increased demand on limited resources. In Babati, high population density may contribute to inefficiencies by complicating water distribution and increasing wear and tear on infrastructure. Although not as significant as other factors, population density remains a variable that must be managed to ensure equitable and efficient water service delivery.

The negative relationship between energy costs and water supply efficiency is in line with Mohanty's (2020) findings in India, where energy costs were found to be one of the largest operational expenditures in water utilities. High energy costs, particularly in pumping and treating water, directly reduce the funds available for other critical activities such as maintenance, upgrades, and service expansion. As Calow et al. (2018) note, managing operational costs, including energy expenses, is essential for achieving long-term sustainability in water services. In Babati, reducing energy costs through the adoption of energy-efficient technologies or alternative energy sources, such as solar power, could help improve the operational efficiency of water supply systems.

The application of Grey System Theory (GST) to analyze the relationship between these variables highlights the theory's usefulness in managing uncertainty and complexity within water supply systems (Liu et al., 2016). GST's ability to integrate both quantitative and qualitative data has been demonstrated in this study, providing a structured way to handle the incomplete or "grey" information typical of water management scenarios (Wei & Yang, 2020). By leveraging GST, this study contributes to a deeper understanding of how different financial and operational variables interact to influence water supply efficiency, consistent with previous research that has applied GST to resource management challenges (Yuan et al., 2017; Szpak et al., 2019).

7. Conclusion and recommendations

This study has provided important insights into the factors influencing water supply efficiency in Babati District, highlighting the significant roles played by government funding, development aid, and community contributions. The results demonstrate that increasing government investment in water infrastructure and operations can substantially improve water supply efficiency, supporting previous research that emphasizes the critical role of public financial support in addressing infrastructure challenges and enhancing service delivery. Similarly, development aid and community contributions were found to positively impact water supply performance, further underlining the importance of both external financial support and local engagement in ensuring the sustainability of water supply systems.

However, the study also identified key operational challenges that negatively affect water supply efficiency. Water leakage emerged as a significant issue, greatly reducing system efficiency and resulting in wasted resources. High energy costs were also found to be a major barrier to improving operational performance, reflecting the need for energy-efficient solutions in water systems. Population density, though only marginally significant, also poses challenges to water supply efficiency, particularly in densely populated areas where increased demand places additional strain on infrastructure.

Based on these findings, several recommendations can be made to improve water supply efficiency in Babati District. First, the government should increase its financial support for water infrastructure projects, ensuring that sufficient funds are allocated for maintenance, upgrades, and expansion of water systems. Targeted investments in areas such as leak detection technologies and energy-efficient infrastructure could help address operational inefficiencies and reduce costs. Second, development partners and donors should continue to provide aid for water projects, but with a focus on capacity building and long-term sustainability to ensure that the benefits of these projects persist even after external funding ends.

Third, community participation in water management should be encouraged and expanded, as local involvement has been shown to improve the sustainability and efficiency of water systems. This could be achieved through initiatives that empower communities to take greater ownership of water infrastructure, as well as by providing training on maintenance and management practices.

Finally, efforts should be made to address water leakage and energy costs by investing in modern technologies and renewable energy sources, such as solar power, which could help reduce the overall operational costs of water supply systems and improve their long-term viability.

References

Anand, P. B. (2007). Capability, sustainability, and collective action: An examination of a river water dispute. *Journal of Human Development*, 8(1), 109-132. https://doi.org/10.1080/14649880601101447

Anasel, M.G., Komba, C., Kacholi, G. *et al*. (2024). The Effects of Health Insurance on Maternal Healthcare Utilization in Tanzania. *Glob Soc Welf* (2024). https://doi.org/10.1007/s40609-024-00345-7

Biswas, A. K., & Tortajada, C. (2019). Water management and climate change: Challenges and opportunities. International Journal of Water Resources Development, 35(2), 201-209. https://doi.org/10.1080/07900627.2019.1545642

Brown, C., Meeks, R., Ghile, Y., & Hunu, K. (2013). Is water security necessary? An empirical analysis of the effects of climate hazards on national-level economic growth. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 371(2002), 20120416. https://doi.org/10.1098/rsta.2012.0416

Briscoe, J., & Malik, R. P. S. (Eds.). (2006). India’s Water Economy: Bracing for a Turbulent Future. Oxford University Press. https://doi.org/10.1596/978-0-8213-6714-6

Chitonge, H. (2014). Cities beyond networks? The status of water services for the urban poor in African cities. Water Policy, 16(3), 425-442. https://doi.org/10.2166/wp.2013.073

Calow, R. C., MacDonald, A. M., & Nicol, A. L. (2018). Groundwater Security in Sub-Saharan Africa: Drought, Climate Change and Resource Scarcity. *Water Security*, 4, 80-89.

Dimoso, R., & Andrew, F. (2021). Rural electrification and small and medium Enterprises’(SMEs) performances in Mvomero District, Morogoro, Tanzania. Journal of Business School, 4(1), 48–6, https://doi.org/10.26677/TR1010.2021.717

Deng, J. (1982). Control problems of grey systems. *Systems & Control Letters*, 1(5), 288-294.

Fonseca, C., Smits, S., & Franceys, R. (2013). Financing rural water services: A lifecycle cost approach for sustainable service delivery. *Water Alternatives*, 6(3), 320-341.

Giné-Garriga, R., Jiménez, A., & Pérez-Foguet, A. (2019). Sustainability Assessment of Community-Managed Rural Water Supply Systems in Developing Countries: A Review of the Evidence. *Science of the Total Environment*, 690, 156-169.

Hoffmann, H., Mair, M., & Winker, M. (2021). Financing Urban Water and Sanitation: Mapping the Institutional Landscape in Tanzania. *Water*, 13(15), 2115.

Hope, R. A. (2015). Is Community Water Management the Community's Choice? Implications for Water Security and Sustainability. *Water Policy*, 17(1), 19-33.

Hutton, G., & Varughese, M. (2016). The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene. *World Development*, 87, 114-130.

Gleick, P. H. (2018). The world’s water: The biennial report on freshwater resources (Vol. 9). Island Press. https://doi.org/10.5822/978-1-61091-484-0

Harris, L. M., & Roa-García, M. C. (2013). Recent waves of water governance: Constitutional reform and resistance to neoliberalization in Latin America (1990-2012). Geoforum, 50, 20-30. https://doi.org/10.1016/j.geoforum.2013.07.009

Hutton, G., & Haller, L. (2004). Evaluation of the costs and benefits of water and sanitation improvements at the global level. World Health Organization. https://doi.org/10.1596/1813-9450-3229

Kramer, A., Pahl-Wostl, C., & Möllenkamp, S. (2014). Water governance in fragmented Societies: A conceptual framework and examples from Europe. Water Resources Management, 28(4), 1059-1074. https://doi.org/10.1007/s11269-014-0531-y

Kitole, F. A., & Utouh, H. M. L. (2023). Foreign direct investment and industrialization in Tanzania admixture time series forecast analysis 1960 - 2020. *Applied Economics Letters*, 1–8. https://doi.org/10.1080/13504851.2023.2211324

Mehta, L. (2014). The politics of scarcity: Conceptualizing the multiple dimensions of water scarcity. Routledge. https://doi.org/10.4324/9780203099667

Javanmardi, S., Madani, K., & Srinivasan, R. (2020). Limitations and weaknesses of grey system theory. *Complexity*, 2020, Article ID 9879874.

Jiménez, A., & Pérez-Foguet, A. (2011). The Relationship between Technology and Functionality of Rural Water Points: Evidence from Tanzania. *Water Science and Technology*, 63(5), 948-956.

Kibassa, D., Lankford, B., & Beresford, M. (2020). Assessing the Impacts of Water Allocation on Smallholder Farmers and Pastoralists in Babati District, Tanzania. *Water Alternatives*, 13(3), 618-636.

Kitole, F.A., & Genda, E.L. (2024). Empowering her drive: Unveiling the resilience and triumphs of women entrepreneurs in rural landscapes, Women's Studies International Forum, Volume 104, 2024, 102912, ISSN 0277-5395, https://doi.org/10.1016/j.wsif.2024.102912.

Kiguchi, O., Shen, Y., & Inoue, N. (2021). Water Demand Projections and Supply Vulnerability in Tanzania: The Role of Water Governance and Climate Change. *Environmental Research Letters*, 16(5), 054020.

Kitole, F.A., Mbukwa, J.N., Tibamanya, F.Y., Sesabo, J.K. (2024). Climate change, food security, and diarrhoea prevalence nexus in Tanzania. *Humanit Soc Sci Commun* **11**, 394 (2024). https://doi.org/10.1057/s41599-024-02875-z

Komives, K., et al. (2019). Tariffs, Subsidies, and the Poor: A Case Study of Water Pricing in Africa. *World Development*, 109, 249-261.

Levine, D., & Fischer, G. (2020). Financial Sustainability and Equity in Water Service Delivery: Insights from Public-Private Partnerships in Tanzania. *Journal of Water Resources Planning and Management*, 146(6), 04020032.

Kitole, F.A., Lihawa, R.M. & Nsindagi, T.E. (2023). Agriculture Productivity and Farmers' Health in Tanzania: Analysis on Maize Subsector. *Glob Soc Welf* **10**, 197–206 (2023). https://doi.org/10.1007/s40609-022-00243-w

Liu, S., & Forrest, J. (2020). *Grey Data Analysis: Methods, Models and Applications*. Springer.

Liu, S., Forrest, J., & Yang, Y. (2016). A brief introduction to grey system theory. *Grey Systems: Theory and Application*, 6(1), 1-9.

Lockwood, H., & Smits, S. (2011). Supporting Rural Water Supply: Moving towards a Service Delivery Approach. *Practical Action Publishing*.

McDonald, R. I., & Webster, K. E. (2020). The Role of Public Policy in Financing Water Services: A Critical Review. *Environmental Science & Policy*, 114, 456-468.

Mohanty, R. (2020). Cost recovery and efficiency in urban water supply systems: An empirical study from India. *Journal of Water Supply: Research and Technology-AQUA*, 69(4), 331-342.

Morid, S. (2022). Efficiency analysis in the water industry: A case study from England. *Water Policy*, 24(6), 1093-1106.

Mugumya, F., Smits, S., & Lockwood, H. (2017). Sustainable Financing of Community Water Management: Lessons from the Field. *Water International*, 42(4), 479-493.

Pories, L. (2016). A Pathway to Financing the SDGs: Improving Water and Sanitation Service Delivery through Market-Based Approaches. *Water Economics and Policy*, 2(1), 1650011.

Shrestha, A., et al. (2018). PPPs in the Water Sector: Balancing Public and Private Interests in Tanzania. *Public Management Review*, 20(3), 440-459.

Smits, S., Franceys, R., & Mekala, S. (2011). Scaling Up Service Delivery: Financing Mechanisms for Water Supply. *Journal of Water, Sanitation and Hygiene for Development*, 1(2), 91-99.

Szpak, D., Chen, J., & Wang, X. (2019). Grey system theory and its application in water resource management. *Water Resources Management*, 33(12), 3981-3992.

Thaler, T., & Levin-Keitel, M. (2016). Mainstreaming Climate Adaptation into the Water Sector: Challenges and Policy Implications in Tanzania. *Water Policy*, 18(2), 219-232.

Utouh, H. M. L., & Kitole, F. A. (2024). Forecasting effects of foreign direct investment on industrialization towards realization of the Tanzania development vision 2025. *Cogent Economics & Finance*, *12*(1). https://doi.org/10.1080/23322039.2024.2376947

van den Berg, C., & Danilenko, A. (2017). Performance of Water Utilities in Africa: Technical Efficiency and Scale Economies. *Journal of Development Studies*, 53(12), 2051-2067.

Wei, X., Shen, J., & Wu, Z. (2018). Application of grey system theory in water demand forecasting: A case study. *Journal of Water and Climate Change*, 9(4), 629-642.

Wei, X., Shen, J., & Wu, Z. (2018). Application of grey system theory in water demand forecasting: A case study. *Journal of Water and Climate Change*, 9(4), 629-642.

Wei, Y., & Yang, J. (2020). Grey system theory for analyzing and managing the uncertainties in water resource systems. *Journal of Hydrology*, 585, 124560.

Whittington, D., et al. (2012). The Challenge of Water Scarcity in Sub-Saharan Africa: A Case Study from Tanzania. *Journal of African Economies*, 21(1), 107-136.

Wu, L., & Wu, X. (2015). Grey relational analysis-based evaluation method for water supply reliability. *Water Resources Management*, 29(6), 1927-1939.

Wu, X., & Malaluan, N. A. (2008). A Tale of Two Concessions: Lessons from Public-Private Partnerships in Water Management in Metro Manila. *Utilities Policy*, 16(4), 249-258.

Yuan, Y., Chen, X., & Huang, Q. (2017). Using grey system theory for forecasting water consumption in urban areas. *Journal of Cleaner Production*, 161, 507-517.