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RESEARCH ARTICLE

WATER SCARCITY AND HOUSEHOLD ADAPTATION STRATEGIES IN GASIZI CELL, NYABIHU DISTRICT, RWANDA

[1*]Theogene Niyonzima, [2]Ferry Hermawan and [3]Maryono Maryono

[1,3]Postgraduate School, Master of Environmental Science, Diponegoro University, Semarang 50241, Indonesia
[2]Department of Civil Engineering, Faculty of Engineering, Diponegoro University, Semarang 50275, Indonesia

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***Corresponding author:**
Theogene Niyonzima

ABSTRACT

The central importance of water is clear in any assessment of life-sustaining needs. But, despite this vital role of water, nowadays people in some parts of the world are suffering from water scarcity /shortage, limited freshwater availability and accessibility impacting both rural and urban communities. This research focuses on water scarcity in Gasizi Cell, Mukamira Sector, Nyabihu District. It examines the factors contributing to water shortages and how local households cope with that issue from season to season. Using a sample of 146 households, the study identified both natural and human-made causes of water scarcity as revealed by respondents. To a number of factors identified, financial constraints and family size were also found to be impacting access and usage of water. While water scarcity often negatively affects communities, it also creates economic opportunities, such as water vendors benefiting from shortages and sell water to generate income. The study recommends implementation of a multi-stakeholder approach, stronger monitoring, improved water supply infrastructures, water harvesting and storage facilities to enhance water supply, availability, and accessibility to water in the area.

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INTRODUCTION

Water's central importance is clear in any assessment of life-sustaining needs. Beyond its essential role in human survival and sustainable development, water not only supports life but also significantly affects economic activities, including production and consumption, and shapes social roles (UNFPA, 2003). Currently, around 750 million people in the world live in utter shortage of access to improved sources of water, mainly in developing countries where social inequality is even more intense especially in the Sub-Saharan countries of Africa (Aleixo, Rezende, Pena, Zapata, & Heller, 2016, Gasirabo *et al*.,2019). Connections of water point to households in Africa remain low. This limits access of households to water. When households are not connected, they have limited options and therefore impact negatively on their livelihoods. This means that these households may collect water from untreated water sources or purchase water from middle persons/vendors who overcharge the prices (UNDP, 2006; Cherutich *et al*., 2015). Despite the vital importance of water to all aspects of human life, the sector has been plagued by a chronic lack of political support, poor governance and under investment. As the result hundreds of millions of people around the world remain trapped in poverty and ill health and exposed to the risks of water related disasters, environmental degradation and even political instability and conflict (WWAP, 2009). Corcoran *et al*., (2010) added that fresh, accessible water is a scarce and unevenly distributed resource, not matching patterns of human development. According to the UNEP (2012) report, the challenges of managing water resources for a multiplicity of uses and threats must be set within the much broader contexts of changes in the economic, social and political landscapes. While water use efficiency is high priority in a good majority of countries, it is clear that introduction and implementation of water efficiency measures is, in general, lagging behind particularly in low human development index countries. In the UNFPA (2003) report, it is stated that water is essential for achieving sustainable development, and it is this resource that will play a large role in determining whether the MDGs are achieved. The core concern is how to achieve equitable access and adequate water supplies, while at the same time protecting and preserving supplies and maintaining environmental security. Water is the key resource for food security, for good health, for providing clean hydroelectric energy, for protecting ecosystems and aquatic biodiversity, and for industrial development. Together these make for a complex set of relationships reflecting water demand and water supply relative to size of population and the multiplicity of end users.

Assumptions about future climate and water use predicted the water scarcity problem in Southern and Eastern African countries including Rwanda because of increasing population and improved living standards (Meigh *et al*.,1999; Karamage *et al*., 2016). Rwanda has a very dense hydrological network and even can be classified as a water rich country. However, insufficient water management leads to an imbalance between the available water and the actual and growing demand and supply. Insufficient and deteriorating water quality may also add to water shortages in the future (Government of Rwanda/NISR, MoE, 2019).

According to the Republic of Rwanda (2009b) & Uwera (2013), in Rwanda, statistics show that about one third of all households consume unsafe water from unprotected sources and are, therefore, exposed to worms, dysentery and cholera all of which are associated with a lack of hygiene. Furthermore, the average time taken to reach a source of drinking water is estimated to be 25 minutes for the whole country, which varies for different parts of the country (Republic of Rwanda 2010; Uwera,2013). In addition, GCF/MoE, (2019) highlights that Rwanda's overall per capita freshwater availability is estimated at 670 m^3 which significantly falls below the 1,000 m^3 per capita per year which is the standard for water security. However, it needs to scale up these investments to meet the country's increasing water demand and to manage the challenge of adaptation and build resilience in the face of uncertain weather patterns.

Table 1: **Overview of water availability in Rwanda**

Parameter	Quantity
Rainfall	27.505 BCM/annum
Ground water recharge	4.554 BCM/annum
Total renewable water resources	6.826BCM/annum
Water availability per capita	670m^3/annum

Source: MINIRENA, (2016)

Although, the national water coverage in Rwanda rose from 58.5% in 1990 to 76.1% in 2015 (see *figure 1*), the MDG drinking water target was not met and there is still inequality between urban and rural water coverage, being driven mainly by population pressures and severe water losses. This national gap of 23.9% in water supply to meet clean water supply for the total Rwandan population could be reduced by the saved water from water loss reduction (Karamage *et al*., 2016).

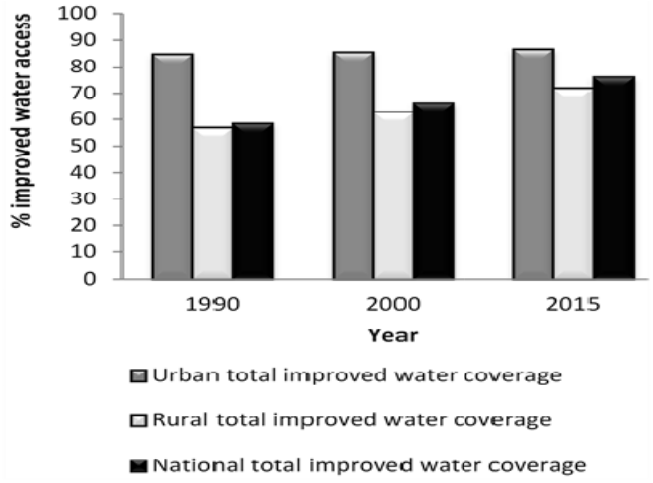


Figure 1. National water Coverage until 2015

Principal threats to water resources for humans include water pollution and water scarcity (Karume *et al*., 2016). The water resources of Rwanda face growing challenges arising from pressures of rapidly changing demographic patterns, the demands of intensified socio-economic development, degradation resulting from unsustainable and inappropriate land use practices; and the uncertainties created by climate change, among others (MINIRENA, 2011). According to REMA (2015) report, Rwanda only uses 2.23 per cent of its available water resources. This means that Rwanda loses almost all of its water resources through evaporation or runoff to other downstream countries. The most common source of drinking water is protected spring water, which accounts for 38 per cent of usage, followed by public tap/standpipe (26 per cent). Only 5 per cent (i.e., 5%) of households have running water in their dwelling or courtyard.

Given that available water resources are limited and that not all demands can be met to the full extent, available water resources shall be shared on the principle of "some for all" (rather than "all for some"), which is an expression of the principle of equitable access among present generations (MINIRENA, 2011). Rwanda has abundant water resources. Although its dense drainage network allows most of the country to receive water, it is unevenly distributed both spatially and temporally: the west receives most precipitation and the eastern part of the country is relatively dry, while there are long dry periods between rainy seasons (REMA, 2015).

Although Rwanda especially North and West of country get abundant rainfall, it still has the problem of water scarcity due to continuous increase of population, limited infrastructure for water storage and topography or hydrological system (Nyasa & Victoria, 2024). Water shortages has affected communities in Mukamira, Jenda, and Kabatwa sectors near Volcanoes National Park (VNP). One of the objectives of this study is to explore additional factors, beyond population growth, contributing to water scarcity in Gasizi Cell, Mukamira Sector, Nyabihu District. The region faces challenges with water supply and access to fresh water, despite receiving significant rainfall due to its proximity to VNP. This issue is exacerbated by natural water drainage to lowland areas. According to Bush *et al*., (2010) study report, the community living around VNP have the problem of water scarcity and they entered to fetch water from park, there are also significant health issues related to poor water supply around VNP.

These communities suffer from seasonal changes in rainfall patterns, and they only have a chance to collect rainwater from the roof top of their houses during rainy season. When it comes the dry season, it takes a long time to go to fetch water from the far away public water points. This has limited their access to safe drinking water, hygiene and sanitation becoming a huge concern with no water for crop irrigation and spraying during the dry season. Women in this region, besides their social roles for household care, and children are responsible for collecting water for domestic use. Even though the government of Rwanda has taken strong measures (i) to strengthen the enabling environment for water, sanitation and hygiene (WASH), (ii) to make good progress in improving access to water and sanitation services and (iii) Government allocations for WASH have significantly increased over the years but there is a considerable gaps remaining in coverage of WASH services (UNICEF, 2024).

It is still debatable if poverty, intra-household inequity, poor water governance, ethical issues and awareness in water management among others are some of the factors limiting water availability and equal access to water. RWH has been targeted to promote water access and availability for rural poor with sensitivity to gender (GCF/MoE, 2019). So, clear understanding of availability, spatial and temporal distribution, quality and trends is crucial for sound-decision making that will lead to effective water resources management as the level of scarcity is expected to increase in the future as the country continues to develop economically, and its population continues to increase (Rwanda water resources board, 2020). It is against this background that this study focused on assessing water scarcity and household adaptation strategies in Gasizi Cell, Mukamira Sector, Nyabihu District, Rwanda. It aims to identify factors contributing to water scarcity in this area which borders Volcanoes National Park of Rwanda, and to explore how local communities cope with the challenges and effects of limited water availability. The study aligns with goals of sustainable water supply, accessibility, and efficient water management. To this end, the study focused on the following: (1) Identifying the factors associated with water scarcity and their impact on the livelihood of people, (2) assessing water accessibility status and community behavioural changes on water consumption during water shortage in Gasizi Cell, (3) Exploring household adaptation measures to water scarcity and (4) Identifying measures that can be taken to improve water availability.

METHODOLOGY

General Description of Nyabihu District: Located in the Western Province of Rwanda and in the west part of the country, Nyabihu District has 12 sectors that are Bigogwe, Jenda, Jomba, Kabatwa, Karago, Kintobo, Mukamira, Mulinga, Rambura, Rugera, Rurembo, and Shyira. These areas are themselves divided into 73 cells and 473 villages. Considering its administrative limits, in the north there is Musanze district and the Virunga National Park, which separates it with the Democratic Republic of Congo (DRC). In the South, there is Ngororero and Rutsiro Districts, and in the East, there is Gakenke and Musanze Districts. Finally, in the West there is Rubavu District Its geographical relief is characterized by 90% rugged mountains with a slope of more than 55% creating a high risk of erosion so that the need for the establishment of effective mechanisms for control and prevention of erosion and other harms associated with climate change is very high. The characteristic of the soil is sandy and clay, laterite and volcanic. It is very fertile. Precipitation is almost uniformly over every month and close to 1400 mm per year. It has a temperate climate with an average temperature of 15^0 C favourable for the growth of the agro-pastoral products throughout the year with less risk of development of bacteria and diseases (Nyabihu District, 2013; Zimmerman, 2012). The district is rural with a not negligible share of urban population accounting for 13.8 % of total district. Most of the population of Nyabihu district is young with 83.6% aged less than 40 years old. Females in this age group represent 82% of all females, while males in this age group represent 86% of all males (Nyabihu District, 2019).

Description and choice of the study area: According to Figure 2, which shows the map of Mukamira Sector, Gasizi Cell is one of seven cells making Mukamira Sector in the north bordering Volcanoes National Park (VNP). This cell is then divided into two small administrative divisions known as villages which are Kamillo Village and Sasangabo Village. Of the two Cells, Kamillo Village extends toward the border of VNP which offers opportunity for its residents to enter the forest for collecting water during some months of the year, mostly in dry season. This region like many other parts of the district experienced some natural hazards resulting from intense rainfall which have impacted communities socially and economically as well as having environmental effects such as land sliding and forest landscape degradation due to erosion and other unsustainable land use activities in this area. Some projects for example Water4Virungas project 2017-2021 (Aidenvironment and Vision Verte, 2022) supported by the Embassy of the Kingdom of the Netherlands in Rwanda have recently been implemented to contribute to integrated water resources management (IWRM) in the Virunga area between DRC, Rwanda and Uganda with the overall objective of reducing conflicts through increased access to water and improved watershed management in the Virunga area where Gasizi Cell was also selected to benefit from this project. Since one of the objectives of the project was to reduce erosion by capturing water from the rooftop of the house, Rainwater harvesting tanks (RWHTs) were provided to households with houses of big roof size which my collect and store too much rainwater which was likely to cause erosion in the lower catchment area.

Therefore, in addition to 359,678 trees planted, 45 RWHTs were installed on the houses and for the sustainability of intervention, 2 water management committees (WMCs) were formed (Aidenvironment and Vision Verte, 2022). The community claims that Rainwater Harvesting Tanks (RWHTs), initially intended to reduce erosion and runoff, also help address water scarcity by serving as water storage. This study area was chosen to explore factors contributing to water scarcity, despite the district having abundant rainfall and other water sources.

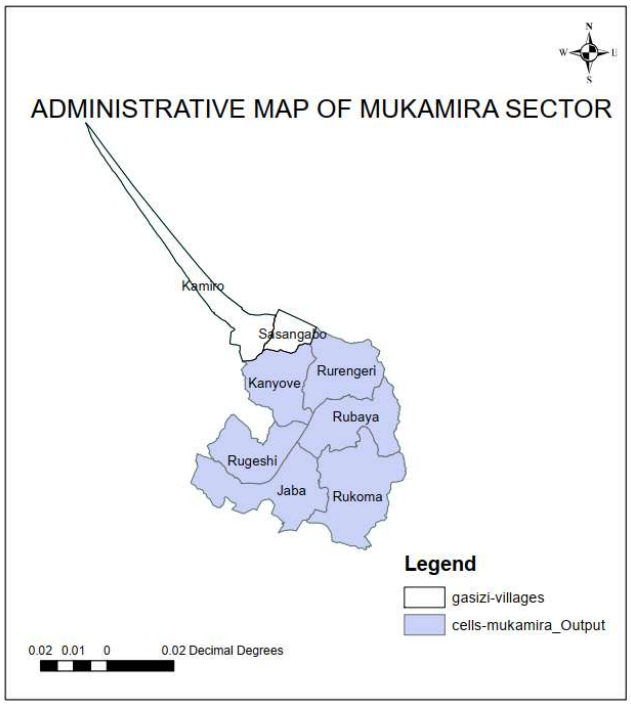


Figure 2.Administrative map of Mukamira Sector showing its cells and villages of study area

Source: Nyabihu District (2013); www.nyabihu.gov.rw, Accessed on August 01, 2023

Figure 3. Nyabihu District Administrative map

According to Bush *at al*., (2010) empirical study, the population around Virunga National Park (VNP) faced by different issues including land availability as first challenge affecting their livelihoods. Erosion and soil degradation came next, followed by traders cheating Irish potatoes producers with purchasing price and weights, family planning, water inaccessibility, shortage of and poor quality of roads and bridges and other more livelihood issues of environmental concern. Furthermore, these researchers described volcanic geology of the VNP area as the driver which favors rapid runoff of rainwater as surface water or through fissures into the ground aquifer.

Population of the study: The study's population included males and females' household representatives from Gasizi Cell, as well as key informants in the water sector. It also involved individuals from administrative institutions working on water resource development in the district. The key informants provided first-hand information about water supply, distribution, and infrastructure development aimed at improving water access.

Sample size, selection and distribution: A sample is a subset of the individuals in a population; there is typically data available for individuals in samples (Hanlon and Larget, 2011). The sample population was withdrawn from the households' members selected in two villages (Sasangabo and Kamiro) of Gasizi Cell of Mukamira Sector and other relevant key informants who meet the requirements to participate in this research. According to the number of households in the sector, the sample population was selected based on Yamane's (1967) simplified formula as follows:

$n = \frac{N}{1+N(e)^2}$ Where: n= sample size required, N = number of households in Gasizi Cell (i.e., two villages), e = allowable (i.e., marginal) error (%).

The marginal error was set to 7% (i.e.,0.07) to reduce sample size. Therefore, with respect to the formula, the sample size for households' representatives was calculated.

$$n = \frac{N}{1+N(e)^2} = \frac{508}{1+508(0.07)^2} = \frac{508}{1+2.4892} = \frac{508}{3.4892} = 145.59 \cong 146\ households$$

Sub-samples (sample in village) were calculated proportionally with the number of households in each village under consideration.

- Sample in Kamiro village:$n_1 = \frac{146*334}{508} = 95.9 \cong 96\ households$
- Sample in Sasangabo village:$n_2 = \frac{146*174}{508} = 50\ households$

The respondents in each village were selected through a mixed method (i.e., Probability sampling/ systematic random for households' samples and non-probability or purposive sampling for key informants).

Data collection and analysis: The study involved collecting data to analyse selected variables. Due to certain limitations, only readily available participants were interviewed.

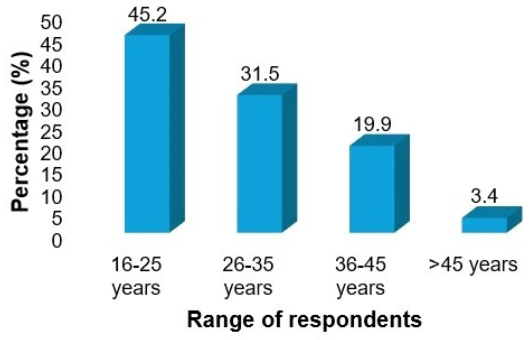
Various methods were employed for data collection. These methods include:

- Direct face to face interview with key informants in water sector (5 persons)
- Questionnaire survey with selected households' members (146 households)
- Documentation for secondary data and qualitative information from selected institutions working in water sector
- Onsite (field) observation

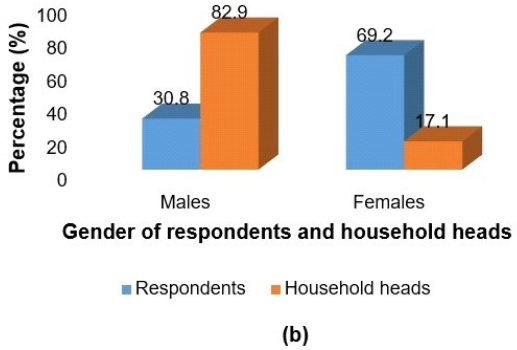
The study employed a mixed methodology, primarily collecting qualitative data through surveys. Descriptive statistics were used to analyse the data, including calculating means and percentages based on frequently stated variables. Computer programs like SPSS and Microsoft Excel were used to create graphs and figures for better data presentation.

RESULTS AND DISCUSSION

Demographic characteristics: The respondents were distributed into groups following age categories as displayed in *figure 4(a)* where many younger respondents were [16-25] while the older respondents were greater than 45 years old. With respect to the age of the youngest, the ages of respondents were arranged, the interval of 10 years was considered. The mean age of respondents is 26.6 years. The mean size of household is 4.9 , mode of household size is 6 whereas median of household size is 5. In Rwanda young people in household are mostly involved in water collection. That has also been the reason in this research to involve them so that appropriate data can be gathered from those respondents with firsthand information. Poor water supply or WASH services affect young especially girls as they have task to fetch water from source to the households (UNICEF, 2024). Amount of water used by household depends on the size of household. As household size increases the amount of water used increases also vice versa, this increase of water usage leading to water scarcity. On the other hand, the age of household members also affects the quantity of water used by household. The young ones use high amount of water compared to the household composed by older person (Keshavarzi *et al*., 2006).



(a)



(b)

Figure 4 (a)&(b). Demographic characteristics of respondents with respect to age, gender and household heads

Figure *4(b)* shows that 17.1% of totally surveyed households were headed by females while 82.9% were headed by males. In addition, classification of respondents based on gender shows that 69.2% were females compared to 30.8% of respondents who were males. Even though many household heads were males, in this study most respondents were females because females are more responsible for water collection. With respect to household heads, the findings of current study are proved by the results of National Institute of Statistics of Rwanda report showing that at national level, there are more households headed by males than female-headed households (FHH). For instance, demographic household survey conducted in 2012 demonstrated that household headed by females were only 29% compared to71% headed by males (NISR, 2012, 2018). These findings are further supported by the UNICEF, 2024 study which asserts that the problem of water scarcity affects girls and women as they are primarily responsible for fetching water from the source to the house. In many communities, water sources are distant from homes, and the responsibility of fetching water often falls on women and girls. This task consumes significant time and energy and can expose them to risks, including attacks from men and wild animals (UN-WATER, 2018). On the other hand, *figure 5* shows education level of most respondents where 67.1% have attended high school (i.e., secondary) and 27.4% have only attended primary school. Many respondents were young, for example 45.2% as shown in *figure 4 (a)* confirms youth involvement in collecting water for daily use at home.

Previous studies agree with current findings. For example, it was highlighted that the lack of appropriate and adequate WASH facilities is also a barrier to education for young person more specifically girls (as they are important for menstrual hygiene)(UNICEF, 2024). On the other hand, it was found that education level of the household members has much influence on the quantity of water used by that household which increases water consumption. If household members are educated, they use much water for hygiene or other sanitation activities, but this is different from household whose members have low level of education because such households aren't much concerned with many hygiene and water-demanding sanitation activities. As the result, they don't use much water. The study of Keshavarzi *et al*., (2006) made it clear and understandable that the higher in educational level of the individual, the more use water for hygiene. Furthermore, the research conducted (Jones *et al*., 2006) about drinking water consumption by Canadians using multivariate analysis highlights that the amount of water consumed was associated with age, in-home treatment of water and education level where the results show that mean consumption of water per 250 ml servings was 4.8 in university/graduate/medical school. Therefore, the research concluded that, consumption decreased with increasing age and was higher in respondents with education levels above the referent group, defined as 'less-than high-school'.

Water scarcity factors and their impacts on community livelihoods: Research findings in *figure 6* display main factors contributing to water scarcity in the study area where the absence or presence of few water supply systems accounts for 98.6%, destroyed and insufficient water infrastructures 97.3%, climate change issues 63.7% and population increase 29.4%. Most respondents reported a severe shortage of water infrastructure in the study area compared to water supply needs.

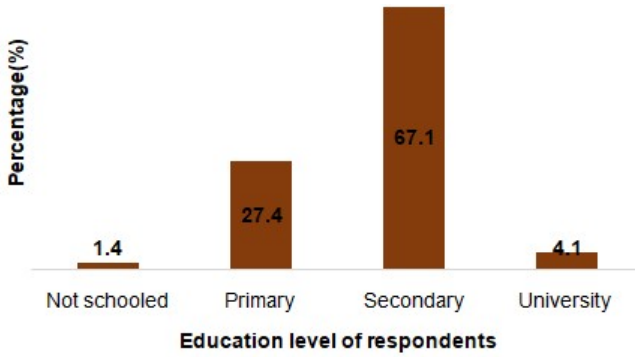


Figure 5. Distribution of respondents with respect to education level

The existing water kiosks are inadequate, with some being nonfunctional for extended periods and others lacking a reliable water supply. This leads to very limited water availability and consumption. Only 16.4% of respondents said that when water pipes are damaged and water isn't available at the kiosk, they go into the forest to collect water from ponds. However, entering the forest without permission from park authorities (RDB) is dangerous, as it can lead to fines or loss of life due to the protected status of the area. In fact, park entrants should get accompanied to ensure their safety. The study of Bush *et al*., (2010) revealed that even though the park authorities often grant permission for local people to access such water sources, this poses a conservation risk. As people access the park, their activities may not be restricted to the collection of water. This is because entry and further activities by people entering the forest are difficult for the park authorities to monitor, and control given their limited resources. The study therefore suggests that attention must be drawn to methods of supplying water to local communities from the permanent water found in the forest or through water harvesting schemes. However, an appropriate environmental impact assessment must be made to evaluate the risks associated with the supply of water from the park. Respondents observed that water shortages happen throughout the year but become more severe during the dry season, often requiring people to walk 2-3 kilometres to find water. According to MacDonald *et al*., (2019) study on groundwater and resilience to drought in the Ethiopian highlands, it was realized that the longest collection times in the dry season and drought were experienced in the highland area, and the impact of drought on collection times was greatest which also have greater implications on the relationship between the volume of water collected and the length of time taken in water collection. This means that the more time it takes to collect water, the lesser amount of water stored and consequently, less water consumption.

The interviewees stated that there are insufficient water sources in the study area. However, field observations indicate that the issue is due to the area's high altitude, which requires water supply systems to use pumps to increase pressure for transporting water from lowland areas. Additionally, high maintenance costs contribute to the poor water supply. The findings of this study are linked with the studies of (Hashimoto *et al.,* 1982; Ruan *et al.,* 2000; Yang *et al.*, 2011) where they asserted that water scarcity becomes more serious due to different factors including anthropogenic activities related to socio-economic development and natural factors like climate change and drought. The country of Rwanda is committed to ensure the availability and sustainable management of water and sanitation for all by 2030. But the present water supply system in the country especially in the study area is hindered by various issues, including high pumping cost for distribution due to hilly terrain, hence high electricity cost to maintain the water supply infrastructure, low water supply coverage, low water production and high non-revenue water CSE, (2019).

It was previously discussed that despite receiving high precipitation, Rwanda's northern and western regions still face water scarcity. This is due to rapid population growth, inadequate water storage infrastructure, and challenging topography and hydrological systems (Nyasa & Victoria, 2024) which imposes limitations on water use. As most Rwandan terrain is mountainous, and most people live on top of the mountains, water is pumped on top of the hills and later distributed by gravity through distribution tanks (Dusingizumuremyi & Bucyensenge, 2019) and later on supplied to water kiosks. Majority of communities living around VNP in Rwanda have water scarcity issues and poor water supply system leading people to enter the forest to collect water (Bush *et al*., 2010). Furthermore, the findings of this study are closely correlated with the findings from related study which reported that climate change mostly long-term drought and increase of population influence the problem of water scarcity. Long term drought leading to dry up and reduction of water whereas increase of population resulting in high demand of water to be used in different activities (both indoor and outdoor activities) (Dolan *et al*., 2021). Both climate change and urbanization aggravate water shortage where water demand exceeds availability (He *et al*., 2021). Having appropriate water supply infrastructure passing in the massive number of households facilitates the availability and accessibility of water to population while reducing the problem of water shortage and scarcity. These strong water infrastructures help communities avoid aggravating other societal challenges such as inequality, and it improves resiliency in the face of an environmental crisis such as a major storm (Barnett, 2023). Furthermore, it was argued by UNICEF, (2021) that exponential population growth leads to high demand of water. When this increase is linked to climate change, poor water management and misuse may result in occurrence of water scarcity.

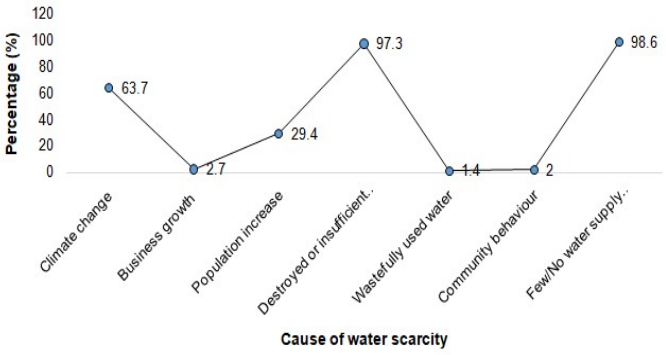


Figure 6. Different causes of water scarcity in the study area

These results are further supported by CISA, (2021) that water supply and demand is influenced by many changing factors, including climate, population, and land use. Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water. This will impact both the region's economy (agriculture, energy, and tourism) and its unique ecosystems. Increasing population and continued development of urbanized areas will increase

water demand and will exacerbate conflicts between urban, agricultural, and industrial uses. Present findings indicate that water scarcity significantly impacts household living conditions. According to respondents as it is shown in *figure7*, 98.6% reported poor hygiene; 97.2% reported health issues including sickness (due to water borne diseases); poor sanitation reported by 95.2%. Effect on children school attendance was reported by 66.4%; dried-up kitchen garden reported by 42.5% while reduction of livestock production was reported by 30.8%. In addition, results in *figure 6* suggest that minimal wastewater (reported by only 1.4% of respondents compared to other factors) highlights the severe lack of water, leaving little room for misuse. Respondents acknowledge that sufficient water could improve hygiene and sanitation, but current shortages lead to waterborne diseases due to inadequate clean water.

The Nature Conservancy (n.d) case study report on the impacts of water scarcity on communities and ecosystems argued that the effects of water scarcity are most severely experienced by indigenous peoples and local communities, who lack the resources and power that large industries, businesses, and governments have to secure adequate clean water for their essential needs. As water becomes scarcer, these marginalized communities bear the greatest burden. Respondents added that water scarcity affects school attendance for children, as they spend significant time searching for water far from home. This often results in them arriving late or missing school, particularly during the dry season. Sometimes, water is found in the distance of 2-3 kilometres. This distance is especially challenging for children walking on foot. Additionally, many households in Rwanda have kitchen gardens, which are crucial for fighting malnutrition. However, during dry periods, these gardens often dry up due to lack of water, leading to a shortage of vegetables and potential malnutrition. Livestock owners also noted reduced production due to insufficient water. Key informants emphasized that the need to fetch water from distant sources causes delays for students, and the use of unclean water leads to waterborne diseases, especially in children. To cope with water shortages, some respondents resort to using contaminated water from ponds and other unprotected sources, which increases the risk of diseases like worms and cholera.

These findings were also highlighted (Republic of Rwanda, 2009b and Uwera, 2013) where statistics published provide an estimate of one third (1/3) of all households with water related issues. Communities lacking access to safe drinking water have to depend on sources like surface water, unprotected and potentially contaminated wells, or vendors offering water with uncertain origin and quality (UN-WATER, 2018). The same situation prevails in the study area where people often purchase water at inflated prices during dry seasons, with little or no knowledge on its source. Other studies which reported corresponding findings have proven the effects of water scarcity, for instance when water sources dry up the problem of water shortage occurs, and then leads to poor hygiene and poor sanitation, children may be forced to be absent even drop out of school in order to spend more time to fetch water from sources that are farther away (UNICEF, 2021; UN-WATER, 2018). During their period, girls might miss school if the school lacks proper water and sanitation resources to manage menstruation. This can also increase their risk of contracting waterborne diseases due to insufficient clean water.

Additionally, water scarcity and changing temperatures and rainfall patterns can negatively impact agriculture, reducing land productivity and leading to food shortages for the population(UNICEF, 2021).

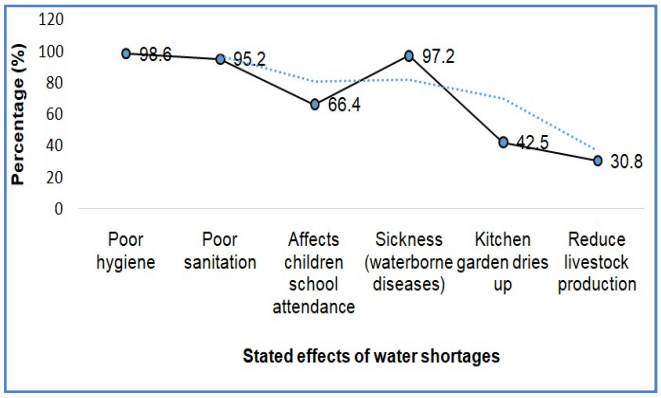


Figure 7. Effects of water scarcity in the study area

Water accessibility status and community perspectives on water use and management: All respondents (i.e.,100%) agree that current water supply in their area is somewhat good and has been improving over the years. However, they noted that it remains inadequate due to the limited number of water kiosks, many of which are non-functional and often run dry for over a week. Results in *figure 8*, show different water sources. The study reveals that respondents primarily get their water from public taps and rainwater, with 100% of them using these sources. Additionally, 82.8% access water from rivers, and 60.9% use ponds. Only 1.4% have a personal tap at home, though it may sometimes be dry. All respondents practice rainwater harvesting during rainy season.

Wealthier households use specialized sheeting for this purpose, while poorer households rely on everyday utensils like jerrycans and buckets. Some poor families also dig ponds to collect runoff water for use in the dry season and for agricultural purposes. These results are then justified by the 2022 population and housing census (PHC) of Rwanda, wherein it was stated that most of the population in Rwanda used water from improved drinking water sources, which include piped water or tap, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water whereas other households used water from unimproved sources. The large number of people who used unimproved water sources were found in the rural areas (UNICEF, 2024).Uwera, (2013) reported that, households in Rwanda who lack piped connections spend a considerable amount of time collecting potentially unsafe water. This is why in their research, Bush *et al*.,(2010) noted the entry of park (VNP) by neighbouring communities to fetch water.

Despite having water kiosks, water is often unavailable in the area during dry seasons, forcing people to travel long distances to fetch water. Households that collect rainwater may sell it at higher prices ($0.15-$0.38 per jerrycan, or 200-500 RWF), compared to the public water rate of $0.015 (20 RWF) per jerrycan, as set by WASAC's tariffs and charges based on monthly water consumption per m^3. Figure 9 illustrates various water usage patterns in communities.

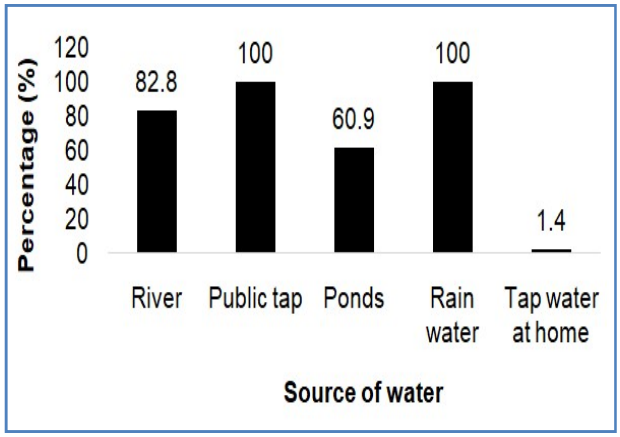


Figure 8. Water sources for the study area

All respondents use water for cooking, drinking, cleaning, and washing. Additionally, 56.2% of respondents use water for feeding and watering animals, while 10.3% occasionally use it for watering kitchen gardens. The limited use of water for gardens highlights the impact of water scarcity on their development and vegetable growth, as farmers struggle to irrigate their crops due to water shortages. Despite these challenges, farmers adapt to water scarcity by attempting to manage limited water available through prioritization of essential activities to ensure reasonable allocation.

According to (Keshavarzi *et al*., 2006; Crouch *et al*., 2021) study reports, it is highlighted that rural community uses water for both indoor and outdoor purposes. The indoor water use purposes may include cooking, drinking, hygiene (laundry, bathing, and cleaning) whereas outdoor activities where water was useful include car washing materials, livestock watering, garden and small-scale greenhouse irrigation. All respondents have experienced inadequate water accessibility for over five years. This issue persists through both rainy and dry seasons, with 55.5% noting that water shortages occur in both periods. Additionally, many respondents lack the necessary infrastructure, like tanks or sheeting, to collect rainwater. These communities also believe that rainwater is unsafe for drinking due to the lack of skills and facilities for proper water treatment which could make it safe for drinking. Ahsan *et al*., (2022) added that sustainable human development and healthy life, require access to adequate and safe drinking water and that water must be available for all. Limited water usage, as current findings acknowledge, is also similar to Bush *et al*.,(2010) study report which confirmed that households around the park (VNP) have the issue of water inaccessibility and scarcity.

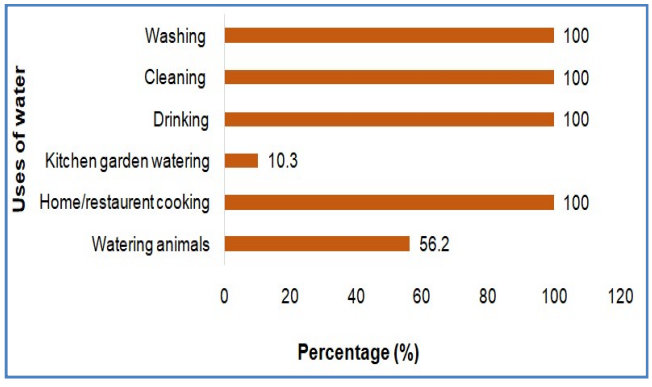


Figure 9. Water uses in the study area

Community behaviour during water scarcity: During water scarcity crises, respondents indicated that they employed various strategies to obtain and save water. Figure 10 illustrates the community's behavior in response to water shortages. These adaptation measures include (1) collecting water from far away river streams 93.1%; (2) use rainwater harvesting tanks 86.3% to collect and store water; (3) collect water from ponds in the forest or elsewhere 65.7%; (4) reducing frequent clothes washing 63.7%; and (5) reduce water for livestock 28.1%. Financial limitations prevent poor families from purchasing water during dry seasons, forcing many to collect water from distant rivers or other sources. Sometimes, they also cannot afford harvested rainwater, which is costly. In contrast, wealthier households with rainwater harvesting systems (RWHTs) use stored water and even sell it to those unable to fetch water from faraway sources. This enables them to generate income by selling water, like other water vendors. To cope with water scarcity, respondents indicated they prioritize water-demanding activities as an adaptation strategy. Key informants noted that during water shortages, farmers adopt adaptation measures such as reducing water for feeding animals, decreasing the frequency of crop spraying (e.g., for potatoes), and halting certain construction activities, etc. Similarly, MINIRENA (2016) report highlights the same behavioural changes to adapt to water shortages where the report suggested the changing patterns and practices of water use to adapt to water scarcity in Rwanda by relying on rainfall to increase water storage through rainwater harvesting at large scale. The report further added that harvesting and using rainwater would not only increase water available for other socio-economic development activities during water crisis but also help mitigating several hazards and resources degradations. That is why previous research such as Bush *et al*., (2010) reported that oftentimes, during water shortages, water used in domestic activities including livestock watering is rainwater collected from park.

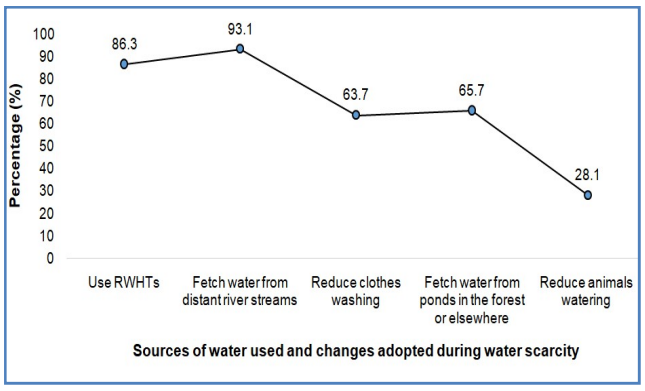


Figure 10. Community behaviour during water shortage periods

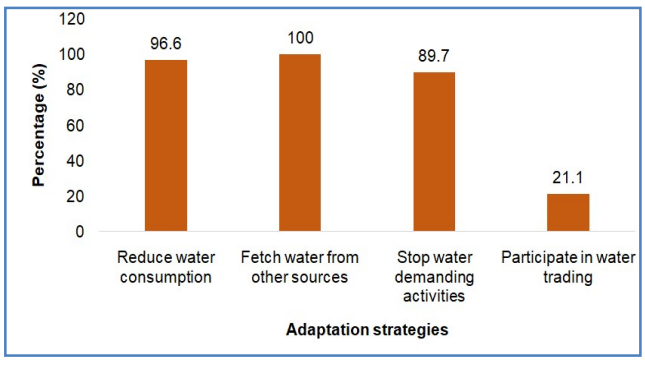


Figure 11. Water shortage adaptation measures

Based on previously highlighted measures as part of behavioural change during water shortage presented in *figure 10,* the study identifies four key adaptation strategies during water shortages, as shown in *figure 11*.These include: (1) fetching water from alternative sources, which 100% of respondents do; (2) 96.6% of respondents suggested reducing household water consumption; (3) 89.7% recommended stopping other water-demanding activities; and (4) 21.1% saw financial opportunity in water trading, suggesting that selling water, if they had transportation, could help them profit during water scarcity. While water shortages have many negative effects, they can also serve as an economic incentive, promoting efficient water use and management at both the household and broader community levels

vegetatble production, preserve water, increase time to fetch water, paying more for access to water, use water reservoirs to reduce household water stress.

Proposed measures to improve water availability: According to respondents, improvements in the water supply made by the government, when comparing current and the previous situation, in the study area suggest that water scarcity or shortage, and accessibility issues can be resolved with certain actions. Figure 12 presents various options suggested by respondents, along with their percentages. The most frequently mentioned measure, considered by the majority as a solution to alleviate water scarcity, was calculated and highlighted in the figure.

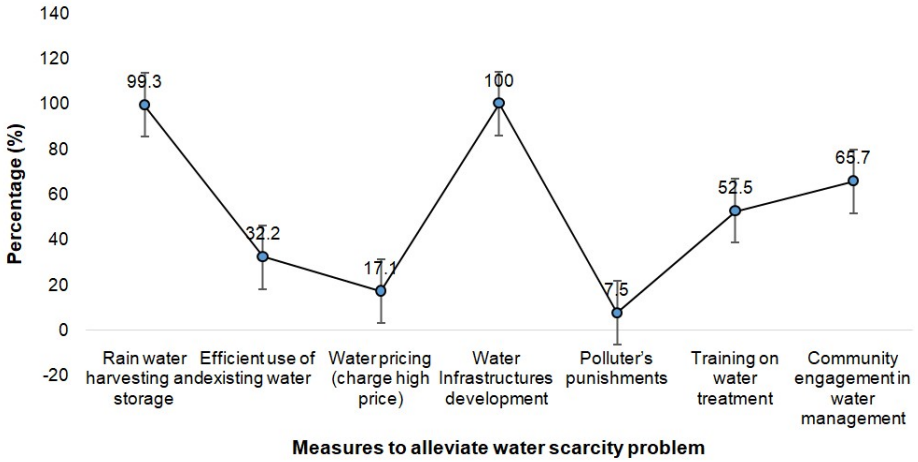


Figure 12. Proposed measures to adapt to water scarcity

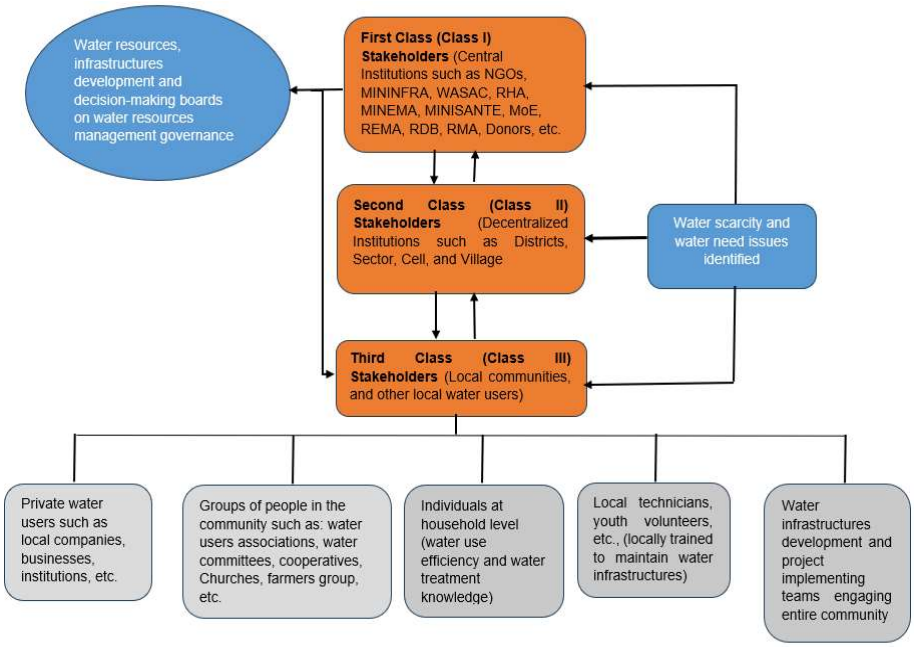


Figure 13. Proposed multi-stakeholder engagement process in water governance and management

Source: Designed by Author, (2024)

For example, in the study area, water scarcity motivated residents to fetch water from sources like Sasangabo. This collected water is then managed carefully by minimizing unnecessary consumption, allowing it to last longer before the next water collection trip. The study of Ahsan *et al*., (2022) reported that when there is the issue of water shortage/ scarcity the population take different adaptation measures, in those measures include reduction of livestock rearing, reduce

The results shown in *figure 12* reveal that 100% of respondents believe that increasing water infrastructures development is a key solution to water scarcity.

Additionally, 99.3% support the provision of rainwater harvesting and storage tanks (RWHTs). Meanwhile, 65.7% recognize the importance of community engagement in water management as an adaptation strategy, and 52.5% consider training in water treatment a solution to improve water

availability and use in the area. Despite the community's perspectives, field observations and the current water supply situation suggest that constructing water supply infrastructure is the most effective solution to alleviate water scarcity in the study area. Since there are currently very few water supply systems, the observation concluded that establishing additional water facilities in the neighbourhoods could potentially resolve the water shortage issues identified. The study area benefits from abundant rainfall, which offers an opportunity to improve water accessibility through rainwater harvesting and storage, potentially alleviating the water scarcity problem. Due to the high rainfall during certain seasons, poor households have suggested using affordable sheeting for rainwater collection. These households, unable to afford Rainwater Harvesting Tanks (RWHTs), have initiated the practice of purchasing inexpensive sheeting to store rainwater for use during dry periods. This approach has helped the community cope, at least partially, with water scarcity issues in the area. According to George-Williams *et al*., (2024) empirical research, it was argued that developing a sustainable water infrastructure entails the planning and management of water systems to ensure the availability, access, quality, and affordability of water resources in the face of social, environmental, and economic challenges. Sub-Saharan Africa (SSA) is currently in an era where it must make significant changes to improve the sustainability of its water infrastructure.

Multistakeholder engagement to adapt to water scarcity: With respect to the characteristics of the study area and research results presented in this report, the findings of the present study compared with similar studies which highlight the needs of stakeholder's engagement in water resources management have led to the development of multi-stakeholders' engagement process (*figure 13*) which allows participants from all levels for sustainable water resources development to meet community needs.In their research, (Al Radif, 1990; Pahl-Wostl *et al*., 2007; Sigalla *et al*., 2021) highlighted that integrating diverse stakeholders in water resources management has been an essential part of sustainable water resources management. Thus, these researchers argued that complexities that arise in the dynamism inherent in the human water interactions are shaped by growth in population and urbanization, which modify the demand for water resources. Furthermore, the USAID and SWP, (2021) study report, highlighted that sustainable water security needs inclusive stakeholder engagement: Sustained participation from local stakeholder representatives including community organizations, water users, government agencies, water managers, and private sector actors. Count and storing water from different without any participation of local community and development partners, the establishment of a safe and sustainable water system cannot be possible.

CONCLUSION

Rwanda, a developing country, faces significant challenges due to climate change and rapid population growth, leading to increased water demand and scarcity. The present study results revealed that climate change (63.7%) and population growth (29.4%) are the main drivers of water scarcity, worsened by both insufficient and absence of water infrastructures.

This is evident from 98.6% of respondents in the study area who revealed that access to water in the area is affected by limited water supply systems, and 97.3% confirmed that the damaged or unmaintained infrastructure also contributes to water scarcity. During dry seasons, the community adapts by fetching water from distant sources (93.1%), using rainwater harvesting tanks (86.3%), and reducing water use in daily activities. However, buying water from vendors is expensive, especially for poor households. If current water supply issues are not addressed, future access to water will worsen, leading to poor hygiene and increased health problems in the study area which can even extend beyond the study area because the neighboring communities can also suffer from the same issues since they share some water supply networks. Geographical challenges resulting from being located in highland areas, along with the high cost of maintaining water infrastructure, further complicate water access. Although population growth contributes to water demand for production and consumption, the study findings show that water scarcity in the study area is primarily caused by insufficient water supply systems, damaged infrastructures, and climate change. Despite these challenges, communities value water highly, and wasteful use is minimal as reported by the lowest number of respondents (i.e., 1.4%) among the totally surveyed population. This shows that water use is efficient during water shortage. Current measures in place to protect the forest (i.e., VNP) have reduced the number of people entering the forest to fetch water during water shortages. Finally, the study outlines recommendations for addressing water scarcity not only in the study area but in Rwanda at large to ensure sustainable access to water. Key solutions include developing water infrastructure, promoting water harvesting and storage, and engaging communities in water management. Training in water treatment is also suggested. Long-term water supply projects, though limited by financial constraints, can be implemented gradually. A multistakeholder approach is essential for success, and strong monitoring and evaluation plans are necessary to ensure timely corrective actions. Decision-making should involve experts familiar with the region's conditions to ensure the feasibility and sustainability of water projects. Continuous law enforcement is also needed to hold stakeholders accountable.

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