Household Coping Strategies for Unreliable Water Supplies in Nzoia River Basin, Kenya

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Abstract: **Nzoia River Basin lies entirely within Kenya along the border with Uganda in the Lake Victoria Basin, and has a population of about 3.7 million people that is rising rapidly with increased water demand. Majority of the people live in rural areas. Unreliable water supplies is a common feature in many developing countries and it threatens the health of millions of people around the world. This study examines the household coping strategies to unreliable water supplies and the factors influencing the choice of strategies in Nzoia River Basin. A cross-sectional research design was used in the study. Three counties were randomly selected from the basin for study with Busia representing the lower catchment, Kakamega middle catchment and Trans Nzoia upper catchment. The study used questionnaire surveys, in-depth expert interviews with selected stakeholders from the water sector, academia and scientists and field observations to examine the Household coping strategies for unreliable water supplies in the basin. Data were analyzed using descriptive statistics. The study identified 18 household coping strategies to unreliable water supplies in the basin. Households use more than one strategy to cope with the problem of unreliable water supplies. There are some strategies which are adopted by large numbers of households whereas the others have only a few households using them. Water storage through storage tanks, roof tanks, drums, pots, buckets and bottles is the most preferred strategy by households followed by collecting water from alternative sources such as springs, rivers, dams and wells; using water sparingly/ limiting water use; treating water through boiling, filtration and chlorination; and drilling wells and boreholes. Strategies like improving water quality; enhancing pressure; rainwater harvesting in the rainy season; installing booster pumps, electrical and hand pumps; installing extra storage space; rescheduling major household activities to when water is available; buying water from neighbors, private tankers, donkey-cart owners, bottled water; moving to another house or area estate with water and community fundraising for construction of water supply are also important to the households in addressing problems of unreliable water supplies in the basin. Other strategies like recycling water; protesting and complaining to authorities; economizing on water use by reduced frequency of baths and economizing on water use by reduced number of meals in a day or altered diet are less important. The choice of household coping strategies used against unreliable water supplies was found to be influenced by socio-economic status: income, education; land tenure and lack of reliability. Unreliable/intermittent water supplies have imposed significant coping burdens to households in the basin. Assessing household coping strategies to unreliable water supplies and the factors influencing the choice of strategies in the basin will provide valuable insights for policy makers, water service providers and national and county governments while planning for improved water supply services. The findings of this study are important to the national and county governments within Nzoia River Basin as it provides a major shift from focusing on water supplies coverage (now widely used in the basin) to improvements in the quality of services anchored on water supplies reliability. This is the focus of the Sustainable development goals, target 6.1, which aims at achieving universal and equitable access to safe and affordable drinking water for all by the year 2030.**

Keywords**: Nzoia River Basin, Household coping strategies, Unreliable water supplies, Factors influencing choice of strategies.**

I. INTRODUCTION

Domestic water supply that is sufficient, reliable, and of good quality is a basic requirement for all human beings. Unsafe domestic water supply is one of the key problems facing developing countries, threatening the health of millions of people around the world. It is projected that improvements in water supply, sanitation, and hygiene could prevent 10% of the overall global burden of disease. Inadequate water supply, sanitation, and hygiene are responsible for 88 percent of diarrhea cases worldwide, resulting in 1.5 million preventable deaths per year, mostly among children. Water supply, sanitation, and hygiene measures can minimize the incidence and prevalence of diarrhea, infectious diseases, and certain vector-borne diseases, as well as infant mortality rates, globally. Improved water supply, sanitation, and hygiene can also save money by lowering medical costs, decreasing mortality, and rising productivity (Pruss-Ustun, et. al., 2015).

In many developing countries, unreliable or intermittent water supply, or water supplied on a sporadic basis, is a common occurrence. Water supply interruptions can last for hours or even days, with the amount of time water is unavailable outnumbering the amount of time it is available. According to the World Bank's online database of utility data (IBNET1), more than 10% of the population in 28 countries has intermittent water supply. In India, for example, 83 percent of the population have unreliable/intermittent water supply, with water available for just 10 hours a day on average. Water is available for one or two hours a few days a week in some cities. There are several drawbacks to having an unreliable/intermittent water source. It causes problems for users, especially the poor who lack the means to store large quantities of water at home. It results in water wastage as consumers leave taps open while waiting for supplies to arrive and then discard the accumulated water once the water is

flowing again. Pressure fluctuations damage pipes and valves, and the changing water levels contribute to corrosion, resulting in higher maintenance costs (Conradin et al., 2010; Christodoulou and Agathokleous, 2012).

Unreliable/intermittent water supply causes capacity constraints (supply scarcity), private water infrastructure investment by households and businesses as a response to supply scarcity, and declining revenues as facilities deteriorate and consumers fail to pay or disengage from the public network. Users cope at the household level by collecting water from hazardous sources such as wells and surface water, buying water from tanker trucks or commercial bottled water, reducing their water intake, pumping to abstract the largest volume of piped water when it is available, and building water storage tanks (Majuru et al., 2016). These coping mechanisms have direct costs and time implications for collection, as well as rescheduling activities based on water availability. To cope, wealthier households spend money, while poorer households spend time or cut back on their consumption (Guragai et al., 2017). Some econometric studies have attempted to measure coping costs, showing that households spend two to five times their current energy bills to deal with intermittency, amounting to 1% to 12% of their monthly income (Cook et al., 2016; Pattanayak et al., 2005; Zerah, 1998). Contaminated water leaking through pipes, cracks and fittings during low-pressure conditions, microbial biofilms that develop under stagnant conditions in pipes and are released during re-pressurization, and contamination during household storage, all contribute to microbial contamination in intermittent supplies (Kumpel ,et.al, 2016).

The lack of systematic longitudinal studies that assess the reduction in coping costs and other impacts following a transition from intermittent to continuous service is a major gap in the literature on unreliable/intermittent water supply (Majuru et al., 2016). As a result, it's unclear how much coping expenses can be turned into payments for better services, as many costs are poured into long-term infrastructure (tanks, pumps), and time savings does not always translate into increased income in high-unemployment areas. However, there are several reasonably straightforward methods for determining a household's willingness to pay (WTP) for a better service. According to Pattanayak et al. (2005), Nepalese households will be willing to pay more than 6 times their coping costs, or 12 times their current utility bill, for a reliable service. These studies will aid in the development of a case for public and private investment in piped water supplies.

According to the available literature, calculating and categorizing intermittency is still a problem that needs to be solved (Majuru et al., 2016). Measurement must go beyond the traditional metrics used by utilities with continuous water supply, such as average hours per week. Guragai et al. (2017) suggest that ‘’at least three measures are needed: frequency of supply (times/week), supply duration (hours/ time), and total supply (hours/week)’’. Surveys should distinguish between rationing that is predictable, supply that is intermittent, and water schemes that are entirely unreliable. ‘’Estimates of household water usage are also essential for determining reduced use during periods of intermittency’’ (Kumpel et al., 2017). Many utilities have made the transition to continuous and consistent service (also known as "24/7" service). When viewed in historical perspective, the present patchwork of intermittent piped water systems resembles the condition that existed not long ago in the United States, Europe, and several Southeast Asian countries that now have reliable services (Wolman and Bosch, 1963; Melosi, 2008; Northover et al., 2016). Prioritizing continuous service was a key strategy for eight effective utilities analyzed by the Asian Development Bank, which also highlighted the value of leadership from the highest levels of government and utility "corporatization," or taking a business approach to operations for greater accountability and transparency (Asian Development Bank, 2010). According to the ADB report, major supply-side infrastructure projects should be prioritized over investments in efficient and effective service delivery. Specific methods for ensuring continuous water supply are based on general utility management best practices: Growing coverage to over 90% (including finding ways to connect the poor), reliable metering, efficient billing, effective human resource management, and real-time monitoring and reporting for accountability are all priorities. Macintosh (2003) provides detailed resources with methods for piped water supply providers seeking to achieve reliable services, and claims that complete cost recovery tariffs actually benefit the disadvantaged, who are still paying high prices to cope with unreliable water supplies. Winrock, 2017 and Conradin, 2010 observes that ‘’new open-access toolkits focused on sustainable management of water resources are available to help bridge the gap between research and practice in water security and sustainability of supply’’.

A recent World Bank-supported intervention in India's Karnataka state demonstrated that a holistic approach that includes household metering and supply and distribution improvements, as well as performance-based contracting tied to service levels, can result in financially viable, continuous water services (Jain and Neti, 2013). Given the many negative consequences of unreliable/intermittent operation, the piped water system's policy priority should be on achieving a secure 24-hour supply. This can be accomplished in small steps by strengthening utility management and steadily increasing supply hours.

Unreliable water supplies affect many people living in developing countries and the subject has been relatively understudied (Kumpel, uiet.al, 2016). A number of studies conducted on water reliability have been done mainly in developed countries. The few surveys conducted in developing countries have been in urban areas. Our choice of Nzoia River Basin as a study area adds to the limited literature covering this subject in rural areas of developing countries. According to Odwori, et.al, 2018, ‘’access to safe drinking water in Nzoia River Basin stands at 51% as compared to the

national figure of 58% (83% in urban areas and 50% in rural areas). These figures are only based on available safe drinking water infrastructure (improved water sources) and do not adequately reflect the quality of service, including the safety and reliability of water supplies''. Unreliable water supplies is not a problem that developing countries like Kenya will solve overnight. It will continue to exist for some time and it's for this reason that this study seeks to examine the household coping strategies for unreliable water supplies in Nzoia River Basin, Kenya.

II. MATERIALS AND METHODS

2.1 Study area

Nzoia River Basin is located between latitudes 1^0 30' N and 0^0 05' S and longitudes 34^0 E and $35^0$45' E in Western Kenya and covers an area of 12,959 km^2 with a river length of 334 km up to its outfall into Lake Victoria (Figure. 1). The area has a population of approximately 3.7 million people that is rising rapidly with the majority of the people living in rural areas. The basin covers the nine counties of Elgeyo/Marakwet, West Pokot, Trans Nzoia, Uasin Gishu and Nandi (in former Rift Valley province); Kakamega, Bungoma and Busia (in former Western province) and Siaya (in former Nyanza province). The basin is characterised by three physiographic regions namely; the highlands (characterised by Mt. Elgon and Cherangani hills); the upper plateau (which includes Eldoret and Kitale); and the lowlands (which includes Busia that experiences the majority of flooding in the basin).The dominant topography consists of rolling hills and lowlands in the Eldoret and Kitale plains. Nzoia river is one of the largest rivers in Western Kenya which drains into Lake Victoria contributing to the waters that form the source of River Nile (Odwori, et.al 2018).

The Climate of Nzoia River Basin is predominantly tropical humid, but it varies from county to county due to varying landscape and elevations in the basin. Due to the inter-tropical convergence zone (ITCZ), the area experiences four seasons; however, the local relief and influences of Lake Victoria change the daily weather patterns. There are two rainy seasons: short rains (October to December) and long rains (March to May). The months of January to February and June to September are the dry seasons. The mean monthly rainfall in the basin for the period 1970 to 2001 varies from about 16.26 mm in January and December (Chorlim ADC. Farm) to about 300.79 mm in April (Kaimos Tea Estate).

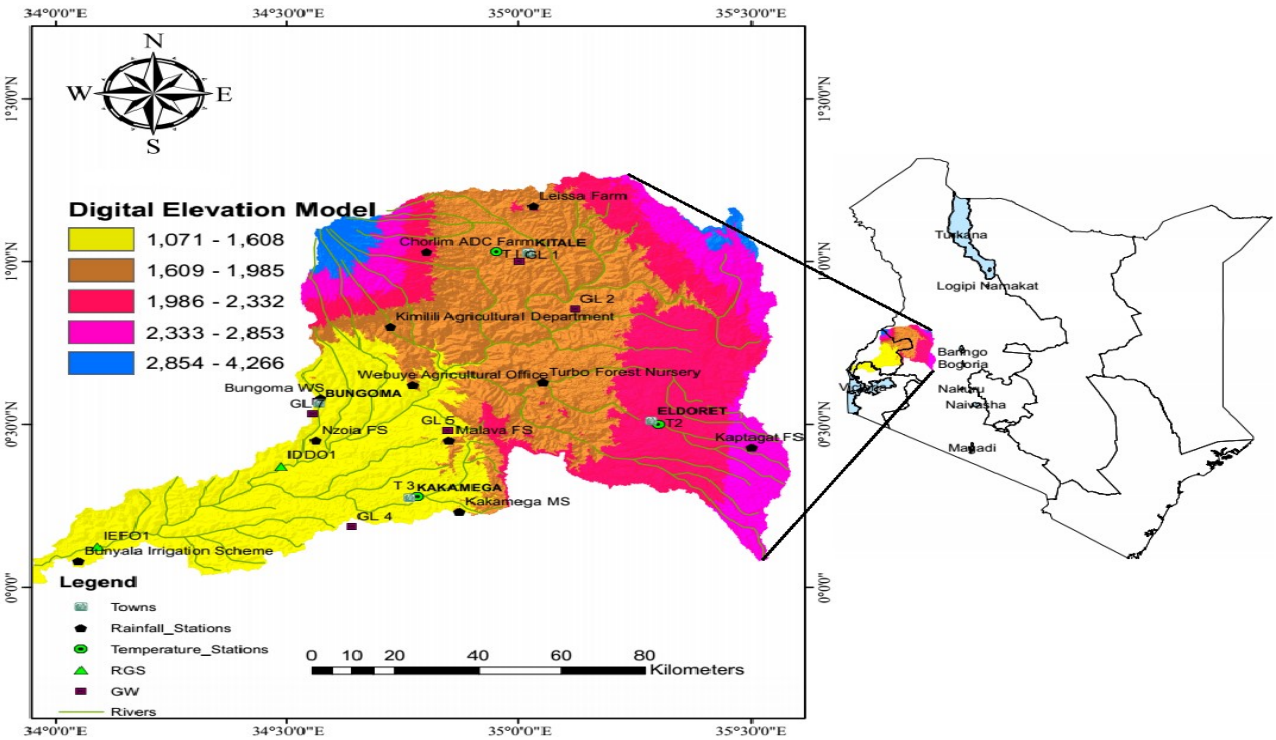

Figure. 1: Map of Nzoia River Basin, Kenya
(Source: Researcher, 2020)

The basin experiences lowest monthly maximum tempratures occuring in July at 16.1 ^{0} C (Eldoret), minimum tempratures in January, July and September at 10.0 ^{0} C (Eldoret) and mean tempratures in July at 16.1 ^{0} C (Eldoret) whereas the highest monthly tempratures in the basin for the maximum occurs in February and March at 29.5 ^{0} C (Kakamega), minimum in April at 15.1 ^{0} C (Kakamega) and mean in March at 22.0 ^{0} C (Kakamega). Temperature trends in the basin are linked to altitude since the lowest temperatures are found at highest altitudes and highest temperatures at lowest altitudes.

Agriculture is the dominant land use in the region and the agricultural activities of the basin mainly depend on rainfall as most of the crops are under rain-fed agriculture with very limited irrigation being practiced. The main food crops grown are maize, sorghum, millet, bananas, groundnuts, beans, potatoes, and cassava while the cash crops include coffee, sugar cane, tea, wheat, rice, sunflower and horticultural crops. The inhabitants of the basin also practice dairy farming together with traditional livestock keeping. Nzoia river and its many tributaries provide water for domestic use, agriculture, industrial and commercial sectors. Nzoia River Basin has the soil type textures forming: clay (77%), loamy (9%) and sandy (14%). In the basin, the Ferralsol form well drained soils found mostly on level to undulating land. The Acrisols in the basin form clay-rich soils associated with humid tropical climates and supports forestry; whereas Nitisols compose deep well drained red tropical soils found mostly in the highlands occupying more than 75% of the catchment.

Groundwater is the main domestic water resource, supplying 78.8% of the residents leaving 21.2% for surface water resources. Many of the large piped schemes supplying the towns and rural areas have their intakes built on Nzoia river and its tributaries. Odwori, E.O (2020) observes that ''On the existing sources of domestic water supply, 62 % of the residents of Nzoia River Basin use improved water sources. Out of these, 3 % use piped water into dwellings, 7 % water piped into compound, yard or plot, 3 % public tap/standpipe, 6% tube well or borehole, 11% protected dug well, 31% protected spring and 1% rainwater collection. Those using non-improved sources are 38%. Out of these, 10 % use unprotected dug well, 19 % unprotected spring, 1% tanker truck/cart with small tank, 8 % surface water (river, dam, lake, pond, stream, canal, irrigation channel) and 0 % bottled water''. In Nzoia River Basin, people often have to wait for long periods of time to draw water from point water sources, particularly during the dry season. The people have strong preferences for reliable, portable drinking water, and will often walk long distances past alternative sources to obtain drinking water from sources deemed safe. Women and children collect water for drinking and cooking and transport it home in relatively standard-size 20 liter jerricans for adults and 5-10 liter jerricans for children. Adults and older children in some villages also tend to bathe in rivers, despite the fact that children under the age of five are normally bathed at home in basins.

2.2. Study design

The study employed Cross-sectional survey research design.

2.3. Study population

According to Saunders et al. (2009), a population is the full set of cases from which a representative sample is taken for detailed study. The targeted population for this study were the water user households, water sector staff from national and county governments, academia and scientists in the area of water supplies, water supply infrastructure in the field, household water collection- storage and use practices in the study area.

2.4. Sampling procedure and sample size

Rift valley and western Kenya regions generally experience problems of unreliable water supplies, hence, Nzoia River Basin was purposively selected for this study as it cover parts of both Rift valley and Western Kenya. The study randomly selected three counties from the basin with Busia representing the lower catchment, Kakamega middle catchment and Trans Nzoia upper catchment. A questionnaire survey for this study involved 403 households through multi-stage random sampling. This was followed by 28 No. in-depth expert interviews conducted with selected stakeholders from water sector staff from national and county governments, academia and scientists in the area of water supplies purposively chosen to share and express their insights and opinion on household coping strategies to unreliable water supplies and the factors influencing the choice of strategies in the basin. The 28 No. water sector experts were purposively chosen because ''purposive sampling helps in ensuring that the persons selected met the criteria for selection before being allowed into the study'' (Sinclair, Jullien, & Garner, 2016). ''The advantage of this sampling method is that it ensures that the individuals who are targeted and meeting the study criteria are considered for the study. It also prevents other people who may not be knowledgeable in the study area from participating in the research'' (Noe & Gelfand, 2018). Field observation involved watching stakeholder activities and processes, and documenting processes and results. The Field observations had the added benefit of enabling the Researcher to identify processes or activities that may have been missed during surveys or in-depth expert interviews. The study also depended heavily on recently published literature on the subject and the industry experiences. The in-depth expert interviews were conducted using an interview guide prepared by the Researcher.

2.5. Type of data

In this study, primary data was first collected through questionnaire survey from households. Secondly, primary data was also collected through in-depth expert-interviews conducted with selected stakeholders from water sector staff from national and county governments, academia and scientists in the area of water supplies purposively chosen. Thirdly, field observations were also carried out in the study area. Field observation involved watching stakeholder activities and processes, and documenting processes and results. The study also collected secondary data which entailed the collection and analysis of published materials and information. The study used both published and unpublished reports that had some relevant information on household coping strategies to unreliable water supplies and the factors influencing the choice of strategies in the basin. Secondary data were gathered from textbooks, internet sources and journals and periodicals, conferences and workshops.

2.6. Data analysis

In this study, the household adopted coping strategies to unreliable water supplies were analyzed using descriptive statistic of percentages in order to compare the differences across the basin as well as the three counties of Busia, Kakamega and Trans Nzoia and then presented in Tables.

III. RESULTS AND DISCUSSION

This study sought to establish household coping strategies to unreliable water supplies and the factors influencing the choice of strategies in Nzoia River Basin, Kenya. Household coping strategies to unreliable water supplies were identified and analyzed using descriptive statistic of percentages in order to compare the differences across the basin as well as the three counties of Busia, Kakamega and Trans Nzoia and then presented as shown in Table-1. Households in the basin use more than one strategy to cope with the problem of unreliable water supplies. 18 coping strategies were identified in the basin. There are some strategies which are adopted by large numbers of households whereas the others have only a few households using them.

Table 1: Household coping strategies to unreliable water supplies in Nzoia River Basin, Kenya

S/no.	Identified household coping strategies to unreliable water supplies in Nzoia River Basin	Adoption of coping strategies			
		Total number of households using strategy in the basin	Upper Nzoia River Basin (TransNzoia County)	Middle Nzoia River Basin (Kakamega County)	Lower Nzoia River Basin (Busia County)
		%	%	%	%
1.	Water storage through storage tanks, roof tanks, drums, pots, buckets, bottles, etc	17.5	5.3	5.2	7.0
2.	Collecting water from alternative sources such as springs, rivers, dams,	11.0	3.0	3.0	5.0
3.	Using water sparingly/ limiting water use	10.5	3.4	3.1	4.0
4.	Treating water through boiling, filtration, chlorination, etc	10.0	4.0	3.0	3.0
5.	Drilling wells and boreholes	9.0	2.0	4.0	3.0
6.	Improving water quality	5.0	1.0	2.0	2.0
7.	Enhancing pressure	4.5	1.0	2.5	1.0
8.	Rainwater harvesting in the rainy season	4.5	2.1	1.3	1.1
9.	Installing booster pumps, electrical and hand pumps	4.0	1.0	2.0	1.0
10.	Installing extra storage space	4.0	1.0	1.0	2.0
11.	Rescheduling major household activities to when water is available	4.0	1.0	1.0	2.0
12.	Buying water from neighbors, private tankers, donkey-cart owners, bottled water	3.5	1.0	0.4	2.1
13.	Moving to another house or area estate with water	3.0	1.0	0.8	1.2
14.	Community fundraising for construction of water supply	3.0	1.0	0.5	1.5
15.	Recycling water	2.0	0.5	1.0	0.5
16.	Protesting and complaining to authorities	2.0	1.0	0.5	0.5
17.	Economizing on water use by reduced frequency of baths	1.5	0.5	0.5	0.5
18.	Economizing on water use by reduced number of meals in a day or altered diet	1.0	0.3	0.3	0.4
Total		100	100		

Source: Researcher, 2020.

Water storage through storage tanks, roof tanks, drums, pots, buckets and bottles is the most preferred strategy by households followed by collecting water from alternative sources such as springs, rivers, dams and wells; using water sparingly/ limiting water use; treating water through boiling, filtration and chlorination; and drilling wells and boreholes as shown in Table-1 (under column on Total number of households using strategy in the basin). Drilling wells and boreholes is an important strategy for households in the study area as majority of the rural populations are dependent on groundwater. A significant number of studies now report that groundwater levels in the basin are declining at a faster rate.

Strategies like improving water quality; enhancing pressure; rainwater harvesting in the rainy season; installing booster pumps, electrical and hand pumps; installing extra storage space; rescheduling major household activities to when water

is available; buying water from neighbors, private tankers, donkey-cart owners, bottled water; moving to another house or area estate with water and community fundraising for construction of water supply are also important to the households in addressing problems of unreliable water supplies in the basin. Other strategies like recycling water; protesting and complaining to authorities; economizing on water use by reduced frequency of baths and economizing on water use by reduced number of meals in a day or altered diet are less important. The spread of all strategies across the basin appears to be uniform.

Water is viewed as a commodity by Kudat et al. (1993) and Humplick et al. (1993), who consider its three key attributes of quantity, quality, and pressure. According to them, if the water source does not reach the optimal standards of these three attributes, it will be deemed unreliable, and households will have to develop coping mechanisms to mitigate the risks of unreliability. According to (Hirschman, 1970), there are two key forms of activist reactions to dissatisfaction with organizations to which one belongs or in which one does business: either voicing one's grievances while remaining a member or client in the hopes of changing things, or exiting the organization and taking one's business elsewhere. This dichotomy was the foundation for exit, voice, and loyalty. Faced with the discontent of unreliability of water supplies, the residents of Nzoia River basin may voice their complaints and protests to water utilities and county governments while continuing with the services in the hope that there will be improvement; or the residents could decide to exit the services by adopting strategies such as rainwater harvesting in the rainy season and moving to another house or area estate with water. Residents can also choose to be loyal, and engage in accommodative strategies such as collecting water from alternative sources such as springs, rivers, dams, etc.; rescheduling major household activities to when water is available; economizing on water use by reduced number of meals in a day or altered diet and reducing frequency of baths.

The identified household coping strategies to unreliable water supplies in Nzoia River Basin can be classified into four major categories as: enhancing and conserving quantity of water available; improving the quality of water; enhancing flow rate (pressure) and collective action and voice. There exists some overlap between these categories.

3.1 Enhancing and conserving quantity of water available

Enhancing and conserving the quantity of water available encompasses the coping strategies such as: water storage through storage tanks, roof tanks, drums, pots, buckets and bottles**;** installing extra storage space**;** buying water from neighbors, private tankers, donkey-cart owners and bottled water**;** collecting water from alternative sources such as springs, rivers and dams; rainwater harvesting in the rainy season**;** recycling water**;** drilling wells and boreholes**;** installing booster pumps, electrical and hand pumps and rescheduling major household activities to when water is available. Water storage through storage tanks, roof tanks, drums, pots, buckets and bottles has been reported by a number of studies as a household coping strategy for unreliable water supplies. Buying water from private tankers, buying water from neighbors, storing water in the home, collecting water from wells, springs, buying bottled water, scheduling major household activities to when water is available and generally limiting water use were among the household coping strategies identified by Gerlach and Franceys (2009), who investigated the status of water supply service and regulatory arrangements with respect to poor and vulnerable consumers in urban Jordan. Dutta et al., (2005) conducted 650 interviews in four unplanned settlements in urban India using multistage stratified random sampling and developed coping strategies such as drilling wells, installing booster pumps, and storage.

3.2 Improving the quality of water

Improving the quality of water includes the coping strategies such as: treating water through boiling, filtration and chlorination; and recycling water. Treating water through boiling, filtration and chlorination is the most reported coping strategy under water quality improvement. Contaminant intrusion into pipelines for unreliable water supply systems may occur when the flow rate is low or the supply is cut off, or when water obtained from alternate sources is unsafe or re-contaminated during collection and storage. This creates a situation that subjects users to poor quality water. Choe et al. (1996) studied a random-stratified cluster sample of 1,100 households in the Dehra Dun urban area of Utter Pradesh, India, and identified coping strategies such as tank storage, increased pressure, and improved water quality.

3.3 Enhancing flow rate (pressure)

Enhancing flow rate (pressure) encompasses the coping strategies such as: water storage through storage tanks, roof tanks, drums, pots, buckets and bottles; installing extra storage space; rainwater harvesting in the rainy season; economizing on water use by reduced number of meals in a day or altered diet and economizing on water use by reduced frequency of baths; using water sparingly/ limiting water use; drilling wells and boreholes and installing booster pumps, electrical and hand pumps. There is overlap in a number of strategies that enhance and conserve the quantity of water available and those enhancing flow rate (pressure). When we store large quantities of water we automatically increase pressure when we release it to flow to areas where it is needed for use. Zerah, 1998 posits that installation of electric pumps to convey water from storage tanks or installation of motors directly onto municipal water connections to boost the flow rate are commonly used coping mechanisms in areas where we experience persistent low pressures.

3.4 Collective action and voice

Collective action and voice includes the coping strategies such as: voicing complaints and protests to water utilities and county governments while continuing with the services in the

hope that there will be improvement; or exiting the unreliable water services by adopting strategies such as rainwater harvesting in the rainy season and moving to another house or area estate with water; or choosing to be loyal, and engaging in accommodative strategies such as collecting water from alternative sources such as springs, rivers, dams, etc.; rescheduling major household activities to when water is available; economizing on water use by reduced number of meals in a day or altered diet and reducing frequency of baths. Kudat et al., 1993 posits that households in Turkey created joint community actions and pressured for better services from the authorities.

The study established the factors influencing the choice of coping strategies to unreliable water supplies among households in Nzoia River Basin. Socio-economic status: income, education; land tenure and lack of reliability are the main factors influencing choice of coping strategies used against unreliable water supplies in the basin. Wealthier, better-educated families who own their homes are more likely to dig wells and boreholes, construct storage tanks, and treat their water. These strategies are capital-intensive and appear to be not only long-term, but also comprehensive; providing to some extent quantity, quality and convenience. Low income households will focus on addressing the more immediate quantity problems by engaging in labor and time-intensive strategies such as collecting water from alternative sources and rescheduling major household activities to when water is available. These strategies not only cost more over the longer term due to the ongoing effort they require, but perversely yield smaller quantities of water. Lack of reliability of water supplies play an important role in determining the choice of coping strategies households use. In cases where water supply unreliability is prolonged, households may actively anticipate poor reliability in their water supply, and construct houses that have in-built storage cisterns, or connect plumbing systems to drilled wells and boreholes. Similarly, perceived water quality influences water treatment behavior, in addition to income and educational status.

IV. CONCLUSION AND RECOMMENDATIONS

Results from this study indicate that households in Nzoia River Basin use more than one strategy to cope with unreliable water supplies; and that there are some strategies which are adopted by large numbers of households whereas the others have only a few households using them. Water storage through storage tanks, roof tanks, drums, pots, buckets and bottles is the most preferred strategy by households followed by collecting water from alternative sources such as springs, rivers, dams and wells; using water sparingly/ limiting water use; treating water through boiling, filtration and chlorination; and drilling wells and boreholes. Strategies like improving water quality; enhancing pressure; rainwater harvesting in the rainy season; installing booster pumps, electrical and hand pumps; installing extra storage space; rescheduling major household activities to when water is available; buying water from neighbors, private tankers, donkey-cart owners, bottled water; moving to another house or area estate with water and community fundraising for construction of water supply are also important to the households in addressing problems of unreliable water supplies in the basin. Other strategies like recycling water; protesting and complaining to authorities; economizing on water use by reduced frequency of baths and economizing on water use by reduced number of meals in a day or altered diet are less important. The choice of household coping strategies used against unreliable water supplies was found to be influenced by socio-economic status: income, education; land tenure and lack of reliability.

Rift valley and western Kenya regions generally experience problems of unreliable water supplies, hence, Nzoia River Basin was purposively selected for this study as it cover parts of both Rift valley and Western Kenya. Residents of Nzoia River Basin are beginning to raise concerns over the unreliability of water supplies. Unreliable water supplies will continue to exist as many leaders have pointed out if the county governments do not create an enabling policy environment for public-private partnership to help secure the much needed funds for the improvement of water supplies. Unreliability of water supplies in the basin has imposed significant coping burdens on the households. Some of the coping strategies adopted do not result into obtaining safe and sufficient quantities of water for the households. The poor households suffer most as they rely on labor intensive and time consuming strategies as opposed to wealthy households who engage in capital-intensive strategies. In the poor households, women and the girl child carry the primary responsibility of water collection, and the time spent results into productivity losses, poor school attendance and ultimately sustained impoverishment. National and county government policies and programs aimed at mitigating unreliable water supplies in the basin should target the poor households. In many parts of the urban areas residents have resorted to digging shallow wells to cope with the increased unreliability of water supplies, but these wells are now heavily contaminated with human feacal matter from the neighboring pit latrines, making the strategy ineffective and counter-productive.

REFERENCES

[1] Asian Development Bank, 2010. Every Drop Counts: *Learning from Good Practices in Eight Asian Cities.*

[2] Choe, K., Varley, R. C. G. & Bijlani, H. U. 1996. Coping with intermittent water supply: Problems and prospects. *Environmental Health Project. Dehra Dun, Uttar Pradesh, India: USAID.*

[3] Conradin, K., Kropac, M., Spuhler, D. (Eds.). 2010. The Sustainable Sanitation and Water Management Toolbox. *Basel: SEECON International GMBH.*

[4] Christodoulou, S., Agathokleous, A., 2012. A study on the effects of intermittent water supply on the vulnerability of urban water distribution networks. *Water Science & Technology: Water Supply 12, 523–8.*

[5] Cook, J., Kimuyu, P., Whittington, D., 2016. The costs of coping with poor water supply in rural Kenya. *Water Resour. Res. 52, 841–859.*

[6] Dutta, V. & Tiwari, A. P. 2005. Cost of services and willingness to pay for reliable urban water : A study from Delhi, India. *Water Economics, Statistics and Finance, 5, 135-144*.

[7] Gerlach, E. & Franceys, R. 2009. *Regulating water services for the poor: The case of Amman. Geoforum, 40, 431-441.*

[8] Guragai, B., Takizawa, S., Hashimoto, T., Oguma, K., (2017). Effects of inequality of supply hours on consumers' coping strategies and perceptions of intermittent water supply in Kathmandu Valley, Nepal. *Science of the Total Environment 599-600, 431–441.*

[9] Humplick F., Kudat A., Madanat S. (1993). Modeling Household Responses to Water Supply: A Service Quality Approach. *World Bank, Transportation, Water, and Urban Development Department; Washington, DC, USA: 1993.*

[10] Hirschman A.O.(1970).*Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations,and States.* Harvard University Press; Cambridge, MA, USA.

[11] Jain, D., Neti, R., (2013). Karnataka Three Towns Pilot 24/7 *Water Supply. Innovations in Development 2013.*

[12] Kudat A., Bell M., Boland J., Humplick F., Madanat S., Mukherjee N.(1993). World Bank Research Observer. World Bank; Washington, DC, USA: 1993. *Reliability of urban water supply in developing countries: The emperor has no clothes.*

[13] Kumpel, E., Nelson, K.L., 2016. Intermittent Water Supply: Prevalence, Practice, and Microbial Water Quality. *Environ. Sci. Technol. 50, 542–553.*

[14] Kumpel, E., Woelfle-Erskine, C., Ray, I., Nelson, K.L., (2017). Measuring household consumption and waste in unmetered, intermittent piped water systems. *Water Resour. Res. 53, 302–315.*

[15] Melosi, M., (2008). *The Sanitary City.* University of Pittsburg Press.

[16] Macintosh, A.C., (2003). Asian Water Supplies: Reaching the Urban Poor. *Asian Development Bank and International Water Association.*

[17] Majuru, B., Suhrcke, M., Hunter, P., (2016). How Do Households Respond to Unreliable Water Supplies? A Systematic Review. *International Journal of Environmental Research and Public Health 2015, Vol. 12, Pages 5954-5974 13, 1222–20.*

[18] Northover, H., Ryu, S.K., Brewer, T., (2016). Achieving total sanitation and hygiene coverage within a generation - *lessons from East Asia. WaterAid.*

[19] Noe, M. H., & Gelfand, J. M. (2018). Research techniques made simple: Pharmacoepidemiology research methods in Dermatology. *Journal of Investigative Dermatology*, 138 (2).

[20] Odwori, E,O, & Obiri, J.F. (2018). Factors influencing sustainable household domestic water use in Nzoia River Basin, Kenya. *International Journal of Scientific Research in Science and Technology; September - October - 2018 ; 4(10) : 297-307.*

[21] Odwori, E.O (2020). Factors determining households' willingness to pay for improved water supply services in Nzoia River Basin, Kenya. *International Journal of Innovative Research and Advanced Studies (IJIRAS)* Volume 7 Issue 7, July 2020. ISSN: 2394-4404.

[22] Pruss-Ustun A., Bos R., Gore F., Bartram J. (2015). *Other Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote.*

[23] Pattanayak, S.K., Yang, J.-C., Whittington, D., Bal Kumar, K.C., (2005). Coping with unreliable public water supplies: Averting expenditures by households in Kathmandu, Nepal. *Water Resour. Res. 41, 163–11.*

[24] Sinclair, D., Jullien, S., & Garner, P. (2016). Response: Development of economics-time to improve research methods. International Journal of Epidemiology, 45(6).

[25] Saunders,M.,Lewis,P.,Thornhill,A.,&Wang,C.(2009).Analysing qualitative data. Research methods for business students. 5th edn. Harlow, Essex, UK: Pearson Education Ltd, 480-525.

[26] WRMA. (2012). Water Resources Management Authority. *Annual reports.* Nairobi, Kenya. Winrock International, (2017). *Improving Water Security, Toolkit.*

[27] Wolman, A., Bosch, H.M., (1963). US Water Supply Lessons Applicable to Developing Countries. *Journal American Water Works Association 55, 946–956.*

[28] Zerah, M.-H., (1998). *How to assess the quality dimension of urban infrastructure: The case of water supply in Delhi. Cities* 15, 285–290.