International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 12 | Dec 2025 www.irjet.net p-ISSN: 2395-0072

Assessment of Water Supply Accessibility, Reliability, and Governance in Haro Sebu Town: Challenges and Opportunities towards Achieving SDG 6.1

Adisu Cheneka[1], Kibru Fekede[2], Bari Kabede[3], Shukare Oljira[4]

[1,2,3,4] *Tongji University, UNEP Institute of Environment for Sustainable Development (IESD), College of Environmental Science and Engineering, Shanghai 200092, China.*

Abstract - *Access to safe and reliable drinking water remains a critical challenge in Ethiopian towns. This study assesses water supply accessibility, reliability, and governance in Haro Sebu Town, evaluating challenges and opportunities for achieving Sustainable Development Goal (SDG) 6.1. A cross-sectional survey of 377 households, supplemented by semi-structured interviews and field observations, was conducted to collect quantitative and qualitative data. Results indicate that only 23.9% of households have piped water connections, while 53.3% rely on wells and developed springs. Physical accessibility is constrained, with 38.7% of households traveling more than 1 km to collect water. Women and girls are responsible for 79.5% of water collection, and manual transport dominates (63.7%). Water supply reliability is low, with only 20. 4% of households accessing water daily. Governance challenges are evident, with 61.5% perceiving distribution as unfair, and only 48.3% participating in local water management initiatives. The findings highlight the need for expanded piped networks, improved reliability, and inclusive governance to meet SDG 6.1 targets. Recommendations emphasize infrastructure upgrades, gender-sensitive strategies, and enhanced community participation*

***Key Words*: Water supply, Distribution systems, Accessibility, Reliability, Water governance, SDG 6.1, Haro Sebu Town, Ethiopia.**

1. INTRODUCTION

Access to safe, reliable, and affordable drinking water is a fundamental human right and a critical pillar of sustainable development [1]. Water is essential for human health, environmental protection, and socio-economic progress. However, in many rapidly urbanizing areas of low-income countries, ensuring consistent and equitable access to clean water remains a major challenge [2]. Urban populations continue to grow at rates faster than the expansion of basic water infrastructure, creating significant service gaps [3, 4]. These conditions have intensified global attention on water security, leading to the establishment of Sustainable Development Goal 6.1, which emphasizes universal and equitable access to safe and affordable drinking water for all [5]. Despite this global commitment, progress remains uneven, particularly in sub-Saharan Africa where many towns still struggle to provide reliable water services to their residents [6].

In Ethiopia, the situation reflects similar difficulties. The country's secondary and emerging towns often experience chronic water shortages, unreliable supply systems, and limited household-level connections [7, 8]. While urbanization has increased rapidly, investment in water infrastructure has not kept pace with demand [9]. As a result, many households rely on alternative sources such as wells, springs, or public taps, which are frequently insufficient or unsafe [10, 11].

These challenges are worsened by aging pipelines, limited production capacity, and inadequate maintenance practices. For towns like Haro Sebu, these factors have created persistent water access constraints that affect daily life, economic productivity, and public health [12]. Understanding these challenges is necessary for planning improvements that can meet the growing needs of urban residents. Haro Sebu Town represents a clear example of the water access challenges faced in many Ethiopian towns. Although the town has multiple water sources including piped connections, public standpipes, wells, and developed springs the majority of residents still lack direct access to household-level piped water. Only a small proportion of households have private connections, while more than half rely on non-piped sources that often require long travel distances. These limitations highlight the infrastructural gaps present in the town, as water supply expansion has not matched rapid population growth or peri-urban settlement expansion [13].

As a result, service inequality is evident, with households in peripheral or newly developed areas facing the greatest difficulties in securing sufficient water for domestic use.

A major component of the water access problem in Haro Sebu is the physical effort required to obtain water. Many households must walk long distances sometimes more than a kilometre to reach their primary water source. Such distances exceed international standards for basic water access and impose significant physical burdens [14]. This responsibility falls overwhelmingly on women and girls, who perform nearly 80% of all water collection activities [15]. The time and energy required for water collection reduce their opportunities for education, household responsibilities,

rest, and income-generating activities [16]. The gender imbalance in water collection mirrors broader patterns across Ethiopia and Africa, where women and girls continue to carry the weight of domestic labour due to cultural norms and limited infrastructural development [17]. Addressing water accessibility is therefore not only a development issue but also a matter of gender equity and social justice [18].

In addition to issues of physical access, the reliability of the water supply in Haro Sebu Town remains a major concern. Many households experience irregular water supply, limited operating hours, and unpredictable distribution schedules. Only a minority of residents receive water on a daily basis, forcing many families to store water in containers for extended periods, which increases the risk of contamination. Intermittent supply disrupts household routines, limits hygiene practices, and contributes to dissatisfaction with water services [19]. These patterns are common across Ethiopian towns, where distribution networks are outdated and production capacity often falls short of demand [20]. Improving reliability is essential for reducing water-related hardships and achieving progress toward SDG 6.1. [5]

Governance challenges further complicate water access in Haro Sebu. Many residents perceive water distribution as unfair, with concerns related to unequal allocation across neighbourhoods, inconsistent supply schedules, and weak communication from water authorities [21].

Community participation in water governance is also limited, which reduces opportunities for residents to voice concerns, propose solutions, or hold authorities accountable [22]. Without transparent and inclusive governance structures, public trust declines, and service delivery becomes less responsive to community needs [23]. Strengthening local governance especially through improved communication, accountability, and community engagement is therefore critical for ensuring equitable and sustainable water services [24].Given these multidimensional challenges infrastructure limitations, long travel distances, gendered labour burdens, unreliable supply, and governance constraints there is a pressing need to evaluate water accessibility, reliability, and governance in Haro Sebu Town[8]. This study aims to assess these key components to identify underlying barriers and inform strategies for improvement. By examining both the physical and institutional aspects of water supply, the research provides evidence that can guide interventions to enhance water access, promote equity, and support the town's progress toward achieving SDG 6.1. The findings are relevant not only for Haro Sebu but also for similar towns across Ethiopia that face comparable challenges in providing safe and reliable drinking water to their growing populations.

2. Research Methods

2.1 Description of the Study Area

Haro Sebu Town is the administrative center of Dale Sedi Woreda in the Kellem Wollega Zone of Oromia, Ethiopia. It is located about 550 km west of Addis Ababa at 8°53′50.60″ N and 35°13′37.60″ E, with an elevation of 1,400–1,600 meters. The area consists of gently undulating mid-altitude highlands and has a warm, humid tropical climate, receiving 1,400–1,800 mm of annual rainfall and temperatures ranging from 16.3°C to 35.1°C.

These conditions support mixed farming of cereals, pulses, oilseeds, coffee, and horticultural crops. The population is predominantly Oromo, speaking Afan Oromo, and practicing Protestant Christianity, Islam, and Ethiopian Orthodox Christianity. The economy is mainly agrarian. The Haro Sebu Agricultural Research Center, established in 2009, contributes to crop and livestock research and natural resource management. The town provides essential services such as education, healthcare, transportation, and trade. The water supply system comprises piped networks, public taps, wells, and springs. Despite challenges such as limited infrastructure, water shortages, deforestation, and soil erosion, Haro Sebu remains an important center for socio-economic activities and agricultural development in western Oromia.

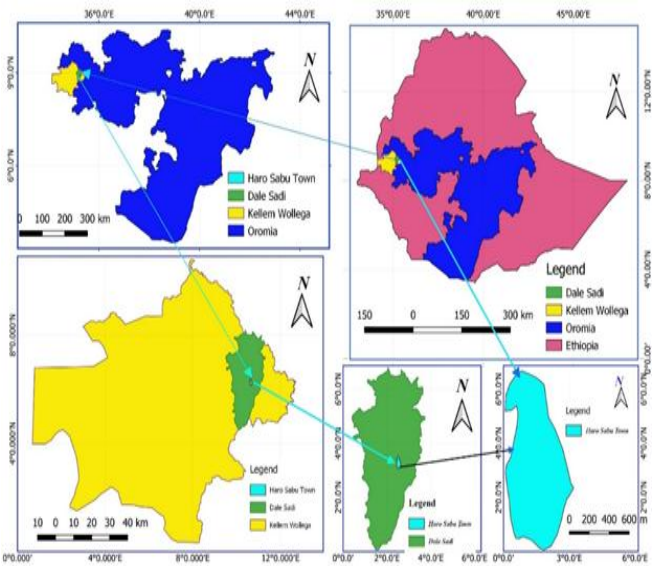

Fig-1: Map of the study area

2.2. Research Design and Approach

This study adopted a cross-sectional mixed-methods research design to comprehensively assess water supply accessibility, reliability, and governance in Haro Sebu Town. The cross-sectional approach allowed for the collection of data at a single point in time, providing a snapshot of the current state of water services and related challenges. The

integration of both quantitative and qualitative methods enhanced the depth of analysis. Quantitative data from household surveys provided measurable and generalizable information on water access patterns, while qualitative data from interviews and observations offered contextual understanding, including perceptions, governance issues, and socio-cultural factors influencing water collection and usage. By combining these approaches, the study ensured triangulation, which strengthens the reliability of findings and reduces biases that might arise from using a single method.

2.3. Data Sources

Data for this study were obtained from both primary and secondary sources to ensure a comprehensive and contextualized analysis of water access in the town. Primary data were collected directly from households and key stakeholders, ensuring the relevance and immediacy of information. Household surveys gathered standardized data on water access, distances to water points, and perceptions of supply reliability, while key informant interviews with municipal officials, water utility staff, and community representatives provided insights into governance structures, decision-making processes, and operational challenges. In addition, field observations enabled an objective assessment of the physical condition and functionality of water infrastructure, helping to identify practical constraints, user experiences, and gender-specific burdens related to water collection. Secondary data complemented these findings by providing broader contextual and institutional perspectives. Municipal reports and water utility documents supplied official statistics, policy frameworks, and records of service provision, while academic and policy publications facilitated comparison with similar urban contexts, highlighting common trends, challenges, and potential solutions. Together, these data sources supported a well-rounded understanding of water access issues by integrating empirical evidence with institutional and policy analysis.

2.4. Sampling Techniques and Sample Size Determination

The target population included all households in Haro Sebu Town, totaling **20,986** individuals. To ensure that the sample size was statistically valid and representative, Cochran's (1977) formula for large populations was used. A 95% confidence level was applied to reduce uncertainty in the estimates, with an assumed proportion of 0.5 to account for maximum variability, and a 5% margin of error to balance precision with practicality [25]. As outlined in Eqs 1 and 2.

$$n_0 = \frac{Z^2.p.(1-P)}{e^2} \quad \text{----------1}$$

$$n = \frac{n_o}{1+\frac{n_o-1}{N}} \quad \text{----------2}$$

Where n_0 is the initial sample size for an infinite population, Z is the Z-score corresponding to the desired confidence level (e.g., 1.96 for a 95% confidence level), P is the estimated proportion of the attribute in the population (commonly set at 0.5 when the true proportion is unknown to ensure maximum variability), and e is the margin of error (e.g., 0.05 for ±5%). Because the target population is finite (N = 20,986), the sample size was adjusted using the finite population correction (FPC). In this context, n represents the final sample size after applying the finite population correction, while N denotes the total population size (20,986 in this study).

Thus, 377 households were selected to participate.

The sample was drawn using a combination of purposive sampling (to target key informants and specific areas of interest) and simple random sampling (to ensure representativeness of households across the town). This approach minimized selection bias and ensured that findings could be generalized to the wider population.

2.5. Data Collection Methods

This study employed a mixed-methods approach comprising household surveys, key informant interviews, and field observations to collect both quantitative and qualitative data on water access, reliability, and governance. Structured questionnaires were administered to selected households to gather quantitative information on water sources, travel time and distance, frequency of service interruptions, and perceptions of water governance. Questions addressing gender roles and responsibilities were included to identify disparities in water collection burdens, enabling standardized and comparable data suitable for statistical analysis.

In addition, semi-structured interviews were conducted with municipal officials, water utility staff, community representatives, and water committee members to obtain in-depth qualitative insights into water management challenges, decision-making processes, and institutional constraints. These interviews complemented the household survey by capturing governance and operational issues not easily quantified. Field observation was also employed to assess the physical condition, operational status, and accessibility of water sources. A structured observation checklist ensured systematic data collection, while GIS tools were used to map water points and infrastructure. This method provided visual verification of facilities, identified potential hazards, and helped validate information obtained from surveys and interviews, thereby enhancing the overall reliability and credibility of the study findings.

2.6. Methods of Data Analysis

Quantitative data from household surveys were coded and analyzed using SPSS software. Descriptive statistics, including frequency distributions and percentages, were used to summarize patterns of water access, reliability, and governance perceptions. Results were presented in tables and graphs for clarity and ease of interpretation. Qualitative data from interviews and field observations were analyzed thematically, focusing on recurring issues such as supply interruptions, institutional inefficiencies, and gendered responsibilities. Thematic analysis allowed identification of underlying causes, trends, and community perspectives that influence water access.

Triangulation of quantitative and qualitative findings strengthened the overall analysis by validating trends, highlighting consistencies and discrepancies between data types, and providing a comprehensive understanding of the complex dynamics of water supply and governance in Haro Sebu Town

2.5. Water Supply Accessibility and Service Delivery Framework

The figure illustrates a framework for assessing water supply accessibility and service delivery. It highlights three key components that influence water service outcomes: physical accessibility of water sources, reliability of water supply, and water governance. Physical accessibility considers the distance to water sources and the time spent collecting water, while reliability focuses on the frequency and availability of water. Water governance emphasizes participation, fairness, and accountability. These three factors collectively impact the overall water service delivery outcomes, including equity, reliability, sustainability, and user satisfaction. Additionally, the framework recognizes the role of gender in water collection, indicating that gender dynamics can affect water service outcomes. Women and girls often bear the primary responsibility for collecting water, which can influence both the time spent accessing water and their ability to participate in governance. By incorporating gender considerations, the framework underscores the importance of equitable and inclusive approaches to water management, ensuring that services meet the needs of all users effectively.

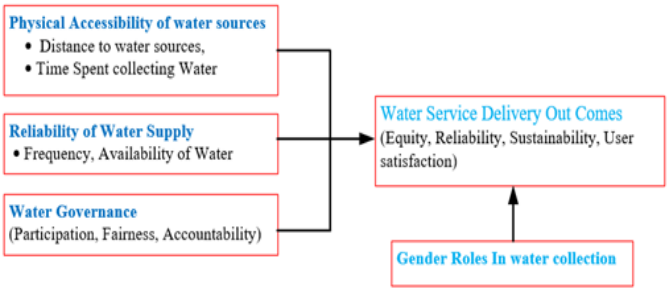

Fig- 2: Conceptual frame work the study

3. Results and discussion

3.1. Access Levels, Distribution, and Socioeconomic Impacts of Water Sources

In Haro Sebu Town, household water access is largely dependent on non-piped sources. Only 23.9% of households have piped water connections within their dwellings, while 22.8% rely on public taps. The majority (53.3%) depend on wells (25.7%) and developed springs (27.6%) (Figure 3). This limited coverage of household piped connections aligns with findings from small and medium-sized towns, where water infrastructure expansion often lags behind population growth [26]. Piped systems in such contexts typically serve a minority of residents, often concentrated in central or older urban areas, and Haro Sebu Town exhibits a similar pattern of partial service provision.

Public taps, which serve nearly one-quarter of households, are traditionally considered interim solutions to supplement household connections [27]. However, evidence suggests that due to financial and institutional constraints, these facilities often persist as long-term coping mechanisms [28]. The high reliance on wells and springs further reflects structural weaknesses in the formal water supply system, with Haro Sebu Town exhibiting an even stronger dependence on communal and semi-improved sources compared to other rapidly urbanizing Ethiopian town. The reliance on communal water sources has significant implications for household labor allocation and time use. Households dependent on wells, springs, or public taps incur substantial time costs for walking, queuing, and transporting water, consistent with findings in other low-connection contexts [14]. Women and children predominantly bear this burden, reinforcing gendered divisions of labor [29]. Similar research from small towns in China indicates that lack of household water connections limits women's participation in income-generating activities and reduces time available for household management [30]. The patterns observed in Haro Sebu Town suggest that inadequate water infrastructure imposes comparable social and economic constraints across different regional context

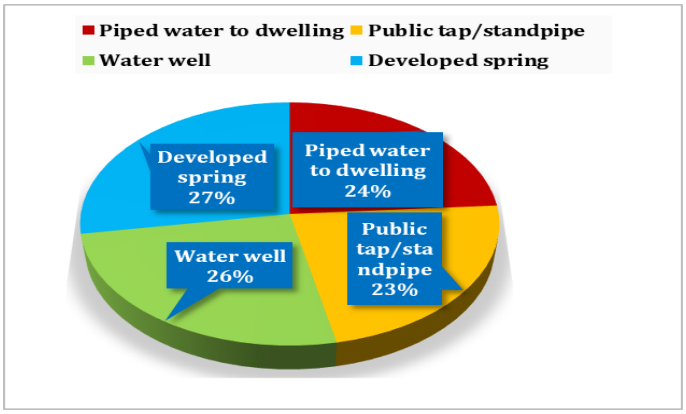

Fig-3: Primary Sources of Water in Haro Sebu Town

3.1.2. Spatial Disparities and Multiple Water Source Use

Intra-urban disparities in water access are evident in Haro Sebu Town. Research shows that households located farther from main distribution lines and public taps are more likely to rely on wells and springs, particularly in peripheral or newly developed areas [31]. This pattern is reflected in the results presented in Fig 3, where non-piped sources dominate household water supply. Previous studies also indicate that households in such settings rarely rely on a single water source, instead adopting multiple-source strategies to cope with unreliable supply [32]. The distribution of water sources shown in Figure 3 explains why many households in Haro Sebu Town combine wells, springs, and public taps to meet daily needs, signaling chronic water insecurity rather than temporary shortages. Seasonal variation further exacerbates these challenges. Declining groundwater levels during dry seasons increase collection distance and waiting time, particularly for households dependent on wells and springs [33]. Given the high reliance on these sources in Haro Sebu Town, similar seasonal stress is likely to affect water availability and accessibility.

3.1.3. Implications for Urban Development and Water Service Expansion

Studies on secondary and small-town urbanization emphasize that rapid population growth is often not matched by adequate investment in basic infrastructure [34]. The water source distribution shown in Figure 3 indicates that Haro Sebu Town reflects this broader development challenge. Research suggests that sustainable urban water systems require a transition from communal water points toward expanded household-level connections [35]. Compared with towns that have achieved higher household connection rates, Haro Sebu Town remains at an early stage of service development, with fewer than one-quarter of households connected to piped water. Inadequate water access has also been linked to negative public health outcomes and reduced economic productivity [36]. The findings from Haro Sebu Town reinforce these conclusions and highlight the need for targeted investment in water supply infrastructure. Expanding piped networks, improving spatial equity, and strengthening system reliability are essential for reducing time burdens, addressing gender inequalities, and supporting sustainable urban development.

3.2. Physical Accessibility of Water Sources

Household travel distance to water sources reveals significant physical accessibility challenges in Haro Sebu Town. As illustrated in Figure 4, only 125 households (33.2%) access their primary water source within 500 meters of their homes, indicating that just one-third of residents enjoy relatively convenient physical access. In contrast, 106 households (28.1%) travel distances between 500 meters and 1 km, while a substantial proportion, 146 households (38.7%), must walk 1 km or more to obtain water. Most notably, 55 households (14.6%) travel distances exceeding 2 km, reflecting severe access constraints for a considerable segment of the population.

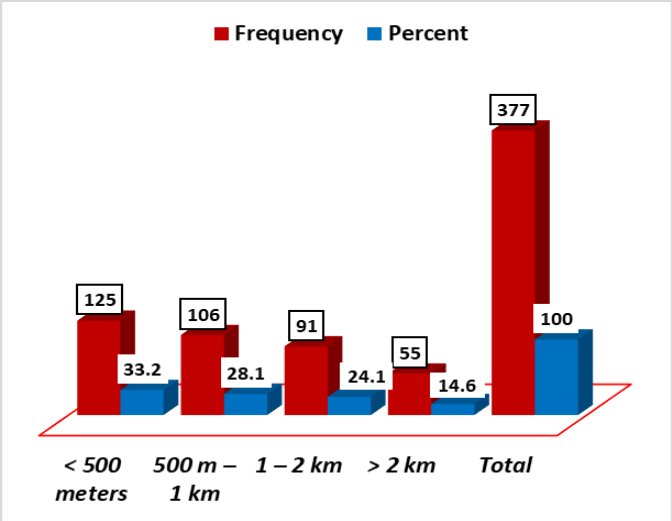

Fig-4: Distance from Home to Primary Water Source

The distribution shown in Figure 4 demonstrates pronounced disparities in the spatial accessibility of water services within the town. Similar distance-based inequalities have been widely documented in small and rapidly growing towns, where water infrastructure development fails to keep pace with horizontal settlement expansion [37]. In Haro Sebu Town, the long travel distances suggest an uneven spatial distribution of improved water sources, particularly disadvantaging peripheral and newly developing neighborhoods. This pattern points to systemic shortcomings in urban planning and highlights weaknesses in the allocation of water supply facilities. Previous studies emphasize that long distances to water sources significantly influence household water-use behavior [38]. When water points are located far from residences, households tend to reduce the number of collection trips, thereby limiting the quantity of water available for domestic use. The accessibility pattern observed in Haro Sebu Town strongly supports this finding, as households traveling more than 1 km are likely to prioritize water for essential uses, often at the expense of hygiene and sanitation practices. Such behavioral adjustments can have direct implications for public health, particularly in densely populated urban environments.

Extended travel distances also impose substantial physical and time burdens on households. Research consistently shows that these burdens fall disproportionately on women and children, who are primarily responsible for water collection in contexts lacking household connections [14]. The high proportion of households traveling long distances in Haro Sebu Town, as

shown in Figure 4, suggests persistent gendered labor inequalities and chronic time poverty. These conditions can limit educational opportunities for children, restrict women's participation in income-generating activities, and reinforce existing social and economic inequalities. In addition to time and labor costs, long walking distances to water sources may expose collectors to safety risks, particularly when water points are located in isolated or poorly monitored areas. Previous studies note increased risks of physical injury, fatigue, and harassment under such conditions [39]. Given the number of households traveling over 2 km in Haro Sebu Town, these concerns are especially relevant for vulnerable groups.

The observed accessibility conditions in Haro Sebu Town deviate from internationally recognized service benchmarks, which recommend that water sources should be located within a distance that allows a round-trip collection time of no more than 30 minutes, including queuing (World Health Organization(WHO, 2017))[40]. The high proportion of households exceeding this threshold indicates inadequate service accessibility and underscores persistent gaps in equitable water provision. Compared with towns that meet these standards, Haro Sebu Town exhibits clear spatial inefficiencies in water infrastructure placement. Addressing these challenges requires a strategic and equity-oriented approach to water service expansion. Previous research highlights the importance of prioritizing underserved neighborhoods, extending piped distribution networks, and integrating water accessibility considerations into urban land-use planning [41]. For Haro Sebu Town, reducing travel distances would not only alleviate physical and time burdens but also promote more consistent water use, improved hygiene, enhanced safety, and greater socio-economic well-being. Such interventions directly support the objective of ensuring universal and equitable access to safe and affordable drinking water, reinforcing the importance of spatially inclusive and sustainable urban water planning.

The abbreviation Indicated that: WHO: World Health Organization

3.3. Household Responsibility for Water Collection

The analysis of household water collection responsibilities in Haro Sebu Town reveals a highly gendered pattern **(Fig. 5)**. Adult women constitute the largest group of primary water collectors, responsible for 160 households (42.4%), followed by female children at 140 households (37.1%). Collectively, women and girls are responsible for 300 households (79.5%) of water collection activities. Adult men (35 households, 9.3%) and male children (42 households, 11.1%) contribute minimally. The high involvement of female children indicates that water collection duties may interfere with schooling and educational performance. These findings are consistent with studies conducted in other Ethiopian regions, such as Oromia, Amhara, and Tigray, which also report a predominance of women and girls in household water collection [42, 43].

These findings indicate that water collection is predominantly undertaken by females, highlighting the persistence of gendered household responsibilities in Haro Sebu Town. The high proportion of female participation in water collection underscores a structural gender imbalance in domestic labor, which may have long-term consequences on the education and empowerment of girls. The burden on female children, in particular, can reduce time available for schooling, skill development, and recreational activities, potentially affecting their academic performance and personal growth. The predominance of women and girls in water collection has significant implications for health, education, and socio-economic well-being. The physical effort required to carry heavy water containers over long distances increases the risk of musculoskeletal strain, fatigue, and other health issues, particularly among adult women [39, 44]. Female children are also exposed to similar physical stress, alongside reduced time for schooling, recreation, and skill development. These burdens contribute to time poverty, limiting opportunities for women and girls to engage in income-generating activities, community participation, and personal development. The persistent allocation of water collection to females reflects entrenched cultural norms and social expectations, reinforcing gender inequalities across generations (UNICEF, 2016) [45, 46].

The gendered pattern of water collection aligns with studies from other Ethiopian regions, including Oromia, Amhara, and Tigray, which document the feminization of water-related labor [47, 48]. This imbalance reinforces entrenched social norms and cultural expectations, perpetuating gender inequalities in domestic responsibilities. The findings suggest that without intervention, the cycle of female burden in household water collection will continue, affecting health, education, and socio-economic outcomes for women and girls.

Addressing this issue requires both infrastructural and social interventions. Reducing travel distances through strategic placement of new water points and expanding household-level piped connections can significantly alleviate the labor and time burden on women and girls [49, 50]. Such interventions directly support Sustainable Development Goal 6.1, which emphasizes universal and equitable access to safe and affordable drinking water, while simultaneously advancing SDG 5 by promoting gender equality, redistributing unpaid domestic work, and enabling greater female participation in education and economic life. Complementary community-based strategies, such as awareness programs that encourage shared household responsibilities, are essential to challenge cultural norms and ensure more equitable distribution of water-related labor. Collectively, these measures can reduce physical strain, increase household water availability, improve health outcomes, enhance educational opportunities, and promote

socio-economic development, fostering a more equitable and sustainable household environment.

The abbreviation indicated that: UNICEF; *United Nations Children's Fund,* ***SDG 5*** *stands for Sustainable Development Goal 5.*

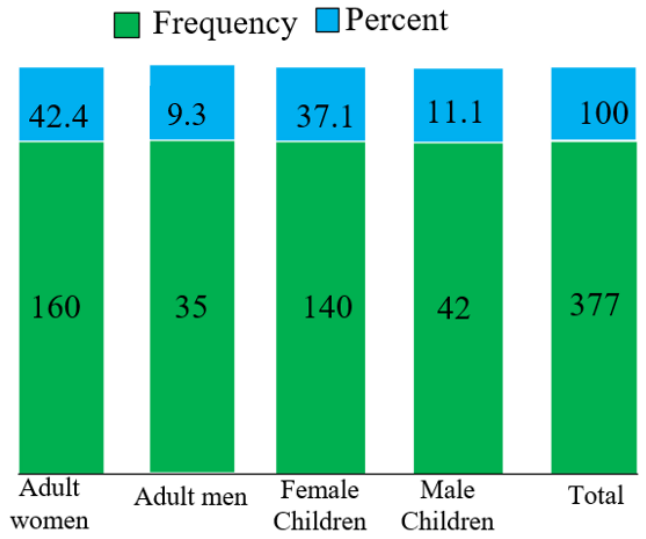

Fig-5: Household Members Responsible for Fetching Water

3.4. Water Transportation

A total of 377 households were surveyed in Haro Sebu Town to assess water transportation methods (Table 1). The majority of households (63.7%) transported water manually. 29.2% of households used donkeys, while only 7.2% employed animal-pulled carts, indicating that labor-intensive human transport dominates and alternative modes are limited.

Table-1: Methods of Transporting Water from Source to Home

Method of Transport	Frequency	Percent
Human load	240	63.7%
Donkey	110	29.2%
Animal-pulled cart	27	7.2%
Total	377	100.0%

The finding that nearly two-thirds of households rely on manual water transport underscores a substantial labor burden, particularly on women and children who are the primary water collectors. The physical demands of carrying heavy containers over long distances increase the risk of musculoskeletal injuries, fatigue, and chronic stress, which can negatively affect school attendance, work productivity, and participation in community and social activities.

The limited use of donkeys (29.2%) and carts (7.2%) indicates unequal access to assisted transport, often associated with differences in household income, asset ownership, or socio-economic status. Households without access to animal-assisted transport face greater time and energy demands, which may constrain the volume of water collected per day and reduce availability for drinking, hygiene, and other domestic uses. These results are consistent with findings from other Ethiopian small towns, where manual water transport predominates and only a small proportion of households use donkeys or carts [51]. This pattern highlights the critical need for infrastructural improvements, such as household piped water connections, and community-based interventions, including affordable animal-assisted or shared transport systems. Such measures would reduce the physical burden, promote equitable access, and improve household water security, hygiene practices, and overall well-being.

3.5. Reliability of Water Supply

The assessment of water supply reliability in Haro Sebu Town indicates considerable inconsistencies in service delivery (Table 2). Only 77 households (20.4%) receive water daily, while 127 households (33.7%) access water 4–6 days per week, reflecting erratic and unpredictable supply patterns. A further 111 households (29.4%) receive water 1–3 days per week, and 62 households (16.4%) receive water less than once per week, suggesting chronic shortages for some residents. Regarding daily availability, 95 households (25.2%) experience intermittent supply within a day, 105 households (27.9%) receive water for less than 6 hours, 100 households (26.5%) access water for 6–12 hours, and only 77 households (20.4%) report that water is available at all times.

Perceptions of water reliability mirror these findings: 147 respondents (39.0%) rate the supply as "unreliable," and 81 respondents (21.5%) as "very unreliable," while only 46 respondents (12.2%) perceive the service as "very reliable," and 103 respondents (27.3%) as "reliable." These data indicate that both actual supply patterns and user experiences reflect significant variability and dissatisfaction with water service quality.

Table-2: Indicators of Water Supply Reliability

Indicator	Category	Frequency	Percent
Days per week	< 1 day	62	16.4%
	1–3 days	111	29.4%
	4–6 days	127	33.7%
	7 days (daily access)	77	20.4%

Total respondents		377	100%
Hours per day	Intermittent	95	25.2%
	<6 hours	105	27.9%
	6–12 hours	100	26.5%
	Always available	77	20.4%
Total respondents		377	100%
Perceived reliability	Very reliable	46	12.2%
	Reliable	103	27.3%
	Unreliable	147	39.0%
	Very unreliable	81	21.5%
Total respondents		377	100%

The intermittent and unpredictable water supply has profound implications for household water security, daily routines, and public health. Limited availability often forces households to ration water, reduce consumption, or collect water during inconvenient hours, which can compromise hygiene practices, food preparation, and other essential domestic activities. Unreliable supply also necessitates prolonged storage of water, increasing the risk of contamination due to improper containers or unhygienic handling. These findings align with national assessments of small towns in Ethiopia, which report frequent service interruptions and insufficient production capacity as major barriers to reliable water supply [7, 52]. The combination of inconsistent availability, limited daily hours, and user dissatisfaction underscores the systemic challenges faced by the town's water infrastructure.

Improving reliability is critical not only for daily convenience but also for broader health, social, and economic outcomes. Infrastructure upgrades such as increasing production capacity, rehabilitating distribution networks, improving pressure management, and expanding storage facilities can significantly reduce service interruptions. Additionally, better scheduling, communication with users, and targeted maintenance programs can enhance household preparedness and public trust in the water system. Addressing these reliability challenges is essential for ensuring that households can maintain sufficient water access for consumption, hygiene, and other daily needs, thereby supporting the broader goals of Sustainable Development Goal 6.1 (universal and equitable access to safe and affordable drinking water) and meeting international recommendations for safe water access as emphasized by UNICEF, which highlights the importance of reliable water services for health, education, and overall well-being.

The abbreviation indicated that: UNICEF; United Nations Children's Fund

3.6. Perceived Fairness in Water Distribution

Community perceptions of fairness in water distribution indicate considerable dissatisfaction with the current system (Fig. 6). Out of 377 respondents, 232 households (61.5%) believe that water distribution is not fair, while only 145 households (38.5%) perceive the system as equitable. These perceptions suggest that many households experience barriers to reliable supply, which may result from preferential allocation to certain neighborhoods, inconsistent scheduling, or inadequate pressure particularly in high-altitude areas where water flow tends to be weaker.

The high proportion of negative responses highlights both infrastructure constraints and concerns regarding service governance and communication. The widespread perception of unfairness (Fig. 6) reflects gaps in water supply management, which can undermine trust in local water authorities. Previous research indicates that when households perceive water distribution as inequitable, community cooperation declines, making it more difficult to implement service improvements and maintain systems effectively (WHO & UNICEF, 2021). Inequitable distribution also exacerbates socio-economic disparities, as households in disadvantaged or peripheral areas often experience more severe shortages or limited access.

Addressing these challenges requires improved transparency in distribution schedules, equitable allocation across neighborhoods, and strengthened accountability mechanisms such as responsive complaint-handling systems. Effective governance interventions can rebuild public confidence, improve user satisfaction, and promote equitable service delivery. Furthermore, fair distribution is essential for achieving Sustainable Development Goal 6.1, which emphasizes universal and equitable access to safe and affordable drinking water (WHO & UNICEF, 2021). Ensuring reliable and fair access for all residents, regardless of location or socio-economic status, can enhance household well-being, reduce resource-related tensions, and support broader social and economic development.

The abbreviation indicated that: WHO: World Health Organization, UNICEF: United Nations Children's Fund

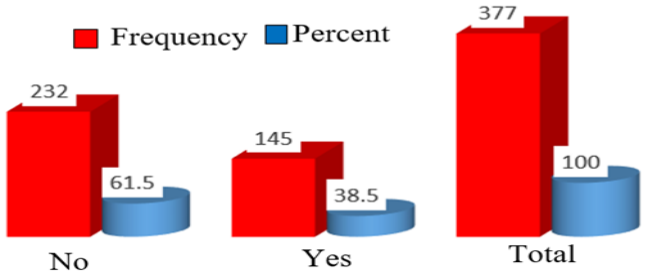

Fig-6: Community Perceptions of Fairness in Water Distribution

3.7 Participation in Local Water Governance

Household participation in local water governance structures, such as community meetings, water user committees, and consultations, remains relatively limited in Haro Sebu Town (Fig 7). Out of 377 households surveyed, 182 households (48.3%) reported being involved in governance processes, while 195 households (51.7%) indicated no participation at all. This suggests that nearly half of the population is excluded from decision-making platforms that influence water allocation, tariff setting, service improvements, and complaint handling.

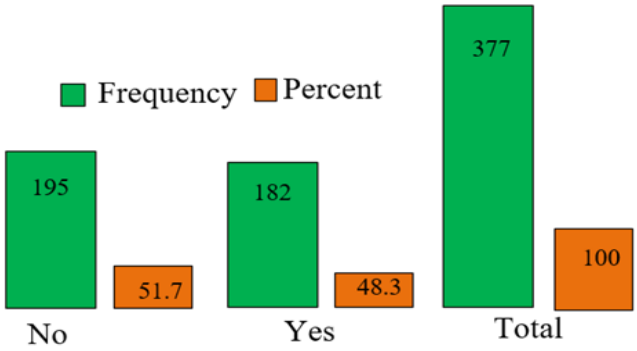

Fig-7: Household Participation in Local Water Governance

Limited household engagement in water governance restricts opportunities for oversight and accountability, thereby weakening the effectiveness and responsiveness of local water management systems. When households particularly women and marginalized groups are underrepresented in decision-making, their concerns and priorities may remain unaddressed, contributing to dissatisfaction and inequitable service distribution. Evidence from other regions suggests that inclusive participation in water governance improves responsiveness, ensures that community needs are addressed, and fosters transparency and fairness in service provision [53].

Strengthening participatory mechanisms can enhance trust between service providers and the community, improve service delivery outcomes, and ensure governance structures align with the principles of equity and inclusiveness promoted under Sustainable Development Goal 6.1, which emphasizes universal and equitable access to safe and affordable drinking water. Empowering women's voices in particular is crucial, as they are often the most directly affected by water access challenges and collection burdens [54]. Ensuring their active involvement in governance processes can lead to more responsive solutions, better resource allocation, and the design of services that reflect the actual needs of households.

Additionally, broader community participation fosters collective responsibility for water resources, encourages local problem-solving, and strengthens accountability mechanisms. When more households engage in planning, monitoring, and decision-making, service providers are more likely to respond to operational challenges, implement timely maintenance, and adopt policies that reflect community priorities. Over time, inclusive participation can also contribute to social cohesion, reduce conflicts over water access, and build local capacity for sustainable water management.

4. Conclusion and Recommendations

4.1 Conclusion

Haro Sebu Town continues to face significant challenges in achieving the targets of Sustainable Development Goal (SDG) 6.1, which emphasizes universal and equitable access to safe and affordable drinking water. The study's findings indicate that household-level piped water coverage is limited, compelling most residents to rely on non-piped water sources. These sources are frequently unreliable, time-consuming to access, and require manual transport, creating substantial physical and temporal burdens for households. The impact of limited water access is not evenly distributed across the population. Women and children bear a disproportionate share of the labor associated with water collection, reflecting entrenched social and gender norms. The time and effort devoted to fetching water reduce opportunities for education, employment, and other productive activities, thereby perpetuating cycles of poverty and social inequality within the community.

In addition to access challenges, the study highlights the unreliability of the existing water supply system. Service interruptions, unpredictable availability, and inadequate infrastructure contribute to widespread household dissatisfaction. Furthermore, deficits in governance exacerbate these issues: perceptions of inequitable distribution, limited community participation, and weak accountability mechanisms undermine trust in local water authorities and hinder effective collaborative problem-solving.

Overall, these findings underscore the urgent need for comprehensive and integrated interventions. Addressing infrastructure gaps alone is insufficient; improvements must also target governance structures, social equity, gender considerations, and participatory management. Without substantial reforms, Haro Sebu Town will continue to struggle to meet the basic water needs of its population, as well as broader sustainability and equity goals outlined in SDG 6.1.

4.2 Recommendations

To improve water access and management in Haro Sebu Town, a multi-faceted approach is necessary. First, expansion of household piped water networks should be prioritized, particularly in underserved areas. Increased piped water coverage would reduce dependence on non-

piped sources, alleviate the physical burden of water collection, and improve overall water security for households.

Second, the equitable distribution of public water points is essential. Strategically locating communal water sources within accessible distances can minimize travel time, improve convenience, and enhance equitable access. Such planning should consider population density and vulnerability to ensure that resources are allocated effectively.

Third, enhancing supply reliability is critical. Regular infrastructure maintenance, leak repair, and the provision of adequate storage capacity can reduce interruptions and unpredictability in water service. Implementing monitoring systems and early-warning mechanisms would further strengthen the community's confidence in the water supply.

Fourth, gender-sensitive strategies must be integrated into water management interventions. Programs that reduce the burden on women and children such as community-managed water transport systems or labor-saving technologies can help promote social equity and improve health and educational outcomes for affected populations.

Fifth, strengthening governance and accountability is vital for sustainable water management. Transparent allocation of water resources, clear communication of service schedules, and mechanisms for citizen feedback can enhance trust and ensure more efficient service delivery. Encouraging inclusive decision-making by actively involving women and marginalized groups in planning and oversight processes will further enhance the equity and sustainability of water management.

Finally, a holistic and integrated approach is recommended. Combining infrastructure development, social equity, environmental sustainability, and institutional strengthening ensures long-term resilience and alignment with SDG 6.1 targets. Such a comprehensive strategy not only addresses immediate water access challenges but also contributes to broader developmental outcomes, including improved health, education, and social equity.

Acknowledgements

The author acknowledges the Government of China for its support of higher education and Tongji University IESD for providing academic resources and guidance. Appreciation is extended to the Ethiopian government and the authorities of Haro Sebu Town for their cooperation during data collection. The author expresses sincere gratitude to Professor Hongtao Wang for continuous supervision, constructive guidance, and invaluable feedback throughout this study. Thanks are also extended to Ebrahim Aman for his assistance. Sincere gratitude is expressed to family, friends, and colleagues for their support. The author is also thankful to God for guidance and blessings throughout this journey.

Reference

[1] K. Eman and G. Mesko, "Access to Safe and Affordable Drinking Water as a Fundamental Human Right: The Case of the Republic of Slovenia," 2020, pp. 465-484.

[2] O. Ejiohuo *et al.*, "Ensuring water purity: Mitigating environmental risks and safeguarding human health," *Water Biology and Security,* vol. 4, no. 2, p. 100341, 2025/04/01/ 2025, doi: https://doi.org/10.1016/j.watbs.2024.100341.

[3] N. Kapucu, Y. Ge, E. Rott, and H. Isgandar, "Urban resilience: Multidimensional perspectives, challenges and prospects for future research," *Urban Governance,* vol. 4, no. 3, pp. 162-179, 2024/09/01/ 2024, doi: https://doi.org/10.1016/j.ugj.2024.09.003.

[4] P. Gober, "Desert urbanization and the challenges of water sustainability," *Current Opinion in Environmental Sustainability,* vol. 2, no. 3, pp. 144-150, 2010/08/01/ 2010, doi: https://doi.org/10.1016/j.cosust.2010.06.006.

[5] S. Rajendrakumar *et al.*, "Drivers and barriers towards achieving SDG 6 on clean water and sanitation for all - an Indian perspective," *World Development Sustainability,* vol. 7, p. 100228, 2025/12/01/ 2025, doi: https://doi.org/10.1016/j.wds.2025.100228.

[6] V. A. Beard and D. Mitlin, "Water access in global South cities: The challenges of intermittency and affordability," *World Development,* vol. 147, p. 105625, 2021/11/01/ 2021, doi: https://doi.org/10.1016/j.worlddev.2021.105625.

[7] M. Adank, J. Butterworth, and M. Abera, "Looking beyond headline indicators: Water and sanitation services in small towns in Ethiopia," *Journal of Water, Sanitation and Hygiene for Development,* vol. 6, 08/18 2016, doi: 10.2166/washdev.2016.034.

[8] D. Bose *et al.*, "Overcoming water, sanitation, and hygiene challenges in critical regions of the global community," *Water-Energy Nexus,* vol. 7, pp. 277-296, 2024/12/01/ 2024, doi: https://doi.org/10.1016/j.wen.2024.11.003.

[9] R. S. Kookana, P. Drechsel, P. Jamwal, and J. Vanderzalm, "Urbanisation and emerging economies: Issues and potential solutions for water and food security," *Science of The Total Environment,* vol. 732, p. 139057, 2020/08/25/ 2020, doi: https://doi.org/10.1016/j.scitotenv.2020.139057.

[10] M. Rashid, M. Manzoor, and S. Mukhtar, "Urbanization and Its Effects on Water Resources: An Exploratory Analysis," *Asian Journal of Water, Environment and Pollution,* vol. 15, pp. 67-74, 01/29 2018, doi: 10.3233/AJW-180007.

[11] L. Mu, L. Fang, W. Dou, C. Wang, X. Qu, and Y. Yu, "Urbanization-induced spatio-temporal variation of water resources utilization in northwestern China: A spatial panel model based approach," *Ecological Indicators,* vol. 125, p. 107457, 2021/06/01/ 2021, doi: https://doi.org/10.1016/j.ecolind.2021.107457.

[12] P. Sharma, A. Ivanova, and B. Hassan, "Aging Infrastructure: Challenges and risks associated with aging pipelines," 09/25 2024.

[13] B. Van der Bruggen, K. Borghgraef, and C. Vinckier, "Causes of Water Supply Problems in Urbanised Regions in Developing Countries," *Water Resour. Manag.,* vol. 24, pp. 1885-1902, 07/01 2010, doi: 10.1007/s11269-009-9529-8.

[14] S. Sorenson, C. Morssink, and P. Campos, "Safe Access to Safe Water in Low Income Countries: Water Fetching in Current Times," *Social science & medicine (1982),* vol. 72, pp. 1522-6, 05/01 2011, doi: 10.1016/j.socscimed.2011.03.010.

[15] Y. Crider and I. Ray, "Water and Development: A Gender Perspective," 05/19 2022, doi: 10.1093/acrefore/9780199389414.013.685.

[16] F. Arku, "Time savings from easy access to clean water Implications for rural men's and women's well-being," *Progress in Development Studies,* vol. 10, pp. 233-246, 07/01 2010, doi: 10.1177/146499340901000303.

[17] P.-R. Agénor and M. Agénor, "Access to infrastructure and women's time allocation: Implications for growth and gender equality," *Journal of Macroeconomics,* vol. 75, p. 103472, 2023/03/01/ 2023, doi: https://doi.org/10.1016/j.jmacro.2022.103472.

[18] S. Dickin and S. Gabrielsson, "Inequalities in water, sanitation and hygiene: Challenges and opportunities for measurement and monitoring," *Water Security,* vol. 20, p. 100143, 2023/12/01/ 2023, doi: https://doi.org/10.1016/j.wasec.2023.100143.

[19] S. K. Abanyie, E. E. Y. Amuah, and D. B. Nang, "Water scarcity and its implications on sanitation: A perspective study in an emerging city in Northern Ghana," *Green Technologies and Sustainability,* vol. 3, no. 2, p. 100138, 2025/04/01/ 2025, doi: https://doi.org/10.1016/j.grets.2024.100138.

[20] A. Mohamed, H. Worku, and T. Lika, "Urban and regional planning approaches for sustainable governance: The case of Addis Ababa and the surrounding area changing landscape," *City and Environment Interactions,* vol. 8, p. 100050, 2020/11/01/ 2020, doi: https://doi.org/10.1016/j.cacint.2020.100050.

[21] A. Gasirabo *et al.*, "Households perception on water scarcity, distribution, and accessibility in Nyanza district, Rwanda," vol. Volume 9, pp. 16-46, 01/01 2019.

[22] G. Kaushik *et al.*, "Chapter 13 - Harmonizing water governance: Exploring governance structures, stakeholder engagement, and policy in water management," in *Advances in Hydrology*, S. Majumdar, M. Choudhury, and M. Sillanpää Eds.: Elsevier, 2026, pp. 225-246.

[23] S. Afiyah, "The Impact of E-Government Services, Citizen Participation, and Transparency on Public Trust in Government," *Global International Journal of Innovative Research,* vol. 2, pp. 1246-1261, 06/10 2024, doi: 10.59613/global.v2i6.200.

[24] D. Mamidi, "Catalysing Water Governance: Empowering Communities for Sustainable Water Management," *Indian Journal of Public Administration,* vol. 0, pp. 1-18, 03/03 2025, doi: 10.1177/00195561241309140.

[25] J. E. Barlett, J. Kotrlik, and C. Higgins, "Organizational Research: Determining Appropriate Sample Size in Survey Research," *Information Technology, Learning, and Performance Journal,* vol. 19, 01/01 2001.

[26] S. S. Sinharoy, R. Pittluck, and T. Clasen, "Review of drivers and barriers of water and sanitation policies for urban informal settlements in low-income and middle-income countries," *Utilities Policy,* vol. 60, p. 100957, 2019/10/01/ 2019, doi: https://doi.org/10.1016/j.jup.2019.100957.

[27] D. Whittington, S. Pattanayak, J.-C. Yang, and B. Kc, "Household Demand for Improved Piped Water Services: Evidence From Kathmandu, Nepal," *Water Policy,* vol. 4, pp. 531-556, 12/31 2002, doi: 10.1016/S1366-7017(02)00040-5.

[28] M. Miller *et al.*, "The impact of staffing structures in long-term care homes on the quality of work-life and work outcomes of care-workers: A narrative

scoping review," *International Journal of Nursing Studies,* vol. 174, p. 105304, 2026/02/01/ 2026, doi: https://doi.org/10.1016/j.ijnurstu.2025.105304.

[29] B. Crow and J. McPike, "How the Drudgery of Getting Water Shapes Women's Lives in Low-income Urban Communities," *Gender, Technology and Development,* vol. 13, pp. 43-68, 12/22 2009, doi: 10.1177/097185240901300103.

[30] G. Liu and F. Zhang, "Inequality of household water footprint consumption in China," *Journal of Hydrology,* vol. 612, p. 128241, 07/01 2022, doi: 10.1016/j.jhydrol.2022.128241.

[31] E. Adams, D. Sambu, and S. Smiley, "Urban water supply in Sub-Saharan Africa: historical and emerging policies and institutional arrangements," *International Journal of Water Resources Development,* vol. 35, pp. 1-24, 02/05 2018, doi: 10.1080/07900627.2017.1423282.

[32] B. Majuru, M. Suhrcke, and P. Hunter, "How Do Households Respond to Unreliable Water Supplies? A Systematic Review," *International Journal of Environmental Research and Public Health,* vol. 13, p. 1222, 12/09 2016, doi: 10.3390/ijerph13121222.

[33] E. Thomas, D. Wilson, S. Kathuni, A. Libey, P. Chintalapati, and J. Coyle, "A contribution to drought resilience in East Africa through groundwater pump monitoring informed by in-situ instrumentation, remote sensing and ensemble machine learning," *Science of The Total Environment,* vol. 780, p. 146486, 2021/08/01/ 2021, doi: https://doi.org/10.1016/j.scitotenv.2021.146486.

[34] A. Allen, J. Davila, and P. Hofmann, *Governance of Water and Sanitation Services for the Peri-urban Poor A Framework for Understanding and Action in Metropolitan Regions Governance of Water and Sanitation Services for the Peri-urban Poor*. 2006.

[35] L. Whaley and F. Cleaver, "Can 'functionality' save the community management model of rural water supply?," *Water Resources and Rural Development,* vol. 9, pp. 56-66, 2017/06/01/ 2017, doi: https://doi.org/10.1016/j.wrr.2017.04.001.

[36] D. C. Ferreira, I. Graziele, R. C. Marques, and J. Gonçalves, "Investment in drinking water and sanitation infrastructure and its impact on waterborne diseases dissemination: The Brazilian case," *Science of The Total Environment,* vol. 779, p. 146279, 2021/07/20/ 2021, doi: https://doi.org/10.1016/j.scitotenv.2021.146279.

[37] E. A. Adams, S. Byrns, S. Kumwenda, R. Quilliam, T. Mkandawire, and H. Price, "Water journeys: Household water insecurity, health risks, and embodiment in slums and informal settlements," *Social Science & Medicine,* vol. 313, p. 115394, 2022/11/01/ 2022, doi: https://doi.org/10.1016/j.socscimed.2022.115394.

[38] R. I. McDonald *et al.*, "Water on an urban planet: Urbanization and the reach of urban water infrastructure," *Global Environmental Change,* vol. 27, pp. 96-105, 2014/07/01/ 2014, doi: https://doi.org/10.1016/j.gloenvcha.2014.04.022.

[39] K. De Guzman *et al.*, "Drinking water and the implications for gender equity and empowerment: A systematic review of qualitative and quantitative evidence," *International Journal of Hygiene and Environmental Health,* vol. 247, p. 114044, 2023/01/01/ 2023, doi: https://doi.org/10.1016/j.ijheh.2022.114044.

[40] A. Cassivi, E. Tilley, E. O. D. Waygood, and C. Dorea, "Evaluating self-reported measures and alternatives to monitor access to drinking water: A case study in Malawi," *Science of The Total Environment,* vol. 750, p. 141516, 2021/01/01/ 2021, doi: https://doi.org/10.1016/j.scitotenv.2020.141516.

[41] P. Hofmann, "Toward equitable urban water supply and sanitation in Dar es Salaam: The dialectic relationship between policy-driven and everyday practices," *Utilities Policy,* vol. 78, p. 101395, 2022/10/01/ 2022, doi: https://doi.org/10.1016/j.jup.2022.101395.

[42] G. Assefa *et al.*, "Assessing the effects of menstrual hygiene, water, and sanitation on girls' academic performances in public schools, Ethiopia," *Journal of Water, Sanitation and Hygiene for Development,* vol. 15, pp. 192-205, 02/27 2025, doi: 10.2166/washdev.2025.233.

[43] K. Degefa, L. Schneider, F. Colombijn, and K. Teji Roba, "Social and Cultural Barriers and Facilitators Affecting Mothers' Dietary Practices in Eastern Ethiopia: A Qualitative Study," *Current Developments in Nutrition,* vol. 9, no. 12, p. 107602, 2025/12/01/ 2025, doi: https://doi.org/10.1016/j.cdnut.2025.107602.

[44] J.-M. Mukiese Nlunda, C. Sangana, and G. Kiyombo, "Burden of Musculoskeletal Pains and Injuries from Water-Carrying Among School-Going Adolescent Girls in Kinshasa's Peri-Urban Settings, Democratic Republic of Congo," *European Journal of Development Studies,* vol. 4, pp. 52-61, 05/13 2024, doi: 10.24018/ejdevelop.2024.4.3.341.

[45] E. A. Chance and I. Sardi Abdoul, "The roles and contributions of women to the health of their families and household economics in rural areas in the district of Mbe, Cameroon," *Social Sciences & Humanities Open,* vol. 11, p. 101456, 2025/01/01/ 2025, doi: https://doi.org/10.1016/j.ssaho.2025.101456.

[46] P. Michael *et al.*, "Can men unburden women from unpaid care work? Evidence from Burundi," *CABI Agriculture and Bioscience,* vol. 6, 02/11 2025, doi: 10.1079/ab.2025.0008.

[47] G. Assefa *et al.*, "Gender Equality and Social Inclusion in Relation to Water, Sanitation and Hygiene in the Oromia Region of Ethiopia," *International Journal of Environmental Research and Public Health,* vol. 18, p. 4281, 04/17 2021, doi: 10.3390/ijerph18084281.

[48] G. Villamor, "Gender and Water-Energy-Food Nexus in the Rural Highlands of Ethiopia: Where Are the Trade-Offs?," *Land,* vol. 12, p. 585, 02/28 2023, doi: 10.3390/land12030585.

[49] J. Winter, G. Darmdstadt, and J. Davis, "The role of piped water supplies in advancing health, economic development, and gender equality in rural communities," *Social Science & Medicine,* vol. 270, p. 113599, 01/14 2021, doi: 10.1016/j.socscimed.2020.113599.

[50] S. L. Young *et al.*, "Perspective: The Importance of Water Security for Ensuring Food Security, Good Nutrition, and Well-being," *Advances in Nutrition,* vol. 12, no. 4, pp. 1058-1073, 2021/07/01/ 2021, doi: https://doi.org/10.1093/advances/nmab003.

[51] M. Addisie, T. Gelaye, and M. Dakarasha, "Households' reluctance to collect potable water from improved sources, Ethiopia," *Journal of Water Supply: Research and Technology-Aqua,* vol. 70, 07/02 2021, doi: 10.2166/aqua.2021.158.

[52] D. Adugna, "Challenges of sanitation in developing counties - Evidenced from a study of fourteen towns, Ethiopia," *Heliyon,* vol. 9, p. e12932, 01/20 2023, doi: 10.1016/j.heliyon.2023.e12932.

[53] C. de Freitas and G. Martin, "Inclusive public participation in health: Policy, practice and theoretical contributions to promote the involvement of marginalised groups in healthcare," *Social Science & Medicine,* vol. 135, 06/30 2015, doi: 10.1016/j.socscimed.2015.04.019.

[54] J. Jia, A. Snider, A. Collishaw, P. E. McNamara, and E. Tumusiime, "Pathways linking WASH access and women's empowerment: Evidence from Zambia and Honduras," *Journal of Rural Studies,* vol. 116, p. 103602, 2025/05/01/ 2025, doi: https://doi.org/10.1016/j.jrurstud.2025.103602.