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Water Availability, Demand and Distribution in Kimng'oror Water Project in Nandi County

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Abstract

Access to adequate and reliable water remains a challenge in many rural areas of Kenya, limiting household use and agricultural productivity. In Kimng'oror Water Project, Nandi County, households experience inconsistent supply despite the existence of piped water systems, raising concerns about water availability, demand and equitable distribution. The objective of this study was to assess the status of water availability, analyze household demand, and examine distribution mechanisms within the project area. The study employed a cross-sectional quantitative research design. Data were collected from 240 households selected through cluster and simple random sampling across four sub-areas: Kimng'oror, Kapter, Koiban, and Kapkoimur. Structured questionnaires were used to gather data, while descriptive and correlation analysis were performed using SPSS version 26. The findings revealed that while 67.5% of residents considered the water supplied by the project sufficient for daily use, 62.8% expressed doubt about the system's ability to meet future domestic and agricultural needs. Only 24.2% of respondents viewed existing infrastructure as adequate for storage and distribution. Water availability was strongly related to demand ($r = 0.684$, $p < 0.01$) and moderately linked to distribution ($r = 0.592$, $p < 0.01$), while the strongest relationship emerged between demand and distribution ($r = 0.721$, $p < 0.01$). This indicates that as availability improves, demand rises, and growing demand directly pressures the distribution system to expand and adapt, influencing the overall sustainability of the project. The study concludes that although the Kimng'oror Water Project has improved access to piped water, supply remains insufficient and unevenly distributed. It recommends strengthening storage and distribution infrastructure, promoting sustainable catchment practices, enhancing community participation in planning and governance and adopting long-term strategies to align water supply with rising demand.

Keywords: Water availability, water demand, water distribution, Kimng'oror Water Project, Kenya

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Introduction

Globally, access to clean and safe water remains a critical challenge, despite being one of the most essential resources for human survival, economic development, and environmental sustainability (Ritchie, 2021). The vast majority of the world's population, roughly 90%, relies on basic drinking water sources that are accessible within a 30-minute round trip (Nilsson et al., 2021). However, over 400 million people still grapple with significant water scarcity, which falls far short of the global target of 96% universal access set for 2030 (Nyika & Dinka, 2023). The demand for water has steadily increased due to rapid population growth, urbanization and expanding agricultural and industrial activities (Sarker et al., 2021; Agrawal, Panda & Bhuyan, 2021). At the same time, the water supply is under immense pressure from climate variability, pollution, and the depletion of freshwater sources (Şen, 2021). Many regions experience seasonal shortages, while others face long-term scarcity because of the over-extraction of both surface and groundwater. Infrastructure gaps further complicate access, leaving millions dependent on unsafe or distant water sources. Even in areas with physically sufficient water, poor management, unequal distribution, and financial constraints severely limit the capacity to meet this rising demand further hindering progress toward Sustainable Development Goal 6 on clean water and sanitation (Mukheibir, 2010).

According to the 2023 Africa Sustainable Development Report, 411 million Africans still lack access to safe water (United Nations Development Programme, 2023). Despite the region's rich network of rivers, lakes, and aquifers, access to clean water remains uneven, with rural communities particularly disadvantaged. Population growth, rapid urbanization, and expansion of agricultural activities have significantly increased water demand, while infrastructure development has not kept pace (Lufumpa & Yepes, 2017). Many rural households still rely on rivers, shallow wells, and rainwater harvesting, which are often seasonal and prone to contamination (Edokpayi et al., 2018). Further, frequent breakdown of pumping systems, inability to afford user fees, and

weak governance structures often force communities to revert to unsafe sources. These barriers compromise sustainability and highlight the importance of community participation in water planning, monitoring, and management (Akinbile et al., 2019).

In Kenya, water access remains a significant challenge despite its recognition in the Constitution of 2010 as a basic human right (Loen & Gloppen, 2021). Rural communities rely on multiple and unreliable sources, often seasonal and contaminated, while government and community water projects face hurdles of rising demand, poor infrastructure, and uneven distribution (Waithaka et al., 2016). Local institutions frequently lack trained personnel and sufficient resources to manage supply effectively.

Nandi County receives high rainfall and has several rivers, yet many households still rely on surface water, shallow wells, and rainwater harvesting, which become inadequate during dry seasons. To address this, the community, with support from the Anglican Church and the Water Services Trust Fund, established the Kimng'oror Water Project in 1987. The project now serves over 330 households within a 9 km radius through reservoirs and storage tanks, improving access to safe drinking water and supporting social and economic activities such as farming, education, and health services. However, demand has continued to outpace supply due to population growth, expansion of agriculture, and increased infrastructure needs. Seasonal variability and uneven distribution mean that households near main lines benefit more than those farther away, while many still supplement piped water with rivers and rainwater. Although management structures exist, challenges of availability, reliability, equity and community participation persist, raising sustainability concerns. This study therefore seeks to examine water availability, demand and distribution in the Kimng'oror Water Project.

Empirical Review

The global water crisis is shaped by increasing demand, uneven distribution, and limited availability of finite freshwater resources. Although 71% of the Earth's surface is covered by water, only 2.5% is freshwater, and much of this is trapped in glaciers and ice caps, making it inaccessible for direct human use (Khilchevskyi & Karamushka, 2021). Recent analyses show that while there has been progress in household access to safely managed drinking water since 2015, large gaps remain in terms of water safety, reliability, and equity. The State of the World's Drinking Water report emphasizes that over two billion people still lack safely managed drinking water and that contamination, intermittent supply, and inequitable distribution persist (WHO/UNICEF, 2022). Furthermore, climate-driven hydrological changes such as prolonged droughts and extreme floods are increasingly undermining predictable supply and intensifying demand competition between agriculture, industry, and urban users (WMO; WHO, 2024). Empirical household surveys and geospatial studies reveal that most households worldwide rely on multiple water sources piped connections, boreholes, surface water, and rainwater. Service distance, reliability, and affordability remain the strongest determinants of household water insecurity (WHO/UNICEF, 2022). These studies consistently link unequal proximity to piped networks and supply intermittency to reliance on unimproved sources and heightened health risks among marginalized populations (WHO/UNICEF, 2022; WHO, 2024).

Empirical research also shows that water demand is growing more rapidly in developing nations compared to

developed ones, driven by population growth, urbanization, and economic expansion (Talat, 2021). Climate change further accelerates this challenge by altering precipitation patterns, creating more water-stressed regions worldwide. As a response, countries are increasingly exploring alternative sources such as desalination and wastewater reuse to meet their needs (UNEP, 2024). However, the expansion of these solutions remains uneven, with developing regions struggling to implement large-scale technologies due to financial and institutional limitations.

In Sub-Saharan Africa, access to safe drinking water remains a critical challenge, with over 1.42 billion people including 450 million children living in areas of high or extreme water vulnerability (UNICEF, 2024). Empirical studies demonstrate that while infrastructure development is essential, many water projects are unsustainable due to frequent system failures and poor management. For example, a large proportion of handpumps are non-functional at any given time, leaving communities without reliable access (Gashaw, 2023). Reviews of rural schemes across the region reveal persistent rural–urban inequalities, high system non-functionality, and vulnerability to governance failures (Anghileri et al., 2024). Many rural projects rely on low-cost technologies such as handpumps, small piped schemes, and rainwater harvesting systems. However, these systems often face frequent mechanical breakdowns, long repair delays, and inadequate funding, forcing households to revert to unsafe water sources. Weak institutional capacity, underfunded operation and maintenance (O&M), and poor tariff collection further undermine distribution equity and reliability (Anghileri et al., 2024). Household surveys confirm that distance to water points, seasonal fluctuations, and user fees are critical predictors of supply interruptions and reliance on unsafe alternatives. Empirical findings also show that community-based management improves outcomes when supported by training, financial resources, and clear governance roles.

Kenya, like many African nations, is classified as a water-scarce country, with less than 1,000 m^3 of renewable freshwater available per capita annually. Approximately 80% of the country is arid or semi-arid land, yet only about 15% of its safe water resources are developed (World Bank, 2024). High population growth, rapid urbanization, and increasing climate variability exacerbate water stress (Nyika & Dinka, 2023). The Ministry of Water and Irrigation (2019) reported that only 13–19% of the potential surface water resources have been exploited, pointing to underdevelopment of available supply. Rainfall variability further heightens the risk of rivers and reservoirs drying up. Unequal distribution of resources contributes to riparian degradation, land use conflicts, and localized scarcity. Rising demand on surface water, driven by population growth, is leading to ecological imbalance and deterioration in social well-being. Inefficiencies in conveyance systems and poorly maintained infrastructure also contribute to significant water losses. Empirical evidence demonstrates that Kenya faces widening gaps between water demand and supply. For example, a recent analysis in Mua Hills Settlement, Machakos County, confirmed that demand already exceeds supply, with groundwater being depleted faster than recharge rates. The study recommended stormwater harvesting as an alternative to meet household demand (Nduku, 2024). Similarly, earlier findings revealed that although rural water access has improved, the proportion of urban residents with piped water has been declining, with many households left dependent on

unreliable or contaminated sources due to poor system maintenance (UNICEF & WHO, 2015). Recent household-level research has also highlighted the persistence of water insecurity. A multidimensional study showed that rural households are significantly more deprived than urban households, with safety, affordability, and adequacy of water as the strongest determinants of insecurity (Njoroge, Smith & von Fintel, 2024). In Nairobi, spatio-temporal studies have demonstrated inequalities in distribution, with neighbourhood income levels, population density, and infrastructure age influencing water sufficiency. High levels of non-revenue water further weaken supply reliability (Mutono, Wright, Mutembei, & Thumbi, 2021). Water access challenges have prompted households to adopt coping mechanisms. In Machakos, for instance, rainwater harvesting has become an important adaptation strategy, with households that invested in rooftop harvesting experiencing improved water reliability compared to those reliant solely on piped or borehole sources (Kyalo, 2018). Moreover, community-based management has been identified as a key determinant of project performance. A study in Machakos County found that community empowerment enhances project implementation and sustainability, while lack of involvement in decision-making weakens outcomes (Wambui, Rambo, & Maitho, 2024).

Methodology

The study was carried out within the Kimng'oror Water Project (Figure 1) in Nandi County, located in the North Rift region of Kenya between latitudes 0°56′N and 0°11′S, and longitudes 34°45′E and 35°25′E. The county covers an area of 2,855.8 square kilometers. It shares boundaries with Kakamega County to the west, Uasin Gishu to the northeast, Kericho to the southeast, Kisumu to the South, and Vihiga to the southwest.

Figure 1: Kimng'oror water plant - water reservoir
Source: Field data, 2024

A cross-sectional design was adopted because it captures multiple variables at a single point in time while remaining cost-effective and time-efficient. The study targeted households in the Kimng'oror area, which has approximately 5,540 residents and an average household size of 4.4. Data were collected from adults aged 18 years and above, as they are most knowledgeable about household water use patterns. Most households in the area depend on farming as their primary occupation and utilize several of water sources, including piped water, rainwater, and rivers. Using Cochran's formula for large populations, a sample size of 240 adult respondents was determined. Cluster sampling was applied to divide the study area into four clusters: Kimng'oror, Kapter, Koiban, and Kapkoimur. Within these clusters, households were selected through simple random sampling to minimize bias. Primary data were collected using structured questionnaires administered face-to-face with respondents, with the assistance of trained research assistants. The

questionnaires contained closed-ended items organized around the key study objectives on water availability, demand, and distribution. A five-point Likert scale was used to measure respondents' opinions on issues such as adequacy of water supply, infrastructure, and participation in water distribution. The questionnaires were pre-tested for validity and reliability through expert review and a test-retest approach with a small sub-sample to ensure consistency in responses. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize demographic details and household water use characteristics. Inferential statistics, particularly correlation analysis, were applied to assess the relationships between water availability, demand, and distribution.

Results and Discussion

Demographic information of participants

During the administration of the questionnaires, participants provided their demographic information such as gender, marital status, age, income level and level of education. Table 1 summarizes their responses.

Table 1: Demographic information of the respondents

Variable		Frequency	Percent (%)
Gender	Male	102	44.15
	Female	129	55.84
Age	18-35	56	24.24
	36-45	97	41.99
	Over 45	78	33.76
Marital status	Single	61	26.41
	Married	144	62.33
	Widowed	21	9.09
	Divorced	5	2.16
Level of education	Never went to school	8	3.46
	Primary school	33	14.28
	High school	114	49.35
	Post-secondary education	76	32.90
Core occupation	Farmer	133	57.57
	Civil servant	34	14.72
	Trader	40	17.32
	Artisan	24	10.38
Household income level (Kshs/year)	Below 50,000	67	29.00
	50,001 – 100,000	99	42.85
	100,001 – 200,000	53	22.94
	Above 200,000	12	5.19

Source: Field data, 2024

Table 1 indicates that 55.84% (129) of the participants were female, while 44.15% (102) were male. This shows that women were more readily available within the homesteads compared to men. Culturally, women take up household chores and responsibilities within the home, which explains their higher presence. Regarding age, most participants were between 31–45 years,

accounting for 42% (97), followed by those above 45 years at 33.76% (78). In terms of marital status, the majority, 62.33% (144), were married, while a minority, 2.16% (5), were divorced.

The level of education revealed that nearly half of the participants, 49.35% (114), had completed high school, while only a few, 3.46% (8), had never attended school. A significant number, 32.9% (76), had post-secondary education, which included university degrees, college diplomas, and vocational training certificates. Regarding income, 42.85% (99) reported earning between Kshs. 50,001 and 100,000 annually, while only 5.19% (12) earned more than Kshs. 200,000 per year. With respect to occupation, the majority, 57.57% (133), were farmers, followed by traders at 17.32%, civil servants at 14.72%, and artisans and craftsmen at 10.38%.

Water Resource Availability in Kimng'oror Area

Table 2 presents findings on the availability of water resources in the study area. It indicates the main sources of water accessed by households and the extent to which these sources meet domestic and livelihood needs.

Table 2: Water resource availability

Statement	Condition	Frequency	Percent (%)
Knowledge of existing water resource in the locality	Yes	123	53.24
	No	108	46.75
The quality and quantity of water supplied by Kimng'oror water project is sufficient for your daily use	Yes	156	67.53
	No	75	32.46
Future water quantity to meet domestic and agricultural use	Yes	86	37.22
	No	145	62.77
Water infrastructure is sufficient to store and distribute water	Yes	56	24.24
	No	175	75.75
Kimng'oror water resources are being managed and exploited well	Yes	112	48.48
	No	119	51.51

Source: Field data, 2024

Majority of the participants 53.24% (123) said that they were knowledgeable and informed about the existing water resource management policies including extraction, management of catchment areas and payment of water services rendered. The study also indicates that a significant proportion of rural residents were unaware of the water resource use policies, management and exploitation. Most of the study participants 67.53% (156) agreed that the quality and quantity of water supplied by Kimng'oror water project was sufficient for their daily use. On the other hand, 32.46% of them did not believe that the water quality and quantity supplied by Kimng'oror water project was sufficient for their daily use. Surprisingly, 62.77% (145) of the participants said that water quantity unlikely to meet future domestic and agricultural use. It implied that existing water resources is insufficient to meet future domestic and agricultural needs of the population. Moreover, more than three quarters of the participants had not attended any training, seminars or workshops in water related issues. Only 24.24% (56) of them mentioned that the existing water infrastructure is sufficient to store and distribute water. On

management of the water project and exploitation of Kimng'oror water resources, the participants were indifferent implying that they did not consider water resources were being well or poorly managed and exploited. Studies on rural Kenya suggest that when people feel excluded from decision making or monitoring, water projects deteriorate faster and suffer higher non-revenue losses (Mutono et al., 2021; Njoroge et al., 2024).

Water Resource Demand in Kimng'oror area

Table 3 presents the findings on rural water resource demand in the Kimng'oror area.

Table 3: Rural Water Resource Demand in Kimng'oror Area

Statement	Mean	Std. Dev.
Water supply is reducing because water is being over-exploited and mismanaged	1.98	0.786
Overuse of surface water has lowered the water table in the past years	2.14	0.721
The ever increasing population is exerting pressure or demand over existing surface water resources	2.67	0.885
Inadequate catchment management has limited surface water availability in the recent years	3.98	0.876
The project water supply is reliable and meets consumer needs	4.32	0.789
Geographical demand and pricing of water outlets is increasing the burden of effective water resource exploitation	4.08	0.762

Source: Field data, 2024

From the Table 3 above, participants were of the view that the project water supply was reliable and met consumer needs (Mean = 4.32, SD = 0.789). They also decried the low allocations and high pricing of water that is discouraging effective water resource exploitation (Mean = 4.08, SD = 0.762). The participants did not think that there was water overuse (Mean = 2.14, SD = 0.721) or population explosion pressure in the area (Mean = 2.67, SD = 0.885) which negative affected existing surface water resource. There was also concern over inadequate catchment management (Mean = 3.98, SD = 0.876) which had limited surface water availability in recent years. Nevertheless, the participants did not think that water supply is reducing because water is being over-exploited and mismanaged (Mean = 1.98, SD = 0.786).

Regarding water resource exploitation in Kimng'oror, the project water supply was reliable and met consumer needs. Even though there were low water allocations and high pricing of water, it has not discouraged effective water resource exploitation. Water supply was not reducing because water is not being over-exploited and mismanaged. The participants did not think existing surface water resource exploitation was being affected by water overuse or population explosion pressure in the area. However, inadequate catchment management had limited surface water availability in recent years. These perceptions mirror broader Kenyan evidence showing that supply reliability can coexist with infrastructural losses, uneven distribution and governance gaps factors that raise costs and limit equitable access (Mutono et al., 2021).

Water distribution in Kimng'oror area

Understanding how water is distributed within Kimng'oror is key to assessing both equity of access and sustainability of the water project. The findings are shown in the Table 4.

Table 4: Water distribution in Kimng'oror area

Statement	Mean	Std. Dev.
Participating in identifying the best sources of water supply	1.56	0.834
Participation in monitoring of water supply systems including pipes, pumps and storage facilities	2.46	0.802
Involvement in reporting leakages and vandalism of pumps and pipes	3.96	0.785
Attending monitoring and evaluation (M&E) on future demand and potential shortages	2.12	0.879
Participation in meetings on policies, regulation and management strategies	1.45	0.654
Public education on sanitation, water conservation and management of groundwater resources	3.24	0.768

Source: Field data, 2024

As shown in the Table 4 above, participants mentioned higher involvement (Mean = 3.96, SD = 0.785) in reporting leakages and vandalism of water pipes and pumps. There was also significant involvement (Mean = 3.24, SD = 0.768) in suggesting public education on sanitation, water conservation and management of groundwater resources. However, locals were least involved in meetings on policies, regulation and management strategies (Mean = 1.45, SD = 0.768) and identifying the best sources of water supply (Mean = 1.56, SD = 0.834). It shows that the project involves the local people the most in aspects of safety and maintenance such as leakages and vandalism as well as instances requiring corrective action and improvements.

These findings were consistent with a study conducted in Kisumu by Miseda and Nyonje (2014), which showed that community involvement in M&E through sharing information, using shared information, and conducting project evaluation activities greatly influenced the sustainability of water projects. According to the author, community involvement guarantees the continuity of the project, it is critical that monitoring and evaluation information systems be put in place and that this information is readily available to all stakeholders.

Additionally, it supports the findings of Oino *et al.* (2015), who showed that community involvement affected the sustainability of rural piped water delivery systems. Because project life cycle management is positively correlated with the sustainability of water supply projects, it is necessary that communities understand the significance of their involvement, contribution, and participation in this process, particularly with regard to monitoring and evaluation.

Correlation Analysis of Water Availability, Demand, and Distribution

Correlation analysis was carried out to establish the strength and direction of the relationship between water availability, water demand, and water distribution in the Kimng'oror Water Project. The results are presented in Table 5.

Table 5: Correlation matrix of water availability, demand and distribution

Variables	Water Availability	Water Demand	Water Distribution
Water Availability	1.000		
Water Demand	0.684	1.000	
Water Distribution	0.592	0.721	1.000

Source: Field data, 2024

The correlation results reveal important dynamics between water availability, demand, and distribution in the Kimng'oror Water Project. The strong positive relationship between water availability and demand ($r = 0.684$, $p < 0.01$) confirms that increasing supply encourages more households, schools, and community facilities to depend on the project. This mirrors findings from Nduku (2024), who reported that in Machakos County, growing demand rapidly outpaces supply where reliable sources exist, leading to groundwater depletion. Similarly, the World Bank (2024) and Nyika & Dinka (2023) note that in water-scarce regions like Kenya, population growth and urban expansion amplify demand whenever supply sources improve. The moderate positive correlation between availability and distribution ($r = 0.592$, $p < 0.01$) highlights that while improved water supply enhances distribution efficiency, access inequities persist, especially for households far from pipelines. This aligns with observations from Waithaka et al. (2016), which emphasize that conveyance inefficiencies and distance from supply points often limit equitable access in rural Kenya. The strongest correlation between demand and distribution ($r = 0.721$, $p < 0.01$) illustrates that rising demand directly pressures distribution systems to adapt and expand. This is consistent with Maino (2011) and Marks (2012), who found that increasing household reliance on piped water systems in rural communities frequently overwhelms infrastructure, resulting in breakdowns or reduced service reliability. Studies across Sub-Saharan Africa (Anghileri et al., 2024) also confirm that distribution networks face stress from population growth, weak maintenance, and underfunded operations, which compromise sustainability.

Conclusion

Based on the findings, the study concludes that while the Kimng'oror Water Project provides a reliable supply for current daily use, its long-term sustainability is at significant risk. The key challenges are not perceived to be water overuse or population pressure, but rather the inadequacy of existing infrastructure and a lack of community empowerment in strategic decision-making. The majority of residents expressed a strong concern that current water quantity and infrastructure are insufficient to meet future domestic and agricultural needs, with over three-quarters of participants stating the infrastructure is not sufficient. While community members are highly engaged in reactive tasks such as reporting leaks and vandalism, their participation is notably low in crucial strategic areas, including policy meetings, management strategies, and project monitoring and evaluation. This low level of strategic involvement, coupled with delays in repairing systems, has led to a significant amount of non-revenue water and undermines the overall sustainability of the project. The strong positive correlations found between water availability, demand, and distribution further underscore that for the project to succeed, improvements in one area, particularly infrastructure and management, will positively impact the entire system.

Recommendations

To ensure the long-term sustainability of the Kimng'oror Water Project, several key recommendations are proposed. First, there is a critical need to invest in upgrading and expanding water infrastructure to increase storage and improve the distribution network, directly addressing the community's primary concern about future water availability. Concurrently, efforts should be made to enhance community empowerment and participation beyond reactive maintenance. This can be achieved by creating formal, structured platforms for residents and leaders to participate in policy formulation, financial oversight, and long-term planning, fostering a genuine sense of ownership and accountability. Finally, a review of the current water pricing and allocation model is recommended to ensure it is both equitable and sustainable.

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