# Examine the Prospects of Residential Water Demand Management Policy Regulations in Ethiopia: Implications for Sustainable Water Resource Management

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*Article*

# Examining the Prospects of Residential Water Demand Management Policy Regulations in Ethiopia: Implications for Sustainable Water Resource Management

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**Abstract:** This study examines the prospects of residential water demand management policy regulations in Ethiopia and their implications for sustainable water resource management. This study aims to evaluate the existing policy regulations and analyze their effectiveness in promoting efficient water use and conservation practices in residential areas. By considering the potential challenges and opportunities associated with these regulations, the research provides insights into the future of residential water demand management in Ethiopia and suggests strategies for enhancing sustainable water resource management. Integrated literature and policy document review, alongside observation and interviews, was used to assess the viability of residential water demand management policies. The assessment of current policy regulations for residential water demand management in Ethiopian urban towns has revealed significant shortcomings in promoting water conservation activities. Hence, there is a need for significant improvements in the current water resource policy guidelines, which lack specificity, particularly in residential water demand management conservation strategies. The lack of awareness among residents regarding the importance of conserving their limited water resources is evident. To address these challenges and ensure the sustainability of the water supply, the government and policy developers must engage with various stakeholders, including the community, in the process of revising current policy documents. A more precise and tailored approach is necessary for its effective implementation.

**Keywords:** policy regulations; water conservation; water demand management; Ethiopia

## 1. Introduction

The global supply of drinking water is facing challenges owing to various factors, such as climate change [1] and improper utilization of limited resources [2]. Developing countries in particular lack resource management practices, and have only recently began taking action to conserve their resources. Water conservation is one of the most critical resource management practices. Securing a reliable drinking water supply is crucial, as water is essential for human existence. Water managers are striving to ensure the sustainability of drinking water resources into the future. However, achieving sustainability should not rely solely on the efforts of water resource managers or municipalities; consumers and communities must also understand the consequences and actively participate in water resource management.

Developed countries have implemented diverse management strategies to reduce water consumption and maintain available resources [3,4]. Policy frameworks and regulations play significant roles in facilitating management practices [5,6]. Furthermore, they play a vital role in promoting sustainable and efficient utilization of water resources, even in the residential areas of developing countries [7]. Implementing restrictions and regulations on the use of residential water supplies is an urgent issue for every developing country, and especially pressing in countries such as Ethiopia [8,9].

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Several studies have highlighted the experiences and outcomes of residential water management and management policies in both developing and developed countries. For example, a study conducted by Stavenhagen et al. [10] in four European cities (Berlin, Copenhagen, Tallin, and Zaragoza) assessed the effectiveness of policies in reducing residential water demand. This study found that policies such as proper maintenance of water networks, promotion of water-saving technologies, rapid leak detection, public awareness campaigns, and municipal regulations, all contributed to a decrease in per capita water consumption between 1995 and 2015. Similarly, studies conducted in developing countries have highlighted the significance of various water demand management strategies for reducing water consumption. In India, the introduction of water pricing reforms and community-based water management approaches has had positive impacts on water conservation and management [11]. Likewise, South Africa's implementation of water restrictions, public awareness campaigns, and efficient irrigation systems has resulted in significant water savings and behavioral changes [12]. Mexico's adoption of water-saving technologies, including low-flow fixtures and rainwater harvesting systems, has contributed to improved water-use efficiency and reduced water demand [13]. The comprehensive studies mentioned above highlight the potential benefits of implementing effective residential water demand management policies and showcase various successful approaches used in different countries. However, the absence of similar or related approaches in Ethiopia poses a challenge to the sustainability of residential water resources. These examples demonstrate the potential benefits of implementing effective residential water demand management policies, as well as the variety of successful approaches used in different countries. Such insights can inform policy-makers and stakeholders in Ethiopian urban areas to develop and implement strategies tailored to their specific contexts, thereby fostering sustainable water management and conservation practices. Unfortunately, there is currently a lack of literature on residential water demand policy regulations specifically conducted in Ethiopia. However, this does not imply that no activities or efforts are being made in Ethiopia to manage residential water resources; rather that the existing programs necessitate further analysis and assessment.

Early water conservation policy measures focused on raising awareness and changing behavior through public education campaigns, and the promotion of individual responsibility [14,15]. These efforts aimed to instill a sense of consciousness among the residents regarding the importance of water conservation and the need to adopt water-saving practices in their daily lives. As scientific understanding of water management has evolved, policy measures have become more comprehensive and targeted. An analysis of the causes of water scarcity and shortages in residential drinking water supply across the three study areas (Arba Minch, Debre Birhan, and Ziway) revealed a notable gap on the government side, indicating a lack of an appropriate system for water demand management [15]. Governments have begun implementing regulations and standards to enforce water-efficient fixtures and appliances in new constructions [16,17]. This includes the requirement for low-flow toilets, water-efficient showerheads, and faucets to be installed, thus reducing water consumption per capita.

Bernedo et al. [18] delved into the effectiveness of social comparisons through a randomized control trial in collaboration with a water utility system in metropolitan Atlanta. Their investigation focused on the enduring impact of a singular behavioral nudge designed to encourage voluntary reductions in water use during a drought. The analysis indicated that the intervention's success came through both immediate adjustments in behavior and sustained modifications to habits over the long term. These findings hold promise for policymakers, suggesting the potentially crucial role of behavioral nudges in shaping environmental policy. Notably, they underscored the cost-effectiveness of such interventions as a means of reducing residential water consumption levels.

In some cases, water-pricing mechanisms have been introduced to incentivize responsible water use [10]. These mechanisms involve the implementation of tiered pricing structures, in which the cost of water increases with higher consumption levels. Their aim is to encourage individuals to be mindful of their water use and adopt water-saving behaviors to avoid higher costs [19,20]. Relatedly, water utilities and municipalities have begun implementing water metering systems that monitor

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and manage residential water usage. These have allowed for a better understanding of consumption patterns, identification of leaks, and implementation of targeted interventions to reduce waste [21,22].

The water resources management policy in Ethiopia was introduced in 1999 by the Ministry of Water Resources, delineating water tariffs for both urban and rural areas. Rural tariffs aim to recover Operation and Maintenance (O and M) costs, whereas urban tariffs aim to recoup total costs, encompassing O and M and additional expenses. Urban tariffs employ an increasing block tariff system for customer water bills, with the mean average price reaching 6.5 Ethiopian birr per cubic meter in 2022 (equivalent to 0.12 USD October 2023 rate) [23]. However, financial self-sustainability remains a challenge for utilities as tariffs fall short of covering full supply costs [15]. The national water resource policy aims to achieve full cost recovery for urban systems, but progress toward this goal has been limited, influenced by factors such as the majority of Ethiopia's population living on less than $3.20 per day. Families often choose self-financed water solutions due to economic constraints, despite the policy's ambitious objectives. Many water supply services in Ethiopia operate with low and varying tariff structures, hindering cost coverage, leading to operational inefficiencies, and restricting investments in system expansion and maintenance [23].

The history of policy measurements as a tool for residential water demand management has progressed from awareness campaigns to comprehensive regulatory frameworks and technological advancements [10,24]. These measures aim to encourage water conservation, promote efficient water use, and ensure the long-term sustainability of water resources. Globally, Water Demand Management (WDM) policies vary widely and reflect geographical, economic, and cultural differences: in the United States, a decentralized model is guided by legislation such as the Clean Water Act, Australia prioritizes local autonomy through its national water initiative, China emphasizes economic incentives and technology for efficient water use, and the European Union focuses on cross-border cooperation [30]. In Ethiopia, policies, influenced by the Water Sector Development Program and Integrated Water Resource Management (IWRM) principles since the early 2000s, concentrate on rural water supply, irrigation, and environmental sustainability. This aligns with global trends, showcasing Ethiopia's adaptation of policies to its agricultural landscape and development priorities and providing valuable insights into its evolving water demand management strategies on the global stage [30].

This research primarily focuses on evaluating current policy regulations concerning residential water demand management in Ethiopian urban areas. It aims to enhance these regulations, particularly from the user's perspective, by drawing on experiences and best practices from other countries. This study examines the historical development of water demand management policies in Ethiopia and highlights the challenges and barriers that have hindered their successful implementation. Through an assessment of prospects and effectiveness, this study identifies implications for sustainable water resource management. Furthermore, utilizing data gathered from three urban areas within the country, this study prioritizes specific short-term and long-term solutions that need to be addressed. The examination of climate parameters further emphasized that the challenges extend beyond supply-side issues, with insufficient attention given to demand-side challenges in addressing the growing demands effectively [25]. Limited awareness among residents regarding the management of their water supply was also identified. In light of these findings, the authors recommend the formulation of a comprehensive government framework, including policy regulations, to establish sustainable water demand management [15]. The discussion in this paper highlights a unique aspect of water demand management, as it addresses on questions which have not been given thorough attention in previous studies: How does the present state of drinking water management policy guidelines in Ethiopia appear? Are existing policy guidelines actively promoting sustainability in water resource management, particularly in the provision of drinking water services? What are the implications for the current and future state of drinking water resources in the country?

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## 2. Study Area Description

The study encompasses three distinct urban towns in Ethiopia, each characterized by unique geographical and climatic features: Arba Minch, Ziway, and Debre Birhan. Arba Minch, located at an altitude of 1,300 meters, stands 500 km south of the capital city Addis Ababa, and has a population of 200,500. Despite its classification as a hotter climate area, Arba Minch is surrounded by the vast natural lakes of Abaya and Chamo. It is therefore also designated as a region with substantial groundwater potential. Ziway, positioned at an altitude of 1,600 meters, is situated 163 km southeast of Addis Ababa, and has a population of 100,000. Ziway experiences mean annual temperature of 20 °C, with an annual rainfall ranging between 700 and 800 mm. The third site, Debre Birhan, is nestled at an altitude of 2,800 m, lies 120 km northeast of Addis Ababa and has a population of 150,000. Recognized as one of Ethiopia's coldest towns, Debre Birhan maintains a mean annual temperature of 15°C, and receives a considerable mean annual rainfall of 1,219.2 mm. Each case study area is characterized by a unique set of environmental conditions that significantly influence water management dynamics, and the overall scope of the research. Detailed background data about the three sites' social demographics, environmental conditions, water sources, water provision structure, and water infrastructure status was described in detail in Timotewos et al. [15].

## 3. Data and Methodology

### *3.1. Data*

This study serves as a continuation of two previous articles [15,25], conducted as part of the first author's PhD research. The findings and insights gained from these articles are integral to the current study. According to Timotewos et, al. [25], the motivation for the study stems from the need to understand the factors contributing to the scarcity of water and the challenges faced by residents in urban areas of Ethiopia in accessing drinking water supply services. This understanding ensures better governance and helps to safeguard the long-term sustainability and access of Ethiopian people to drinkable water.

This study focuses on the water demand management policy status of the current Ethiopian government. Building on previous studies [15,25] and addressing the gaps identified, the research aims to provide comprehensive insights into the issues surrounding water scarcity and demand management in Ethiopian urban areas. The ultimate goal is to propose practical guidelines, solutions, and strategies that can be implemented by residents, water managers, and municipalities to ensure more efficient and sustainable use of water resources.

Data used for this study includes both qualitative and quantitative secondary data. A variety of documents were reviewed to extract the information needed for the study, including records of environmental conditions and usage data. Information gathered from the interviewed water managers of the three case study towns of the country was also used enhance the analysis. Prior to beginning the project and throughout the analysis, other countries' residential water demand management policy documents were reviewed to extract relevant experiences which could be used for our study area country.

### *3.2. Methodology*

Both quantitative and qualitative data analysis were used to achieve the objective of the study. Documents were reviewed to contextualize and attempt to predict the future residential drinking water management of developing countries that were relevant to Ethiopia. The study therefore also evaluated current Ethiopian policy documents, identified existing gaps, and proposed necessary inclusions and improvements by comparing them with policies from other countries. The study also relies on data elicited by conducting interviews with water managers and municipal officials in three chosen urban towns in Ethiopia. Through these interviews, the research gathered valuable insights into the current activities related to drinking water management and identified specific areas that would benefit from policy regulations to enhance the long-term sustainability of water resources.

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The study mainly focuses on: 1. Evaluating the current policy documents around residential water demand management in Ethiopia; 2. Reviewing other countries' water demand management policies in order to form initial guidance for Ethiopia; 3. Describing areas where guidelines should be included based on the challenges and barriers shared by urban water managers in Ethiopia.

The research study focused on three areas with distinct altitudes, natural landscapes, and climatic characteristics (see above). Qualitative methods were utilized, primarily involving in-depth, open-ended interviews with water office officials, and observations of the water supply system and water management situations. The fieldwork included observations of the water supply utilities in all three areas. The status of the water situation regarding the supply, distribution system, treatment mechanisms, public water points, and consumers' water tap accessibility was analyzed. Six water management experts from each urban area were interviewed, and unstructured open-ended questions were posed to two officials from each water office regarding the status of policy implementation and current water demand management activities in their respective towns. The interviews focused on topics such as water demand management regulations, national and federal government policies, implemented measures, and any applicable restriction techniques. The interviews were approximately half an hour long, with answers recorded for easy reference during data and analysis.

Additionally, various documents available at the municipal water offices, including water production records, water demand data, reports, and analyses, were reviewed by the authors. The included literature review covers a variety of developing water demand management policies and a field survey on the urban water supply situation in three Ethiopian towns. Articles published in scientific journals from 2000-2023 were reviewed, especially those concerning factors related to the sustainability of urban water supply service. Literature was identified in Google Scholar and Scopus using search terminology such as water demand management, water policy frameworks, and sustainable water management. The research articles that appeared were filtered for relevance. Thematic analysis was rigorously applied to the collected data, facilitating the extraction of meaningful patterns. The iterative nature of the analysis allowed for the refinement of themes and the identification of overarching trends. The insights gleaned from the interviews were seamlessly integrated into the literature and broader context of the study, contributing to a comprehensive understanding of water conservation practices and the current status of demand management policies in urban areas.

### *3.3. Method of Data Analysis*

The literature review and policy document analysis provided an overview of the history of policy regulations, specifically regarding drinking water, from their emergence to the present. This information is crucial for understanding the origins of drinking water policy regulations and evaluating their current effectiveness in achieving sustainable water management goals. The implications of these policies were determined through interviews and observations at the study sites. Indicators such as water conservation, efficiency, and equitable access are utilized. The status of drinking water supply services in the study areas serves as an input for analyzing the implications of policies on sustainable water resource management.

Gaps and problems in urban water resource management were identified through interviews and site observations. Shortcomings from urban municipalities were pinpointed in order to propose recommendations for achieving sustainable water resource management. The effectiveness of the policies was assessed using information gathered from interviews as well as by evaluating factors that indicate actual implementation and changes in sustainable urban drinking water management, such as resident awareness and a reduction in water consumption. A ten-year trend of water consumption data was also analyzed through regression analysis, producing an R-squared value for the study areas through which the proportion of variability in water consumption could be assessed.

Prospects and opportunities for better water management were identified by identifying gaps within the policy guidelines and stakeholder engagement in the study areas. The interview results were analyzed to understand the perspectives of water managers on water conservation practices,

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revealing the collective attitudes of residents. Furthermore, interview findings were integrated with findings from other data sources, such as literature reviews, document analysis, and observations, to provide a comprehensive understanding of the research topic. Successful strategies from other countries, both developed and developing, were assessed through a literature review, helping to provide insights into the best practices for Ethiopia. Finally, recommendations for enhancing sustainable water resource management in Ethiopia were drawn by comparing strategies from other countries and identifying problems from within the study area. Figure 1 illustrates the general description of the employed methodology and methods.

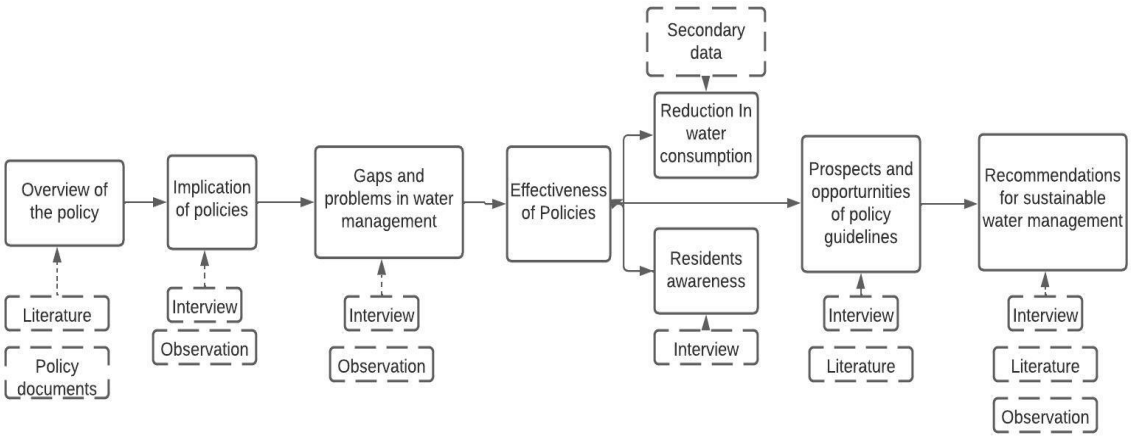


**Figure 1.** Research methodology overview and methods used.

## 4. Results and Discussion

### *4.1. Policy Framework for Residential Water Demand Management*

Overview of Existing Policy

The history of using policy measures for water resource management in Ethiopia is linked to the time when concerns over water scarcity, unsustainable water resource patterns, and the impacts of climate change first entered public discussions [26]. The first water resource management policy of Ethiopia was established in 1999 by the Ministry of Water Resources (MoWR). Under this policy, three subsectoral issues are addressed: water supply, irrigation and hydropower. This policy is considered a significant framework for guiding the management and utilization of water resources throughout the country. It was established to address the growing challenges of water scarcity, inefficient water use, and inadequate water resource management. The key objectives of the 1999 MoWR policy included promoting sustainable and equitable water resource development, improving water resource planning and management, ensuring the efficient use of water, and enhancing water conservation and environmental protection. To achieve these objectives, the policy emphasized the importance of integrated water resource management, a method which involves considering the social, economic, and environmental aspects of water management. Integrated water management encourages the active participation of stakeholders, including government agencies, local communities, and water users in decision-making processes related to water resource management.

The 1999 policy also underscored the need for effective water governance structures and institutions at both national and regional levels. It called for the establishment of regulatory frameworks, monitoring systems, and coordination mechanisms to ensure sustainable and equitable allocation and utilization of water resources. Furthermore, the policy fostered the development and implementation of water demand management strategies to optimize water use and minimize waste. This includes promoting water conservation practices, implementing efficient irrigation techniques,

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and raising awareness among water users regarding the importance of responsible water use. Overall, the 1999 Ethiopian Water Resource Management Policy serves as a comprehensive framework for guiding sustainable management and utilization of water resources in the country. It laid the foundation for effective water governance, promoted equitable access to water, and encouraged responsible water use for the benefit of present and future generations.

The Ethiopian National Water Sector Strategy, established in 2001, is a comprehensive framework that outlines the long-term vision and strategic direction for the development, management, and utilization of water resources in Ethiopia. This strategy was developed to address the country's water challenges including water scarcity, inadequate water infrastructure, and inefficient water management practices. It was an instrument for translating the Ethiopian water resource management policy established in 1999 into action. In other words, it was a roadmap for attaining the water policy objectives. Two major pillars of this strategy were increasing the water supply coverage and improving sanitation services. The 2001 strategy set targets for expanding access to safe drinking water sources and adequate sanitation facilities, particularly in rural and underserved areas. Realizing these improvements involved the advancement of water supply schemes, construction of water infrastructure, and promotion of hygiene and sanitation practices. The strategy also focused on the development and management of water resources. This emphasized the importance of efficient water use and conservation practices, as well as the protection and rehabilitation of watersheds and water catchment areas. As part of this practice, Ethiopia adopted more appropriate water management technologies such as irrigation systems to support agricultural productivity and food security.

Different policy measures have emerged for general water resource management activities; the guidelines around residential drinking water resource management are one prominent example. However, there are no specific regulations or restrictions on urban drinking-water demand management. Some of the proclamations that first emerged were the Water Resource Management Policy (Proclamation No. 114/1999), which emphasized the need for sustainable water resource management, including urban water demand management. This policy provided a framework for integrated water resource planning, development, and conservation with the aim of ensuring equitable and efficient utilization of water resources in urban areas. The urban Water Supply and Sewerage Service Proclamation (Proclamation No. 124/1999) also established a legal framework for urban water supply and sewerage services in Ethiopia. This proclamation included provisions for managing water demand, promoting water conservation practices, and ensuring efficient water use in urban areas. Later, national water policy emerged in 2012 via the National Water Policy, a document which set out the guiding principles and strategies for water resource management and highlighted the importance of demand management as a key component of sustainable water use. The 2012 policy particularly emphasized the need for public awareness, pricing mechanisms, and water-saving technologies. In this same area of concern, a report on second national wash inventory and management information systems outlined the goals and objectives for improving water supply and sanitation services in the urban areas of Ethiopia, including targets for reducing water losses, promoting water-saving practices, and implementing demand management programs [27].

Implication of the Policies

The implications of the current Ethiopian water resource policies on sustainable water resource management were determined from the three study areas, with a particular focus on aspects such as water conservation, efficiency, and equitable access. The efficiency of current water management policies in Ethiopia varies across different aspects, particularly in terms of urban drinking water management. Although efforts have been made to improve water resource management, challenges and inefficiencies persist. One major concern is water loss and leakage within the distribution system resulting from aging infrastructure, inadequate maintenance, and technical difficulties. For instance, Arba Minch faces significant challenges related to old infrastructure and leakage problems in its distribution systems. Ten years of data (2010-2020) obtained from the water utility indicates that, on average, 21% of water is lost within the distribution system due to leakage and water theft.

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Addressing these infrastructure and leakage issues is crucial for minimizing water loss and improving the overall efficiency of the water supply in the Arba Minch. These losses not only affect water availability but also lead to financial losses for utility service providers [28]. Unequal access to water services is another issue, with certain neighborhoods experiencing intermittent supply or inadequate pressure. This contributes to water scarcity and inconvenience for the residents. Addressing these challenges requires comprehensive approaches such as infrastructure development, leak detection systems, and equitable water distribution.

Additionally, an analysis of the policies highlights the significant need to strengthening institutions, enhancing capacities, and establishing effective governance structures in the water sector. Ziway and Debre Birhan faced particular challenges in their water demand management efforts in these areas. Frequent changes in leadership and water tariff recording application software created obstacles in ensuring proper data collection and monitoring systems, which are essential for evidence-based decision-making. A lack of consistent data can impede the ability to assess the effectiveness of policies and thus hinder effective water demand management practices [29]. Furthermore, fragmented institutional structures in these areas may contribute to inefficiencies in policy implementation and coordination, making it difficult to implement comprehensive and coherent water management strategies. Attending to these issues is crucial for establishing a stable and efficient water demand management framework in both cities. In general, changes in institutional structures and data monitoring systems have direct and indirect consequences on water resource management and water supply sustainability. These implications affect the efficiency of policy implementation, data collection, and monitoring, leading to challenges for water conservation and efficiency measures.

Based on the interview results from each of the study areas, it was found that there was limited involvement or interference from regional or zonal water offices in the formulation of policy regulations specifically related to residential water resource management. This lack of engagement from higher-level authorities results in a lack of orientation and guidance for regional water offices to effectively implement policy. Consequently, there is a general lack of awareness regarding water demand management at the regional level. The policy itself outlines the importance of community and stakeholder involvement at every stage of formulation and implementation. However, there is a gap in the effective translation of policy into actionable plans and strategies at the community level. To address this, it is essential to provide comprehensive training to town water offices, specifically focusing on residential water demand management and strategies. This would enable the offices to more effectively educate and engage the local community in water demand management.

The Ethiopian National Water Sector Strategy emphasizes the importance of developing policies, regulations, and monitoring mechanisms to ensure sustainable water resource management and equitable water distribution. By serving as a comprehensive framework, the strategy guides sustainable development and management of water resources across the country. It creates a roadmap for enhancing water supply and sanitation services, advancing water resource management practices, and addressing the water requirements of Ethiopian citizens. Ultimately, the strategy contributes to socio-economic development and environmental sustainability, aligning with broader national goals and aspirations.

### *4.2. Assessment of Policy Effectiveness*

#### Evaluation of Implementation

Effectiveness and evaluation of the implementation of Ethiopian water policy management are crucial aspects for ensuring the successful achievement of policy objectives and sustainable water resource management. Evaluating the extent to which policy regulations have been implemented in major urban residential areas involves considering factors such as compliance, enforcement, and awareness [30]. This indicator evaluates the degree of compliance with the policy regulations of water users and the effectiveness of enforcement mechanisms. It assesses the penalties for noncompliance and whether the policy has been successful in ensuring adherence to water conservation measures.

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Policy effectiveness refers to the degree to which a policy's intended outcomes are achieved. In the context of Ethiopian water policy management, it involves assessing whether policy regulations effectively address the challenges and goals outlined in policy documents. This assessment involves analyzing the impact of the policy on water resource management, water supply, and water use practices in residential areas. The assessment of the three urban areas in this paper clearly indicates that there is a lack of effective policy implementation. According to urban water workers, this is primarily due to the absence of clear guidelines for policy implementation and the broad scope of the policy, which encompasses sectors not under their utility responsibility. Without a well-defined policy, it is challenging to evaluate its effectiveness. Furthermore, there appears to be a gap between the federal water office and the towns, with some industries, particularly floriculture industries (in Ziway) obtaining their water supply permission directly from the federal and regional governments rather than the towns. As a result, these private industries have their own water supply sources, such as groundwater, and are not subject to the control of the town water supply sewage authority for groundwater discharge. This lack of control poses additional challenges for effective water demand management for the town. The overexploitation of groundwater can deplete aquifers, reducing available water reserves for urban consumption and leading to water scarcity and increased competition for water resources [31].

The evaluation of policy implementation examines how well policy regulations have been put into practice. This involves assessing the level of compliance with the regulations by different stakeholders, including water users, water managers, and relevant institutions. The evaluation considers factors such as the availability and adequacy of resources for policy implementation, effectiveness of monitoring and enforcement mechanisms, and level of coordination and collaboration among stakeholders. During our assessment of the three study areas, we discovered a significant gap in the monitoring and evaluation of water resource policy implementation. Dedicated committees or sectors responsible for overseeing the effective execution of water management policies are lacking.

Another important aspect of evaluating policy implementation is assessing the level of awareness among the target population regarding policy regulations [32]. This involves examining whether residents in residential areas are informed about policy requirements, understand the importance of sustainable water management, and actively participate in water conservation practices. In the case studies evaluated, specific regulations related to water conservation and demand management have not been effectively put forth at the community level. As a result, there was a general lack of awareness among residents regarding responsible water usage practices. This gap in awareness poses challenges to achieving sustainable water resource management in these urban areas.

According to information obtained from Arba Minch and Debre Birhan, people react carelessly when reporting broken main pipes, resulting in delayed maintenance and significant water loss. This behavior suggests a limited understanding and knowledge among the community regarding effective water resource management. Such a lack of awareness and failure to enact a proactive response to water infrastructure issues can hinder efforts to conserve and manage water resources efficiently. Addressing this issue through awareness campaigns and educational initiatives could play a crucial role in promoting responsible water usage and reducing unnecessary water wastage. Awareness campaigns, education programs, and community engagement initiatives play crucial roles in enhancing awareness and promoting behavioral change [33]. Despite these challenges, it is crucial for the government to prioritize awareness campaigns targeting residents and promoting water conservation measures. Recognizing that changing people's behavior takes time, focusing on younger generations becomes an important step towards achieving long-term results.

After evaluating the effectiveness and implementation of Ethiopia's urban water demand management policy through interviews, observations, and monitoring of performance indicators, it is evident that significant improvements are needed. The findings indicate a lack of awareness among urban water authorities regarding policy formulation, who thus do not prioritize compliance with policy regulations. The primary focus of these authorities is on providing clean water to residents,

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while obstacles, such as inadequate infrastructure, limited water resources, and distribution system leakages, contribute to the non-supply of water. These challenges hinder the successful implementation of the policy, emphasizing the need for further action. Other challenges towards implementing effective water demand policies are a limited institutional capacity and amount of resources to develop and implement proposed strategies. Insufficient resources include a lack of trained personnel, missing technical expertise, and a dearth of financial resources. In some cases, insufficient data and information directly impact policy implementation.

Effective water demand management requires accurate and updated data on water resources, consumption patterns, and population dynamics. Nevertheless, the presence of data recording issues in the three urban areas and frequent changes in software for tariff calculations present considerable challenges to data collection, monitoring, and analysis. These obstacles impede the acquisition of accurate and reliable data, thereby impacting evidence-based decision-making and policy development in water demand management. Without a robust and consistent data collection system, it becomes difficult to assess consumption patterns, identify trends, and make informed decisions regarding resource allocation and policy adjustments. Addressing these challenges requires addressing the underlying issues with data recording processes, and therefore ensuring the stability and reliability of software systems used for tariff calculations. By improving data collection and analysis mechanisms, policymakers will have access to reliable information that can facilitate better decision-making and policy formulation in water demand management.

Overall, evaluating the effectiveness and implementation of Ethiopian water policy management in residential areas is essential for ensuring sustainable water resource management. Evaluation provides valuable information on the achievements, challenges, and opportunities in implementing the policy regulations, and ultimately guides the development of strategies and interventions to enhance water management practices, promoting the efficient and equitable use of water resources.

### Impact on Water Consumption

Understanding the impact of water policy management in Ethiopia on water consumption is crucial aspect for assessing the effectiveness of policy regulations and their role in promoting sustainable water use practices. Analyzing the impact involves also evaluating how well the policy regulations have been able to reduce water consumption, promote conservation behaviors, and address water scarcity challenges.

Water policy management in Ethiopia aims to address the growing demand for water resources and mitigate the effects of water scarcity [34]. One key indicator of policy effectiveness is the reduction in water consumption. This can be measured by assessing changes in water use patterns over time and comparing them to baseline levels. Policy regulations may include measures such as the implementation of water metering systems, the promotion of water-saving technologies, and the establishment of pricing mechanisms that incentivize water conservation. Analyzing the impact of these measures can provide insights into their effectiveness in curbing excessive water consumption. For example, Figure 2 illustrates the water consumption trends over the past ten years in the three analyzed areas. This trend indicates a notable increase in water consumption for Arba Minch and Debre Birhan, while Ziway town experienced a relatively modest rise in water consumption. Through a regression analysis, the trends of water consumption in the three study areas over the ten year period produced an R-squared value of 0.92, 0.97, and 0.72 for Arba Minch, Debre Birhan, and Ziway respectively. This R-squared value indicates the proportion of the variability in water consumption that is explained by the regression model. In this case, an R-squared value of 0.97 suggests that approximately 97% of the variability in water consumption in Debre Birhan can be attributed to the factors considered in the regression model. A higher R-squared value signifies a stronger relationship between the independent variables (time) and the water consumption trends, providing confidence in the model's ability to capture and explain the observed patterns. It's important to note that while the R-squared value is a useful measure of goodness of fit, it does not imply causation, and other unaccounted factors may contribute to the remaining variability in water consumption.

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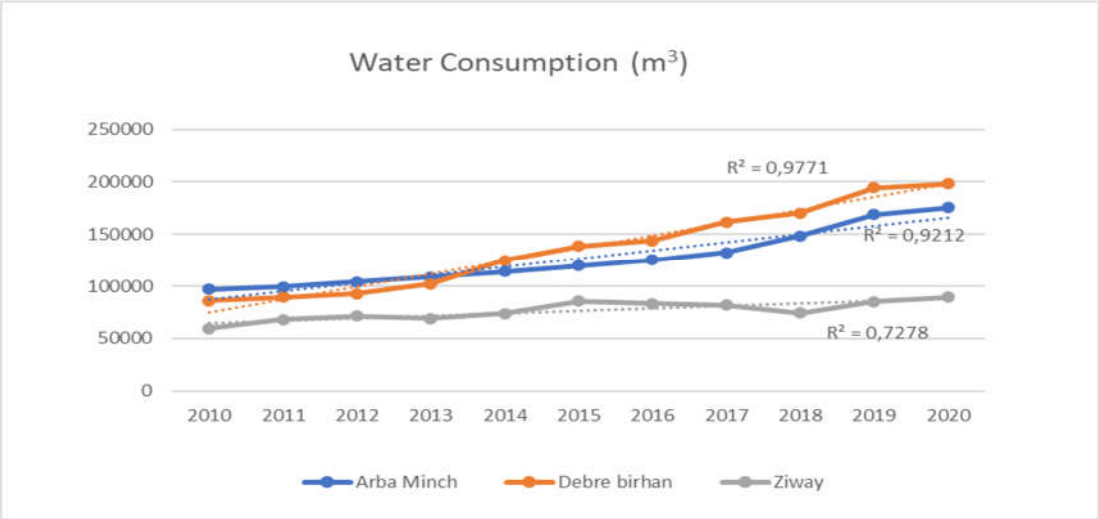


**Figure 2.** Water consumption pattern data.

The effectiveness of policy regulations can be evaluated by assessing their impact on promoting conservation behaviors among water users. This study examines whether these regulations have successfully raised awareness about water scarcity challenges and encouraged individuals, households, and businesses to adopt water-saving practices. Examples of such water-saving practices include repairing water leaks, implementing efficient irrigation techniques, and utilizing rainwater harvesting systems. Evaluating the adoption and effectiveness of these behaviors provides insights into the success of policy regulations in fostering a water conservation culture. The current water demand management policy regulations in Ethiopia lack clear and specific provisions regarding the importance of raising awareness about water conservation techniques and sustainable use of water supply resources among residents. This absence should be addressed thorough policy revision that can encompass these crucial aspects. Including provisions that promote community awareness and education on water conservation into an updated policy would be instrumental to fostering a culture of responsible water use among residents. By addressing this deficiency, the revised policy would be more effective in achieving sustainable water resource management and ensuring a more resilient water supply system for future generations.

Addressing water scarcity is another key aspect of improving policy effectiveness. This involves evaluating whether policy regulations have been successful in improving water availability and reducing water stress in areas facing scarcity. Ziway and Arba Minch, which are vulnerable to droughts, require focused attention and specific water use policies to address their complex water challenges. These regions face the risk of water scarcity, making targeted regulations for effective water management more crucial. By tailoring policies to suit the needs of these drought-prone areas, a sustainable and equitable water supply can be ensured. A more constructive policy would include measures such as the development of new water sources, implementation of water reuse and recycling systems, and protection and conservation of water catchment areas. Assessing the impact of such measures on water availability and the overall management of water resources will determine the effectiveness of policy in addressing water scarcity challenges. Special attention must be given to this assessment in order to ensure sustainable water supply service in urban areas. By incorporating targeted measures and strategies into the policy framework, such as promoting water conservation practices, implementing efficient water use technologies, and encouraging rainwater harvesting, the challenges posed by water scarcity in these regions can be effectively addressed. Including these specific points in the water policy regulations will play a vital role in safeguarding the water resources and enhancing the resilience of Ziway and Arba Minch to drought conditions.

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*4.3. Prospects and Opportunities*

Identification of Gaps

Ethiopia's existing water resource management policy provides a general framework for managing all water resources. However, it lacks a specific focus and description when it comes to urban residential drinking water demand management. There is a need for more targeted and detailed guidelines that can address the unique challenges and requirements of managing water demand in urban areas. In addition to the lack of descriptive clarity, national water authorities lack sufficient clarification and guidance on how to implement the policy effectively. There is a dearth of specific tasks and responsibilities assigned to local authorities, which hinders their ability to perform their roles effectively.

Given the current expansion of urban areas, it is crucial to incorporate specific regulations into water management policies. The increasing number of residential multistory buildings in urban cities highlights a growing demand for water within these structures. These buildings are characteristic of the unique demands and challenges associated with urban developments, and policy guidelines which address their operation are crucial for sustainable water management [35]. As one part of policy, water-saving fixtures should be explicitly mandated in the regulations governing building constructions. By stipulating the use of water-efficient appliances such as low-flow toilets, water-saving showerheads, and faucets, we can effectively reduce water consumption in urban areas [36]. By introducing specific regulations and guidelines tailored to urban residential water demand management, policymakers can ensure that policy implementation is more effective and responsive to the evolving needs of urban areas. This would facilitate sustainable water management practices and support the growing water requirements of the population in urban setting.

Several key themes emerged in the examination of water managers' perspectives on water conservation practices in urban areas. Nearly all interviewed water officials underscored a heightened awareness of the significance of water conservation, emphasizing individual responsibility and behavioral changes. Some respondents highlighted the pivotal role of community engagement and education in cultivating a water conservation culture. Attitudes towards government-led initiatives displayed variance, ranging from strong support to uncertainty about their effectiveness. The interview findings uncovered the nuanced landscape of water conservation attitudes in urban settings, revealing a dynamic interplay between individual behaviors, technological considerations, and perceptions of collective responsibility in shaping water demand management policy regulations.

Urban water supply coverage and demand management policy regulations are closely related to efficient and sustainable water management. Water supply coverage refers to the percentage of the urban population that has access to safe and reliable water supply services. It is an indicator of the availability and accessibility of water resources to urban residents. Relatedly, water demand management policy regulations aim to regulate and optimize water usage patterns, ensuring that water resources are used efficiently and sustainably. Effective water demand management policy regulations play a vital role in achieving and maintaining adequate urban water supply coverage. By implementing policies that promote water conservation, efficient water use, and responsible water management practices, it is possible to reduce wastage and meet the water demands of the growing urban population. According to a recent report on the second national Water, Sanitation and Hygiene (WASH )inventory and management information system, water supply coverage in Ethiopian urban towns varies significantly across different locations. For instance, the survey showed that Arba Minch has a water supply coverage of 49%, indicating that less than half of the population has access to adequate water supply services. Ziway has an even lower coverage rate of 29%, suggesting that the majority of the population in this town lacks access to reliable water supply. In contrast, Debre Birhan shows a relatively higher water supply coverage of 75%. A much larger proportion of the population in Debre Birhan has access to adequate water supply services compared to that of Arba Minch and Ziway [27].

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The disparity in water supply coverage among the study towns reaffirms the need for targeted interventions and strategies to improve access, particularly in areas with low coverage. It also emphasizes the importance of effective water demand management policy regulations in order to ensure efficient and sustainable use of water resources, regardless of the level of coverage. By addressing the challenges in establishing water supply coverage and implementing comprehensive demand management policies, Ethiopian urban towns can work towards increasing coverage and simultaneously ensuring equitable access to safe and reliable water supply services for all residents.

One of the key shortcomings in the development of Ethiopian water resource management policy regulations is their predominant focus on other sectors, such as river basin management, irrigation, water borders, and watershed management. Although the decentralization of water resource management to the national level is a positive step to streamline responsibilities and enhance responsiveness, specific activities related to drinking water resource management are lacking. The scarcity of drinking water has become a pressing issue in urban areas owing to rapid population growth and subsequent high demand. However, policy regulations do not advance water conservation programs or encourage users to reduce their water consumption in urban areas. Further challenging, water utility officials responsible for these activities have a limited awareness of residents' participation in water conservation programs. Despite these issues, and challenges related to shortages of materials and maintenance infrastructures, they are making efforts to minimize leakage, maintain the distribution network, and ensure equitable water distribution to consumers.

Best Practices

Regulations are a successful strategy for both developed and developing countries to ensure good residential water demand management. For example, in some German cities, washing cars at home using a hose is prohibited due to water conservation concerns. Instead, residents are encouraged to use commercial car washing facilities which recycle water more efficiently[37]. Countries like Australia, the USA, the UK, and South Africa, particularly in regions prone to drought, often impose strict watering restrictions, such as designated watering days and times, restrictions on using sprinkler systems, and limits on outdoor water use [38]. In Kenya, in areas with limited access to piped water supply, regulations govern the use of shared water sources such as community taps or water kiosks [39]. These regulations also include guidelines for fair distribution, payment systems, and hygiene standards. In certain regions of Indonesia, regulations promote rainwater harvesting as a means of reducing pressure on municipal water supply. These regulations further include incentives, guidelines for system installation, and support for community-level rainwater harvesting initiatives [40]. Given the challenges of centralized water supply systems, regulations exist to govern the drilling of boreholes for private water supplies in Nigeria. These regulations include permits, licensing, and guidelines for sustainable borehole usage [41].

The practices and regulations implemented throughout both developed and developing countries offer valuable examples for Ethiopia to enhance water resource management. Even with limited resources and technology, there are policy measures and regulations which can be applied at minimal cost to effectively conserve scarce water resources. Limiting water usage by private companies and regulating bottled water manufacturing can help to reduce unnecessary water consumption and ensure more sustainable water use. In addition, promoting rainwater harvesting is a proactive approach that can significantly promote overall water conservation. By encouraging communities to adopt rainwater harvesting systems, Ethiopia can tap into an alternative water source and alleviate the pressure on existing supply systems.

In a joint press statement released March 2023, the governments of Ethiopia and the Netherlands, along with a number of strategic partners, endorsed the launch of an innovative Water Management initiative by Nedamco Africa. This digital approach has the potential to significantly enhance water quality, ensure direct access, and increase water availability for approximately 10 million residents of Addis Ababa. The Ethiopian SDG6 Water Management initiative, also supported by these partners, aims to improve water services through digitally verifiable outcomes such as reducing non-revenue water, enhancing water quality, increasing access, and ensuring availability.

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Using cutting-edge technologies such as Digital Twins (virtual model of a physical object), this initiative will measure, report, and verify outcomes, starting in a subset of Addis Ababa, setting a precedent for digital and transparent water management. These programs are indicative of the Ethiopian government's commitment to addressing challenges such as non-revenue water and residential water demand management [42].

In addition to technological innovations, raising awareness and building capacity within the community are essential for successful water demand management. Public education campaigns and community engagement initiatives can empower residents to make conscious choices regarding their water usage, fostering a water-conscious mindset. By incorporating such practices and regulations, Ethiopia can take significant strides towards achieving sustainable water resource management and ensure a more secure water future for its urban areas.

Stakeholder Engagement

Effective stakeholder engagement is vital for improving water supply services in any region [43]. However, it is essential to establish a robust monitoring system to fully ensure the accountability and performance of these stakeholders. Collaboration among various entities, including government agencies, non-governmental organizations (NGOs), development partners, and local communities, is instrumental for improving drinking water demand management. The authors emphasize the pivotal role of the community as the most influential stakeholder in driving significant changes in Ethiopian urban towns. Stakeholder engagement, particularly with reputable NGOs such as World Vision, WaterAid, and Water.org, has immense importance in shaping water demand management policies and water supply services in urban areas such as Arba Minch, Debre Birhan, and Ziway. These NGOs bring valuable expertise and resources to address the challenges of water scarcity and ensure efficient water use. By collaborating with local communities, government bodies, and the private sector, they have created a collective effort to promote water conservation and sustainable practices. Through community-based initiatives and education campaigns, NGOs empower residents to play an active role in managing their water resources. Their data-driven approaches and expertise contribute to evidence-based policy formulation and effective implementation. By bridging the gaps between different stakeholders, including vulnerable communities, these NGOs pave the way for equitable access to clean water, improved water supply services, and a more resilient urban water management system in Ethiopia.

### *4.4. Strategies for Enhancing Sustainable Water Resource Management*

Policy Recommendations

Effective policy regulations and follow-up mechanisms are crucial for the success of developmental endeavors, including urban water demand management [44]. Therefore, it is essential to implement stringent regulations aimed at reducing water consumption and promoting water conservation strategies. In developing countries such as Ethiopia, a significant challenge lies in the limited awareness among residents regarding resource management, particularly when it comes to drinking water. Therefore, it is imperative to formulate policy guidelines that provide detailed descriptions of and incentives to encourage responsible water usage. Despite the current challenges related to financial and infrastructural limitations, initiating action from the residents is essential for effective water resource management. Although addressing these challenges may require time and resources, taking proactive steps at the community level can yield significant benefits in conserving water and ensuring sustainability. These policies should emphasize the importance of water conservation and educate users on effective ways of managing this scarce resource. Water policy guidelines must highlight the significance of water demand management, specifically focusing on residential water resources. The essential policy implications required to promote responsible water use and sustainable water management practices should be emphasized. By implementing comprehensive policy measures, including awareness campaigns and incentives, it is possible to effectively manage and optimize the residential water demand in urban areas.

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It is widely recognized that changing human behavior requires time and effort, and the same applies to educating residents about water conservation and efficient water use. Some developed countries have adopted a proactive approach by incorporating water conservation mechanisms into the education curriculum, starting from the lower grades [45]. This ensures that the younger generation grows with strong awareness of the importance of water conservation. Implementing incentives for residents who actively participate in water conservation activities can be an effective policy regulation. Clearly stating these incentives and promoting them to all residents helps raise awareness of the significance of water conservation. Furthermore, capacity-building initiatives are crucial for enhancing the residents' understanding of the importance of sustainable water demand management. By implementing these strategies, Ethiopia can make significant efforts to promote water conservation and achieve sustainable water resource management.

In conclusion, it is essential to empower regional water offices and establish a well-defined strategic structure that eliminates overlapping duties and responsibilities, particularly during policy implementation. This structured approach will enable effective monitoring of the actions required and ensure a continuous evaluation of the policy's progress. Additionally, it is important to extend the implementation of leak detection mechanisms, utilizing technological instruments, to lower urban towns, such as Arba Minch, Debre Birhan, and Ziway. Addressing the issue of water resource loss owing to distribution system leakage is crucial for efficient water management. By taking these measures, there will be enhanced policy implementation, effective monitoring and evaluation, and a reduction in water loss, ultimately improving water resource management in these urban areas. Figure 3 illustrates the water demand management framework aimed at achieving sustainable water resource management in these urban areas.

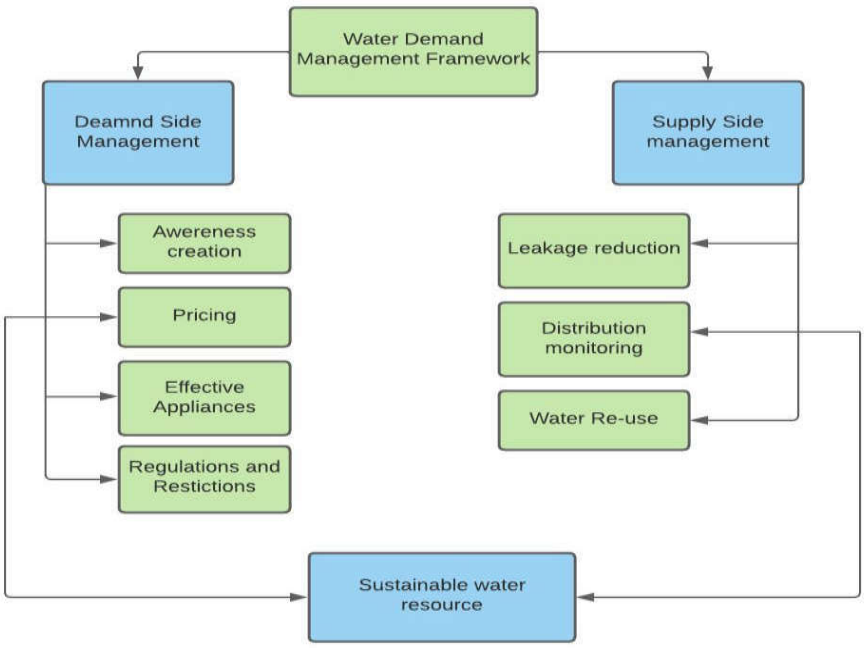


**Figure 3.** Sustainable water demand management framework.

Community Engagement

Community engagement plays a vital role in fostering a sense of ownership and raising awareness of water resources [46]. When communities are actively involved, they become more inclined to effectively protect and manage scarce water resources. Implementing regulations and policies that promote the conservation of drinking water resources empowers communities to take charge of water management. One effective approach to mobilize community members and establish monitoring groups responsible for overseeing water usage and promoting responsible consumption practices. By actively involving the community in policy formulation and collaborating closely with

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government water utilities, a sense of shared responsibility and effective resource management can be achieved. This collaborative approach ensures that the community's needs and perspectives are considered, leading to more sustainable and efficient water demand management practices.

Integration with Water Resource Planning

Water sectors worldwide have recognized the need for new approaches to address the growing water crisis. Thus, an integrated water resources management (IWRM) approach has emerged as a comprehensive framework for managing water resources and services [47]. The concept of IWRM has attracted significant global interest in recent decades, as evidenced by theoretical developments and its implementation in various regions [48,49]. This approach has become increasingly important as many developing countries face challenges related to increasing water demands for various purposes (examples can be found in [48,49].

However, it is important to note that relying solely on demand management, as advocated by the IWRM approach, may not be sufficient to meet the residents' water demands. To manage water resources effectively, there is a need to integrate residential water demand management policies with broader water resource planning and management strategies. This integration requires active community engagement in which the community plays a crucial role in shaping and implementing water management plans. By involving the community in the decision-making processes and promoting active participation, a more comprehensive and sustainable approach to resource management can be achieved.

## 5. Conclusions

The interrelations of the findings from the case studies, interviews, document analysis, and literature review reveal a nuanced and comprehensive understanding of the research question. Through case studies, distinct patterns and contextual variations have emerged, providing rich insights into the specificities of individual cases. Interviews added a qualitative dimension, offering perspectives from key stakeholders and diverse lighting experiences. Document analysis contributed to depth by uncovering the historical and contextual information embedded in official records. The literature review, serving as a foundation, provides a broader context and allows for the identification of trends, gaps, and theoretical frameworks. The synthesis of these findings not only elucidates the multifaceted nature of the research topic, but also demonstrates the complementary roles played by each method in constructing a holistic and nuanced understanding of sustainable water demand management.

As identified from this study, the current water policy guidelines focus more on other sectors of water resource management, with less attention given to drinking water management. The policy's implications have not effectively influenced residents' attitudes toward water conservation, leading to inequitable and scarce water supply services in towns such as Arba Minch and Ziway. Additionally, clear and well-defined policy guidelines for urban water supply and sewerage services emphasize water conservation practices and efficient water utilization in urban settings [50].

The prospect of residential water demand management policy regulations in Ethiopian urban towns has provided valuable insights into the challenges and opportunities of sustainable water resource management. The study findings suggest that the implementation and effectiveness of existing policies and regulations in the selected urban areas are significantly hindered by limited resources and unclear guidelines. As a result, the overall impact of these policies on water demand management was very low. One of the major challenges identified was the lack of clear guidelines and community awareness regarding water conservation practices. This gap hinders effective adoption of water-saving techniques and limits the impact of policy regulations. Addressing this issue through public education campaigns and targeted community engagement is crucial for achieving successful water demand management. While financial and infrastructural challenges may pose hurdles, initiating efforts from the residents is a crucial step towards fostering a water-conscious society. Abansi et al. [51] emphasized that evaluating urban water demand management policies must consider factors such as compliance, enforcement mechanisms, and awareness among water

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users to ensure successful implementation and outcomes. Empowering individuals with knowledge and encouraging a sense of responsibility for water resources can yield meaningful long-term results.

The assessment also highlights the importance of efficient data monitoring systems and institutional structures. Fragmented institutional arrangements and frequent changes in leadership can hinder evidence-based decision-making and policy implementation. Strengthening institutional capacities and ensuring a seamless flow of information are imperative to improve the overall effectiveness of water demand management policies.

Furthermore, the study emphasized the significance of tailored approaches for drought-prone areas, such as Ziway and Arba Minch. Implementing specialized regulations and strategies to address the unique water demands of these regions is essential to ensure sustainable water supply services during periods of water scarcity. The water consumption patterns observed over the past decade in the three study areas indicate a lack of focus on water conservation mechanisms from a policy perspective, even for a growing population. The current policies and regulations seem inadequate to address the increasing demands for water in these urban towns, which could lead to potential water scarcity issues in the future.

Moreover, drawing inspiration from successful practices in both developed and developing countries, Ethiopia can adopt relevant water demand management strategies to conserve scarce water resources. Simple and cost-effective policies, such as rainwater harvesting promotion and water-saving fixture regulations, can significantly contribute to water conservation efforts.

Finally, an integrated approach that involves community engagement, clear policy guidelines, and tailored strategies for specific regions will be instrumental in achieving sustainable residential water demand management in Ethiopian urban towns. By addressing the identified gaps and leveraging successful practices, Ethiopia can move closer to a water-secure and resilient future given its growing urban population.

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