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Movable and Immovable Modes of Potable Water Storage and Distribution in Rural, Peri-Urban and Urban Areas in Uasin Gishu and Nandi Counties in Kenya, East Africa

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Abstract:
In developing counties, especially in Africa, the storage and distribution of clean and safe water for domestic consumption remain a great challenge. The current study investigated the various modes of storing and distributing potable water in a classical African setting. Potable water is majorly stored and distributed in two modes, i.e., movable and immovable. Selection is determined by several factors, i.e., geographical locality (rural/urban), water infrastructure, distance to the water source and water morbidity, economic disposition, and cultural considerations. Cultural beliefs and norms dictate certain modes of storage and distribution that are assigned along gender lines. The availability of certain animals, i.e., beasts of burden in some geographical localities, also influenced the selected mode. To determine the various modes of storing and distributing potable water in Uasin-Gishu and Nandi Counties in Kenya, a total of (50) subject respondents were purposefully identified and interviewed using an on-spot questionnaire. The sampling of respondents considered diverse demographical considerations, e.g., age bracket, educational background, and profession. The respondents were assured of confidentiality in the responses submitted. The results obtained were analysed using statistical methods and presented using frequencies, graphs, and pie charts as follows:

Movable modes
Overhead water pipeline, 19%;
Water Boozer, 5%;
Hand Carts, 8%;
Beasts of burden, 15%;
Pick-up/lorry (tanks), 9%;
Motorcycle, 17%;
Manual (head), 21%;
Rollable water container, 4%;
Water tunnel, 1%;
Underwater pipeline, 1%.

Immovable modes
Jerricans, 8%
Containers, 3%
Calabash/gourd, 1%
Water jug, 6%
Dispenser, 4%
Traditional pot, 11%
Overhead steel tank, 14%
Household tanks, 53%

The findings indicate that the household tank (53%) is the main mode of immovable potable water storage, and the manual-head (21%) is the main mode of movable potable water distributed in Nandi and Uasin Gishu Counties.

Keywords: *Movable, immovable, potable water, distribution, Uasin Gishu County, Nandi County*

1. Introduction

1.1. Water as a Scarce of Critical Natural Resource

Across the developing world, including Kenya, the availability and distribution of clean water have a vital role in the socio-economic status of African societies (UNICEF/WHO, 2016). According to UNESCO (2012), the population of the continent of Africa is expected to hit 1.4 billion inhabitants by mid-2023. This increase in population will place enormous strain on the already over-exploited water resources (WHO/UNICEF, 2012). Estimates by WHO (2012) show that in Sub-Saharan Africa (SSA), about 39% of the population have water connected to their homes – and in the rural and peri-urban areas, the figure drops to just 19% (United Nations, 2012). This indicates that 1 in 3 Africans are directly impacted by water scarcity, translating to at least 400 million people lacking access to clean and safe drinking water (Stephenson & Latham, 2000; WHO, 2012). On average, a citizen in sub-Saharan Africa (SSA) travels 30 minutes daily, sourcing water resources (Gleick, 1996). The main causes of water scarcity in Africa are as follows: deepening poverty, rapid urbanization, rainfall deficit and drought, rapid population growth, and the 'climate crisis' (Berkman & Lescano, 2002; WHO/UNICEF, 2010). The 'water crisis' is a global phenomenon, despite 80% of the Earth's surface being covered by water (Niehaus & Moore, 2002). Governments in Africa are developing strategies to mitigate challenges posed by scarce water sources on the health, well-being, and living standards of their citizens. However, several economic instruments are being used to alleviate this crisis, depending on the availability of sustainable water resources (Dillingham & Guerrant, 2004). The

interdependence between the availability of water resources and development is exemplified by the relationship between water and poverty (UNECA, 2009). As a direct consequence of water scarcity and reduced sanitation, the prevalence of communicable diseases has created a huge disease burden in Africa (Stephenson & Latham, 2000). According to WHO/UN-Water (2012), about 115 people in Africa die every hour from diseases attributed to poor sanitation, poor hygiene, and contaminated water (Dillingham & Guerrant, 2004). The available water resources in Africa are not available at the right time, quality, and quantity (White & Bradley, 1972; UNICEF/WHO, 2016). The availability of water resources in Africa may encounter challenges aggravated by poor and inefficient water storage and distribution methods that include both movable and immovable. These disparities in water management across communities vary greatly between countries on the continent, including Kenya (UN-HABITAT, 2007).

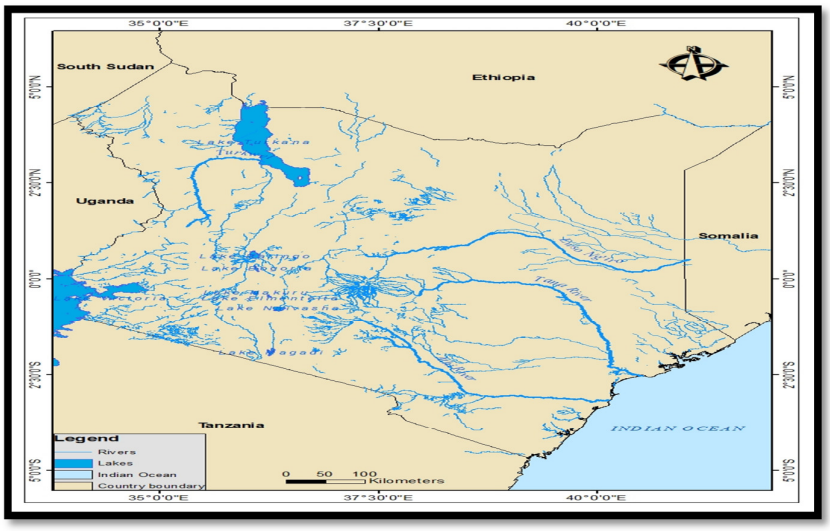

Figure 1: Major Rivers and Lakes in Kenya

Cumulatively Kenya is home to a total of 64 lakes representing 9.5% of Africa's lakes (White & Bradley, 1972; FAO, 2008). The collective volume of water in these lakes is around 20 billion m^3 – heavily influencing the local climate, ecosystem, and biodiversity (UNEP, 2010). Major rivers in Kenya include: Tana, Athi, and Galana in the east and Kerio, Nzoia, Sondu-Miriu, Mara, and Nyando in the west. Small lakes include: Magadi, Turkana, Naivasha, Baringo, Elementata, Nakuru, and Bogoria, located in the Eastern Rift Valley (UNEP, 2010).

1.2. Pollution of Water Resources in Kenya

The majority of the population in Kenya relies on unsanitary sources of water, mainly for domestic use (UN-HABITAT, 2007). These sources include:

- Streams
- Rivers
- Ponds
- Dams
- Stagnant wells
- Lakes
- Springs
- Aquifers, etc

The majority of these water sources are prone to bacterial contamination and pollution (White & Bradley, 1972). Dependence on such water for domestic usage has created the 'water crisis' in Kenya. Studies by Mbui *et al.* (2016) show that many rivers flowing through urban areas in Kenya are contaminated with potentially dangerous concentration levels of lead (Pb), Zinc (Zn), copper (Cu), Manganese (Mn), Iron (Fe) and Chromium (Cr). Additionally, the presence of high levels of Escherichia coli (E. coli), Helicobacter pylori (H. pylori), fecal coliforms, and other forms of enteric bacteria has been detected in a majority of water sources across Kenya (Mbui *et al.,* 2016). Anthropogenic activities, domestic waste that includes raw sewage and municipal waste contribute significantly to the pollution of water resources (UNICEF/WHO, 2016). Outdated agricultural practices result in runoff accessing and contaminating water resources with heavy metals and fertilizers, leading to nutrient pollution of water, and causing algal growth (Carruthers, 1973). These algae reduce the amount of Dissolved Oxygen (DO) in water, thereby harming aquatic life. Estimates show that by the year 20215, Kenya's per capita water availability is projected to drop to 235 m^3, down from 650 m^3 in 2011 (UNECA, 2009).

1.3. Water Resources Regulations Legal Framework in Kenya

According to [article 62] & [article 43. (1)(d) of the Constitution of Kenya, 2010, water resources, i.e., rivers, lakes, and water catchment areas, are held in trust for the people of Kenya by the National Government (Wafula, 2010; Constitution of Kenya, 2010). Furthermore, [Article 204] of the constitution of Kenya, 2010, operationalized the

equalization fund to promote equity in service provisions that includes water services. Access to a safe and steady water supply is a right of every Kenyan citizen under [Article 43] of the constitution. The law also provides access to reasonable sanitation standards that include access to safe water for domestic consumption (Constitution of Kenya, 2010). Access and regulation of water resources are regulated by the [Water Act, 2016 (No. 43 of 2016)] that defines ownership of and defines the rights in water resources of Kenya (Constitution of Kenya, 2010). The legal instrument strengthened the role of the Water Authority (WARMA) established under section 11 of the [Water Act, 2016] as an agent of the National Government to safeguard the right to clean water by ensuring effective regulation of the management and use of water resources, in order to guarantee access to sufficient water by all citizens (Constitution of Kenya, 2010). The [Water Act, 2016 (No. 43 of 2016)] also regulates the provision and designation of national public water works managed by individual sewerage and water treatment bodies at the County levels in Kenya.

2. Modes of Potable Water Distributed in Rural, Peri-Urban & Urban Areas

2.1. Movable Modes

Several modes of potable water storage and distribution are reported to be in use across the developing world and particularly in Sub-Saharan Africa (SSA). In Kenya, the modes vary from one geographical locality to another. The modes are dictated mainly through:

- Income levels
- Terrain
- Socio-cultural considerations

Some modes of potable water distribution are reserved for a specific gender, e.g., carrying water manually-head (Figure 5) is reserved for mainly females. The use of beasts of burden-donkeys (Figure 2), hand carts (Figure 3), and motorcycles (Figure 6) are generally utilized by males. Households and individuals of higher incomes used water boozers (Figure 8) and pick-ups/trucks (Figure 4) to distribute potable water to homes and business premises.

Figure 2: Donkey

Figure 3: Hand Carts

Figure 4: Pick-up Carrying Water Tank

Figure 5: Manual Ferrying Water

Figure 6: Motorcycle

Figure 7: Rollable Water Containers

Figure 8: Water Boozer

Figure 9: Water Tunnels

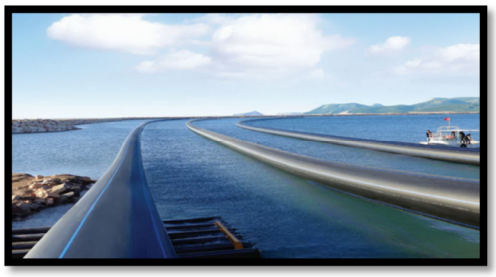

Figure 10: Underwater Pipelines

Figure 11: Overhead Water Pipelines

The various modes of movable potable water distribution in Nandi and Uasin Gishu are shown in figures 2–6 above.

2.2. Immovable Modes

In most developing countries, most modes of potable water storage and distribution result in leakages and the wastage of critical resources. Most of the potable water storage methods reported in the current study, i.e., containers (Figure 13), jugs (Figure 15), and calabash/gourd (Figure 14), are limited in capacity to hold a large volume of the resource. In urban areas, the use of household water tanks (Figure 19) and overhead steel water tanks (Figure 18) was found in many areas across Nandi and Uasin Gishu. In domestic environments (households), the use of water dispensers (Figure 16) was reported as a convenient immovable mode of potable water storage. In rural areas, the Traditional African water pot (Figure 17) was reported to be widely in use in most households.

Figure 12: Jerricans

Figure 13: Container

Figure 14: Calabash-Gourd

Figure 15: Water Jug

Figure 16: Table Water Dispenser

Figure 17: African Traditional Water Pot

Figure 18: Overhead Steel Water Tanks

Figure 19: Household Water Tanks

The figures 7–10 show the various immobile modes of potable water storage in Nandi and Uasin Gishu.

3. Methodology

3.1. Research Question

The research study aimed to identify the various modes of distributing movable and immovable potable water in rural, peri-urban, and urban areas in Uasin-Gishu and Nandi Counties in Kenya.

3.2. Research Design

A total of 25 respondent subjects (male/female) were purposefully identified and interviewed to provide information. The respondents were requested to participate in the study by completing a research questionnaire confidentially. The study used a combination of descriptive survey and naturalistic design methods of data acquisition, employing both qualitative and quantitative approaches in research, and raw data were collected using one questionnaire (Kombo & Tromp, 2006). The researchers purposefully identified potential respondents and requested them to participate in the research study. The instruments of data collection were an on-the-spot questionnaire and interview guide to enhance comprehensive data collection (Kothari, 2004). The obtained raw data were analysed using statistical methods to arrange and summarise the results into frequencies and percentages. Statistical methods were used to analyse, arrange and summarise the raw data obtained into frequencies and percentages. The qualitative data processed was arranged thematically.

3.3. Research Instrument

The raw data were handwritten in the questionnaires before reporting in themes, frequencies, and percentages. The questionnaire was sub-divided into two sub-sections based on the research objective. Each respondent was then expected to respond to questions in the questionnaire. Questionnaires were used for this study because it was the most suitable research instrument for descriptive research design (Kombo & Tromp, 2006). The obtained data were processed using descriptive statistics, i.e., frequencies and percentages, and the results were presented in charts, tables, and graphs.

3.4. Maps of Study Area

3.4.1. Uasin Gishu County

Figure 20 below shows a map of Uasin Gishu County in Kenya.

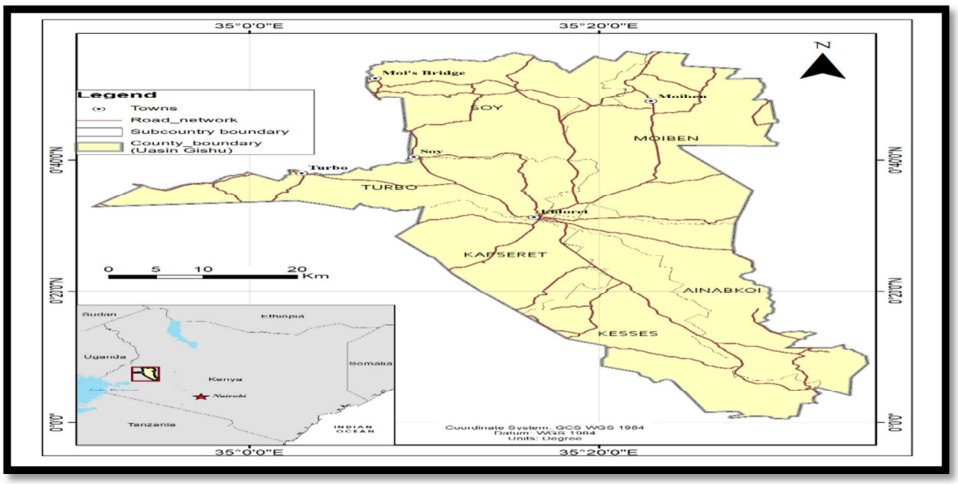

Figure 20: Map of Uasin-Gishu County

Uasin Gishu County is located in the former Rift Valley Province in Kenta and geographically situated in the mid-west. The County headquarters is located in Eldoret town. Uasin Gishu is located on a plateau and has a cool and temperate climate. The area has high and reliable rainfall, relatively large farm sizes, and mechanized farming. According to the Kenya Housing and Population census (2019), Uasin Gishu is inhabited by 2.1 million people.

3.4.2. Nandi County

Figure 21 below shows a map of Nandi County in Kenya.

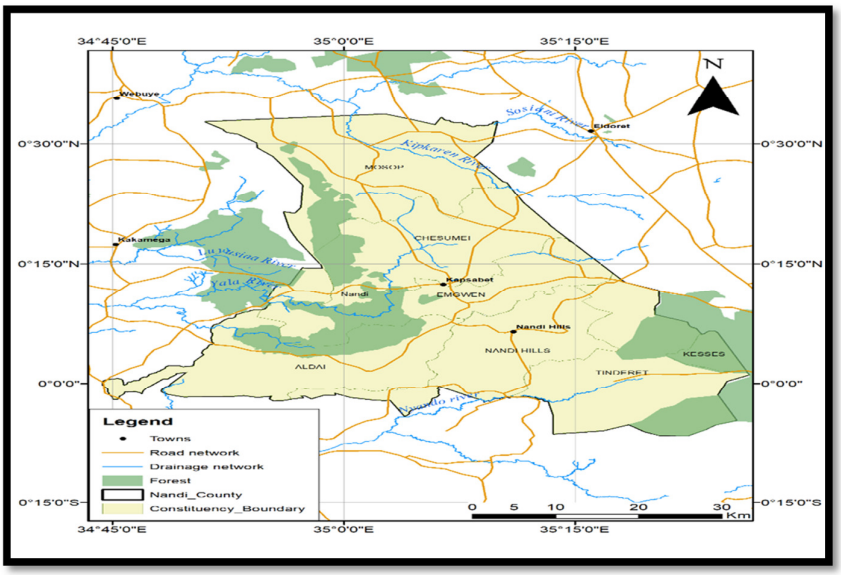

Figure 21: Map of Nandi County

Nandi County is located in the former Rift Valley province in Kenya. The County headquarters is located in Kapsabet town. The County experiences a cool, wet climate with sufficient rainfall. According to the Kenya Housing and Population census (2019), the County population was 885.711.

4. Results and Discussion

4.1. Classification of Respondents by Gender

The respondents that participated in this study were categorized according to their gender and the results are shown in figure 22 below.

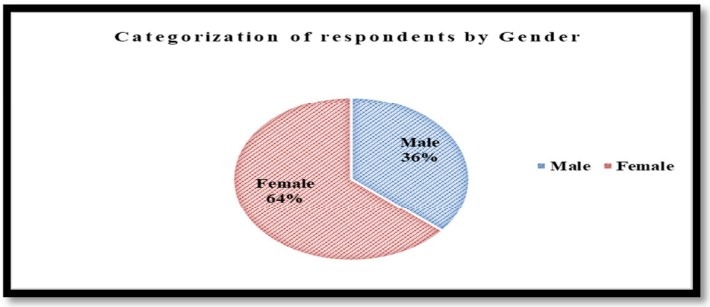

Figure 22: Categorization of Respondents by Gender

From figure 22, the respondents in this study were sampled from both male and female gender to obtain representative data. The respondents in this study were categorized as follows: [(female= 64%, 16 respondents; male=36%, 9 respondents)]. The results show that female respondents were more willing to participate and provide information on the research study, i.e., modes of potable water storage and distribution by an index (28%) in comparison to the male respondents.

4.2. Age Bracket of Respondents

The categorization of respondents according to their age bracket is shown in figure 23 below.

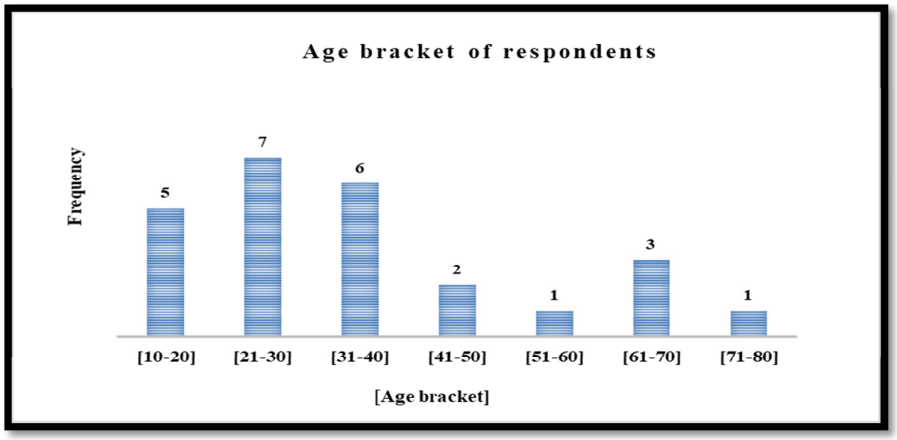

Figure 23: Categorization of Respondents by Age Bracket

The age bracket of the respondents in this study is shown in figure 23. The categorization was determined as follows:

- (10-20)=6 respondents,
- (21-30)=7 respondents,
- (31-40)=6 respondents,
- (41-50)=2 respondents,
- (51-60)=1 respondent,
- (61-70)= 3 respondents,
- (71-80)=1 respondent

The results indicate that a majority of respondents were in the age bracket (21-30) = 7 respondents, while the least number of respondents were in the age brackets (51-60); (71-80), each represented by a single respondent.

4.3. Highest Educational Qualifications of Respondents

The categorization of respondents according to the highest educational qualifications attained is shown in figure 24 below.

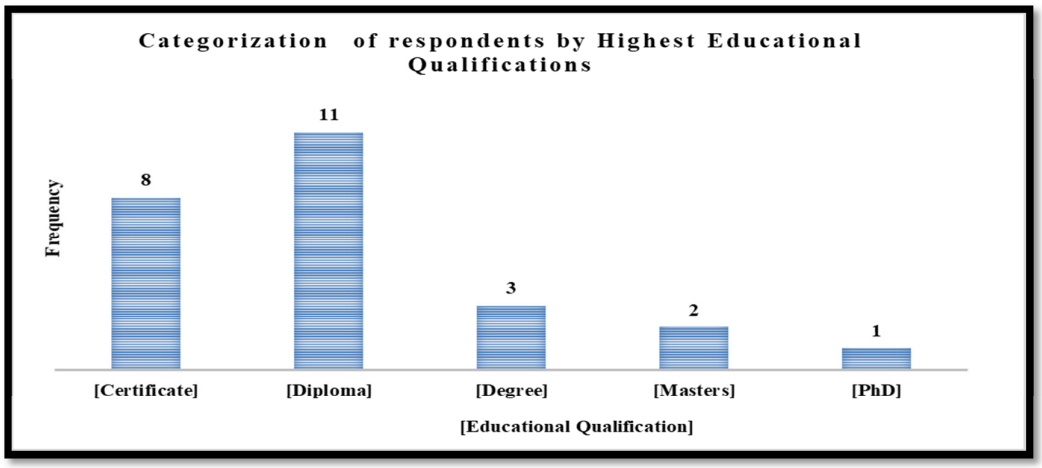

Figure 24: Categorization of Respondents According to the Highest Educational Qualifications Attained

The respondents were categorized according to their highest educational qualifications, and the results are shown in figure 24. The respondents had attained the following educational qualifications:

- (Certificate) = 8 respondents,
- (Diploma) = 11 respondents,
- (Degree) =3 respondents,
- (Masters) = 2 respondents,
- (Ph.D.) = 1 respondent

The results indicate that a majority of respondents had attained a diploma, (11) respondents as the highest educational qualification. The least number of respondents, (1), had attained a Ph.D. qualification.

4.4. Movable Modes of Potable Water Storage and Distribution

The various modes of movable potable water storage and distribution are shown in figure 25 below:

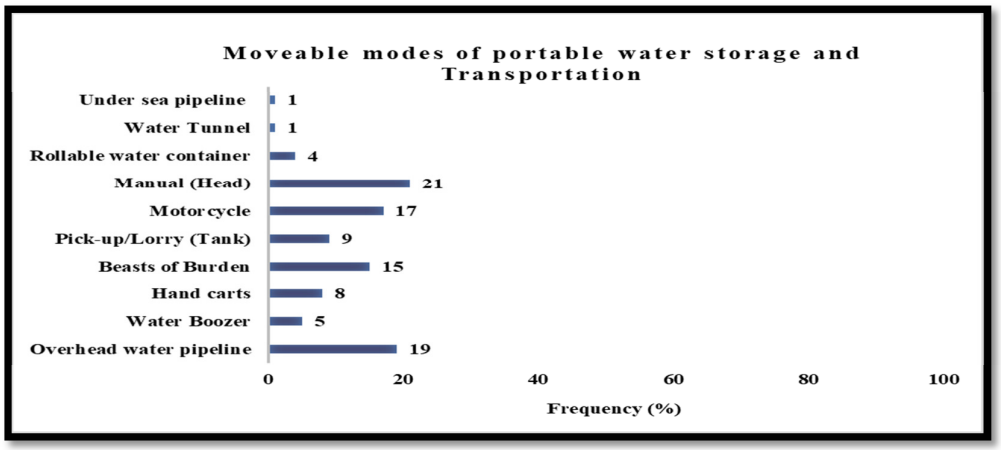

Figure 25: Movable Modes of Potable Water Storage and Distribution

Figure 25 shows the various modes of movable potable water storage and distribution as reported by the respondents in this study. The results were as follows:

- (Overhead water pipeline) = 19%,
- (Water boozer) = 5%,
- (Hand carts) = 8%,
- (Beasts of burden) = 15%,
- (Pick-up/lorry –Tank) = 9%,
- (Motorcycle) = 17%,
- (Manual-head) = 21%,
- (Rolleable water container) = 4%,
- (Water Tunnel) = 1%,
- (Undersea pipeline) = 1%

The results show that the main mode of movable potable water distribution in Nandi and Uasin Gishu counties is (Manual-head), reported by 21% of the respondents.

4.5. Immovable Modes of Potable Water Storage

Figure 26 below shows the various modes of immovable potable water storage.

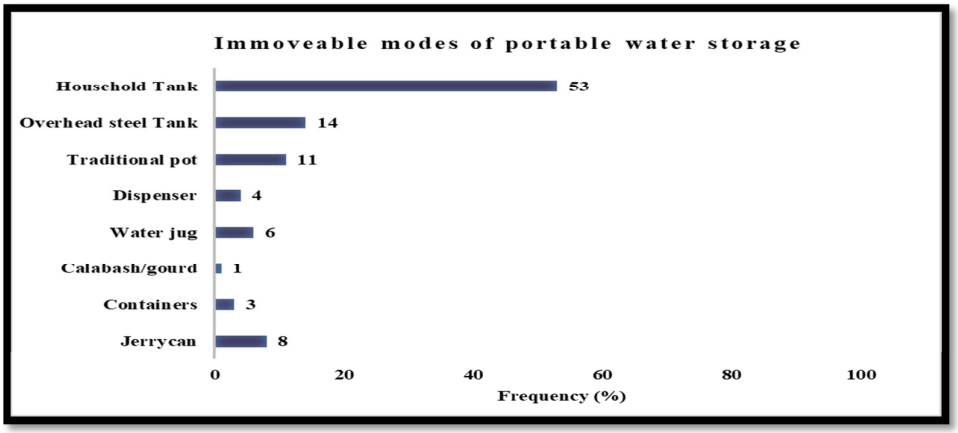

Figure 26: Immovable Modes of Potable Water Storage

Figure 26 shows the various modes of immovable potable water storage as reported by respondents. The results indicate that the various modes are as follows:

- (Jerrycan) = 8%,
- (Containers) = 3%,
- (Calabash/gourd) = 1%,
- (Water jug) = 6%,
- (Dispenser) = 4%,
- (Traditional African pot) = 11%,
- (Overhead steel Tanks) = 14%,
- (Household Tanks) =53%

The findings reveal that the most widely used mode of immovable potable water storage in Uasin Gishu and Nandi Counties was the (Household Tank) = 53%.

5. Conclusions

The study concludes that in Nandi and Uasin Gishu Counties, both modes of water distribution and storage, i.e., movable and immovable, were found to be used widely. The modes selected by the inhabitants were influenced mainly by income levels, terrain, geographical locality, and socio-cultural considerations, e.g., gender. The modes of potable water storage and distribution in urban areas are fairly effective compared to peri-urban and rural areas, where large volumes of water are lost due to ineffective modes of storage and distribution. The communities in this study are faced with a severe 'water crisis' occasioned by depleted water resources and poor distribution infrastructure.

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