Name of QA reviewer (author of the report):	**Muhammad Sheriffdeen**
Signature: (insert full names only)	
Date:	**15/10/2024**
Name of Approver (Supervisor):	**Mustapha Muhammad Dewu**
Signature:	
Date:	
Status	**Quality Assurance Components**
☑	I reviewed the objective of the report and ensured the report I wrote was responsive to the objective.
☑	After finishing the report, I closed it for at least 4 hours, or at best overnight, then returned with a fresh pair of eyes to reread the whole document.
☑	I have used Grammarly to review the whole report. (GHI is made of British/UK English, not American English.)
☑	I have used Microsoft spell and grammar checker to ensure punctuation and other simple errors are fixed.
☑	All facts, figures, and statements have been verified and referenced accordingly.
☑	All comments and feedback from previous reviews have been addressed.
☑	All font types and sizes in the document are properly harmonised.
☑	Document formatting rules: font type: Calibri, font size: 12, 1.5 line spacing, justified paragraphs. All sections are clearly identified with proper bullet identifiers (1.2, 3.5, 2.5, etc.) All new chapters start at the beginning of a new page. An automated table of contents (if needed) is included. A cover page of the report is inserted.

Impact of Borehole Surveillance System (PUMPVIEW)

Table of Contents

List of Abbreviations

GIS - Geographic Information Systems

IoT - Internet of Things

JSS - Junior Secondary School

PHC - Primary Healthcare Center

WASH - Water, Sanitation, and Hygiene

WASHNORM - Water, Sanitation and Hygiene: National Outcome Routine Mapping

1.0 Executive Summary

This report presents the findings from a survey conducted to assess the impact of the innovative Pumpview monitoring system of GHI, on the functionality of water systems and its broader effects on healthcare, education, and businesses in select communities. The survey compared communities with water systems where Pumpview sensors were installed to those control communities without Pumpview sensors on their systems, focusing on key differences in water access and its influence on operational efficiency, health outcomes, livelihood, economic activities and educational attendance.

1.1 Key Findings:

1. **Water Availability:**
    - In communities with water systems (solar-powered water pumps) equipped with the Pumpview system, **96.77%** of respondents reported that water unavailability is rare, with only **3.23%** facing occasional disruptions.
    - Conversely, in communities without Pumpview systems on their water systems, **65.52%** of respondents indicated daily water shortages, revealing a stark contrast in water reliability between the two groups.
    - Only **3.23%** of respondents in Pumpview communities experienced daily water shortages, compared to **65.52%** in non-Pumpview areas.
2. **Healthcare Sector:**
    - In healthcare facilities, water interruptions are significantly shorter in Pumpview-equipped health centres. **100%** of responses reported that interruptions lasted less than a day, while in non-Pumpview centres, water outages can last up to a week.
    - Healthcare centres in Pumpview communities reported fewer cases of waterborne diseases. **Only 2 cases** of waterborne diseases were reported in the past year, compared to **5 cases** in communities without the system, indicating a **60%** reduction in such illnesses.

- Both sets of respondents agreed that water availability improves the quality of care, with healthcare providers in both types of communities acknowledging that water scarcity reduces the overall quality of healthcare services.

3. **Education Sector:**
    - Schools in Pumpview communities reported **100%** water availability, with interruptions lasting less than a day. In contrast, schools in non-Pumpview areas faced water outages lasting up to a month.
    - The availability of water in schools equipped with Pumpview has contributed to improved attendance, especially for female students and teachers. Schools reported a **significant reduction in absenteeism** among girls due to reliable access to water, with **85%** of respondents citing improved hygiene and menstrual health management as key benefits.
    - In non-Pumpview schools, prolonged water shortages resulted in frequent absences, especially among girls, highlighting the system's positive impact on educational continuity in Pumpview communities.
4. **Business Sector:**
    - The data shows that **73.33%** of businesses in Pumpview communities (11 out of 15) indicated that water availability does not affect their operations. Similarly, **78.95%** of businesses in non-Pumpview areas (15 out of 19) reported no reliance on water for their day-to-day activities.
    - However, **26.67%** of businesses in Pumpview communities (4 out of 15) reported that water availability affects their operations, while none of the businesses in non-Pumpview communities expressed a similar concern. This suggests that the presence of Pumpview increases awareness of water dependence and possibly the confidence of businesses to rely on a more stable water supply.

2.0 Introduction

2.1 Background of the Study

In rural Nigeria, access to safe, clean, and reliable water remains a persistent challenge. Despite various initiatives to improve water, sanitation, and hygiene (WASH) services, millions of Nigerians continue to depend on unsafe water sources, leading to significant health, economic, and educational consequences (Water Aid, 2023). According to the World Bank, approximately 71 million people in Nigeria still rely on unsafe water sources. The 2021 WASHNORM survey revealed that a staggering 87% of the population of around 179 million people do not have access to safely managed drinking water services. The problem is particularly severe in the Northeast, where only 2% of the population has access to such services, compared to 29% in the Southwest. There is also a considerable disparity between rural and urban areas, with only 6% of rural residents having access to safely managed water, compared to 27% in urban areas. Additionally, the poorest households, with just 2% access, are 17 times less likely to benefit from safe water services compared to the wealthiest, where 37% enjoy access.

A significant contributor to this crisis is the breakdown of water supply facilities (Cronk and Bertrand, 2017). According to the WASHNORM survey, only 62% of all water facilities in Nigeria were functional at the time of the survey. Privately owned water points fared better, with 68.5% reported as functional, while only 52.8% of publicly owned facilities were operational. The number of privately owned water points is also higher, with 1.3 million compared to 1 million publicly owned points. These statistics underscore the widespread challenges faced by water infrastructure in Nigeria, particularly in rural and underserved regions, where water points frequently experience prolonged breakdowns due to the absence of efficient maintenance systems. Communities often wait until complete failure occurs before initiating repairs, resulting in higher repair costs, extended downtimes, and livelihood disruptions. Women and girls, in particular, bear the brunt of these challenges, as they are primarily responsible for fetching water, which often affects their health, education, and overall well-being (Gulumbe, 2023).

Innovative solutions like PUMPVIEW are vital to addressing these systemic challenges. Pumpview is a remote water facility monitoring system (built by Green Habitat Initiative between 2022 and 2023) that utilizes Geographic Information Systems (GIS) and Internet of Things (IoT) technology to monitor borehole functionality in real-time. Access to Pumpview is through a dedicated website (www.pumpview.com.ng) that can be accessed on any mobile phone or laptop with internet access. By providing early fault detection and data on water usage, Pumpview enables local government authorities, communities, and social enterprises to carry out preventive and corrective maintenance efficiently, significantly reducing downtime and ensuring continuous water supply. This technological solution not only improves the sustainability of water infrastructure but also enhances health outcomes and promotes community development across rural Nigeria.

Pumpview portal and Pumpview sensors were built and installed on 100 pumps in Kebbi and Sokoto States in northwest Nigeria in April 2023. Social enterprises and rural water supply and sanitation agencies (RUWASSAs) in the two states were taught how to utilise the system. After more than a year of operation, GHI decided to conduct a post-assessment of the impact of Pumpview system on water functionality, in communities with and without Pumpview sensors installed on water systems. This document is a report of this survey conducted in August 2024.

2.2 Research Objectives

The research focuses on assessing the impact of the Pumpview system in rural communities. The specific objectives are:

I. To evaluate the impact of PUMPVIEW on the functionality and downtime of boreholes and water facilities in rural communities.
II. To analyze secondary outcomes, including health, education, and economic benefits arising from improved access to clean water.
III. To assess the role of social enterprises in utilizing PUMPVIEW data for timely repairs and maintenance.

IV. To provide recommendations for scaling PUMPVIEW across other regions in Nigeria and integrating it into broader WASH (Water, Sanitation, and Hygiene) strategies.

2.3 Research Questions

To meet the objectives of the study, the following research questions will be addressed:

I. How does the implementation of PUMPVIEW affect the functionality and downtime of water facilities in intervention communities compared to control communities?
II. What health outcomes have been observed as a result of improved water access in these communities, specifically regarding the incidence of waterborne diseases?
III. What is the impact of improved water access on education, particularly for girls, who are often responsible for fetching water for their families?
IV. How has the availability of real-time water monitoring affected the operations of social enterprises engaged in borehole repairs, and how has this created new economic opportunities?

2.4 Overview of The Pumpview System

The Pumpview system is a transformative innovation in the realm of water infrastructure management, particularly tailored to improve the monitoring and sustainability of boreholes in rural and remote areas. By leveraging two key technologies—the Internet of Things (IoT) and Geographic Information Systems (GIS) Pumpview provides real-time, actionable insights into the performance and operational status of water facilities. This invention directly addresses the critical challenges of water scarcity and infrastructure failure, especially in underdeveloped regions where manual monitoring and maintenance are difficult due to lack of access, high operational costs, and limited technical expertise.

The key objective of Pumpview is to enable communities, government agencies, and WASH (Water, Sanitation, and Hygiene) stakeholders to track borehole functionality, water flow, and consumption patterns in real time. This technological solution facilitates early detection of

functionality, allowing for timely preventive and corrective maintenance actions, which significantly reduce operational downtimes and associated financial burdens. Moreover, the system's GIS integration provides geographical mapping and detailed locational data on water facilities, enhancing resource allocation and enabling data-driven decisions for better water resource management.

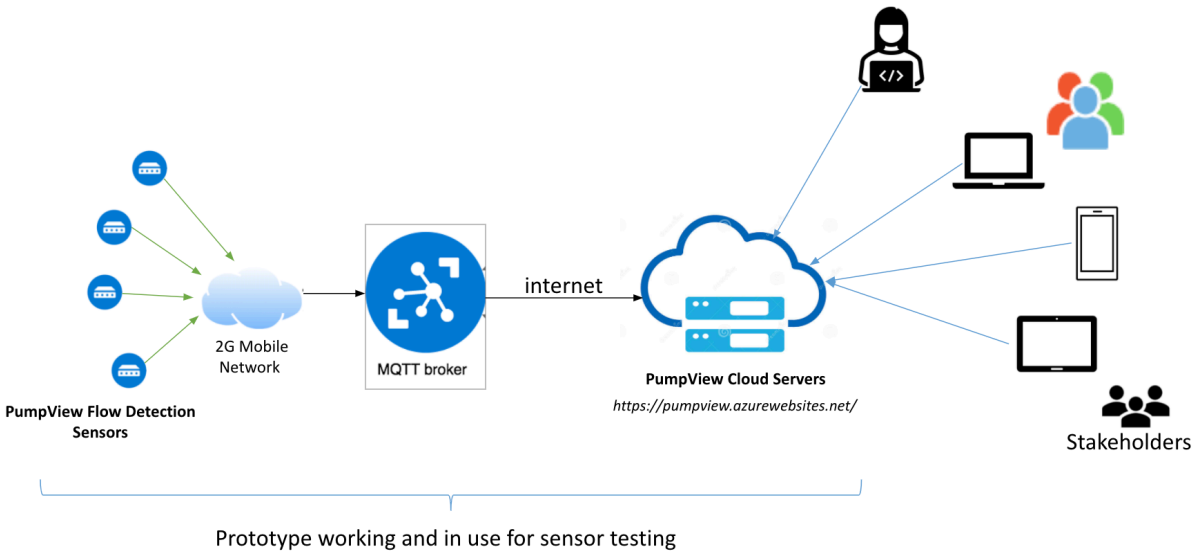

Figure 1: Conceptual design for the Pumpview system

Pumpview is also designed with sustainability in mind. It utilizes solar-powered sensors with long battery life, ensuring continued operation even in the most remote regions with unreliable electricity. Additionally, its low power consumption and GSM communication compatibility make it highly suitable for rural deployment, where cellular networks are often the only available means of communication. Ultimately, Pumpview not only increases the lifespan of borehole infrastructure but also strengthens community engagement through transparent water usage data, fostering sustainable water resource management.

3.0 Methodology

3.1. Study Design

This study employed a quasi-experimental design with three intervention communities and three control communities. The intervention communities are communities where the PUMPVIEW sensors are installed, while the control communities are communities with water facilities without the PUMPVIEW sensors.

3.1.1 Intervention Communities

1. Gwandu Rumbukawa
2. Dalijan Shiyar Nizamiya
3. Dangoma
4. Gwandu General Hospital
5. Dangoma JSS

3.1.2 Control Communities

1. Ambursa Town
2. Zauro Town
3. Unguwan Jeje
4. Unguwan Jeje PHC
5. Sani Ajiya Secondary School Gwandu

3.2. Variables

The variables considered for the survey include:

I. Primary Independent Variable:

Installed PUMPVIEW sensors on solar power water borehole.

II. Primary Dependent Variable:

Functionality/Downtime rates of water facilities.

III. Secondary Dependent Variables:

1. Health outcomes (e.g., incidence of waterborne diseases).
2. Educational outcomes (e.g., school attendance rates for girls).
3. Local business operations (e.g., business continuity rates).
4. Maintenance costs (e.g., average cost of repairs).
5. Time spent on water search by women (e.g., average hours per day).

3.3. Data Collection

The following data were collected from communities, schools and health centres during the survey exercise:

I. Quantitative Data:

- Functionality/downtime rates (daily logs)
- Health outcomes (clinic records, surveys)
- Educational outcomes (school attendance records)
- Local business operations (business continuity surveys)
- Maintenance costs (repair logs)
- Time spent on water search (household surveys)

II. Qualitative Data:

- Focus group discussions with community members
- Interviews with local business owners, school administrators, and health centre officials.

3.4. Analysis

The data was analyzed using descriptive statistics, including charts, graphs, and tables, to compare outcomes between communities with and without the Pumpview system. These visual and statistical tools allowed for a clear comparison of water availability, health, education, and

business outcomes, providing insights into the direct and indirect effects of the Pumpview system on these communities. Through this approach, the pathways by which Pumpview influences various outcomes were identified and illustrated.

4.0 Results/Findings

This chapter presents an in-depth analysis of the results derived from the survey examining the impact of the Pumpview monitoring system within the selected communities. By conducting a comparative evaluation between communities, healthcare centres, local businesses, and schools that are equipped with the Pumpview system and those that are not, this chapter aims to highlight the tangible benefits that the system offers, while also identifying potential areas where further enhancements could be made. Through this comparison, the study seeks to underscore the positive effects that Pumpview has brought to various aspects of community life, as well as to reveal any shortcomings or gaps that may exist. These findings will form a crucial foundation for developing a deeper understanding of the broader social, economic, and health-related implications that the implementation of the Pumpview system has had on these communities. By exploring these impacts in detail, this chapter hopes to provide valuable insights into the overall effectiveness of the system and to contribute to future efforts aimed at optimizing its use for even greater community benefit.

4.1 Household Survey

This section provides a comprehensive analysis of the findings obtained from the household survey, which was conducted to assess the impact of the Pumpview system in the targeted communities. The results presented in this section offer valuable insights into how the introduction of Pumpview has influenced various aspects of daily life, including water facility functionality, accessibility, and the overall well-being of the residents.

4.1.1 Water shortages

The data in Figure 2 reveals a significant and striking disparity in water availability between communities equipped with Pumpview monitoring facilities and those that are not. In communities where the Pumpview system is operational, instances of water shortages are reported to be exceedingly rare, with an overwhelming 96.77% of respondents indicating that they seldom, if ever, experience disruptions in their water supply. In stark contrast, communities

lacking the Pumpview system face frequent and substantial challenges regarding water access, with a notable 65.52% of respondents reporting that they experience water unavailability on a daily basis.

This data can be further broken down to highlight the differences between the two groups. Among the communities with Pumpview, only one report of daily water unavailability was recorded, underscoring the system's effectiveness in maintaining consistent access to water. On the other hand, in communities without Pumpview, a significant number of 19 instances of daily water shortages were reported, highlighting the frequent and ongoing struggle to secure a reliable water supply.

Conversely, 30 reports of rare water unavailability came from Pumpview-equipped communities, compared to only 10 from those without, illustrating the marked improvement in water accessibility provided by the Pumpview system.

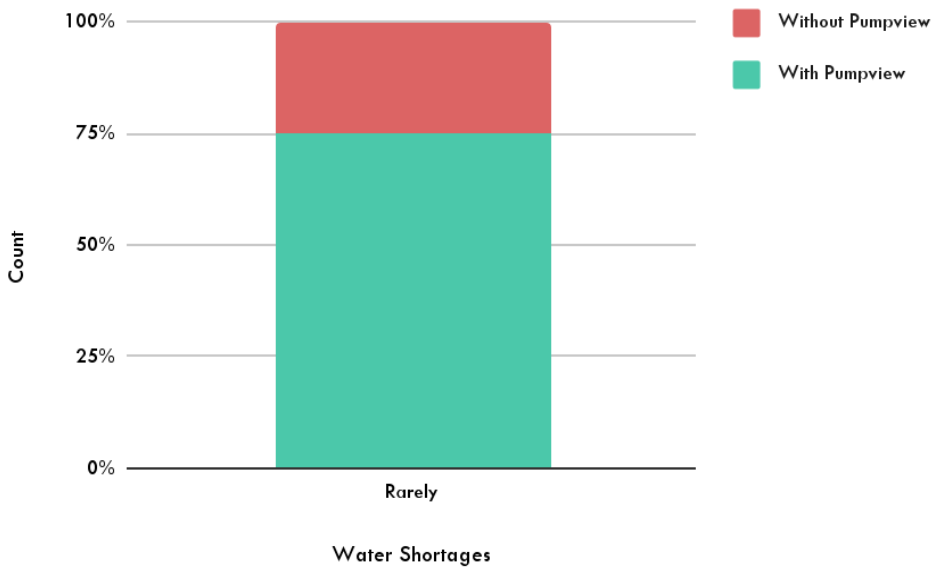

Figure 2: Graph showing data on the frequency of water unavailability in selected communities.

This stark contrast underscores the vital role that the Pumpview monitoring system plays in ensuring a steady and dependable water supply, illustrating its value in significantly reducing the frequency of water shortages in communities where it has been implemented.

4.1.2 Time Spent to Get Water

The data in Figure 3 reveals a clear distinction in the amount of time it takes to fetch water between communities equipped with Pumpview facilities and those without. In communities that benefit from the Pumpview system, the majority of respondents, an impressive 87.10%, report that fetching water requires less than 15 minutes. This suggests that the presence of Pumpview significantly reduces the time and effort needed to access water.

In contrast, the situation is notably different in communities without the Pumpview system. Here, only 58.62% of respondents are able to retrieve water in under 15 minutes, indicating that a substantial number of residents in these areas face longer wait times for accessing this vital resource. A significant portion of the population in Pumpview-absent communities, approximately 37.93%, report that it takes them more than 15 minutes to fetch water. This highlights the additional time burden these individuals endure, often exceeding the threshold of what is considered a reasonable time to secure water.

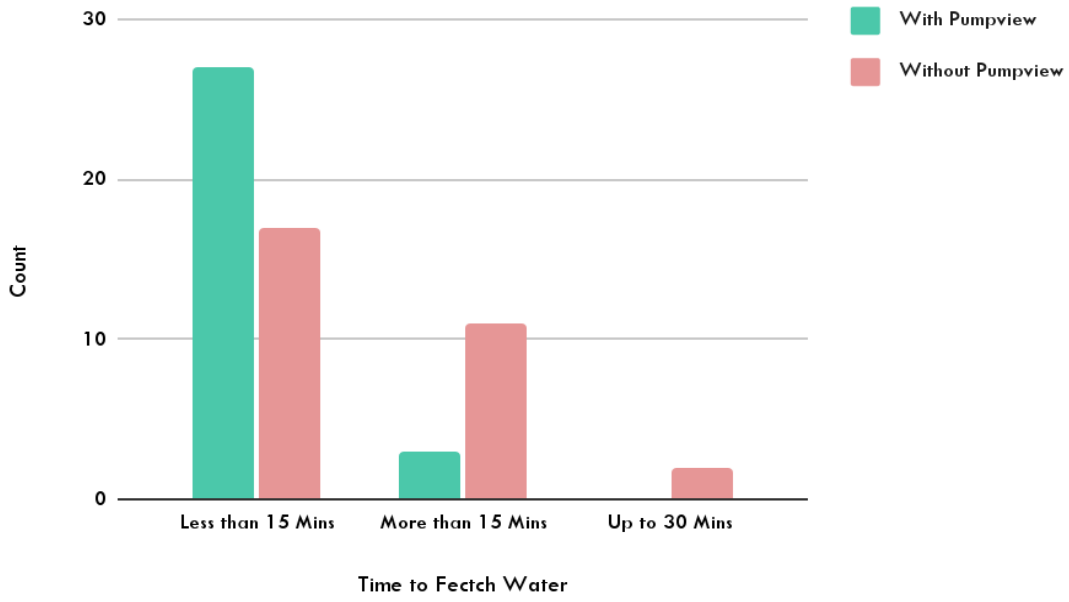

Figure 3: Graph showing the length of time it takes respondents to get water.

Breaking down the figures further, 27 respondents from Pumpview-equipped communities stated that it takes them less than 15 minutes to fetch water, compared to only 17 from communities without the system. Additionally, only 3 individuals in Pumpview-equipped areas reported taking more than 15 minutes to retrieve water, while a notable 11 respondents in communities without Pumpview reported longer wait times. Furthermore, two respondents from communities without Pumpview reported needing up to 30 minutes to access water, further emphasizing the challenges these areas face.

This data underscores the positive impact that the Pumpview system has on increasing the functionality of available water facilities thereby reducing over-dependence on mostly few functional water facilities which ultimately reduces the time required to fetch water, making it a crucial component in enhancing water accessibility and efficiency in the communities where it is implemented.

4.1.3 Water Facility Breakdown

The analysis of the data reveals a clear distinction between communities equipped with the Pumpview monitoring system and those without it in terms of the frequency of water facility issues. In communities with Pumpview, a significant majority—67.74%—rarely face water-related challenges. An additional 29.03% encounter occasional issues, while only a small 3.23% report never having any problems.

Conversely, in communities lacking Pumpview, the situation appears more troublesome. A majority (55.17%) encounter issues occasionally, while 44.83% report rare occurrences of problems. Notably, no communities without Pumpview reported ever experiencing issues with their water facilities.

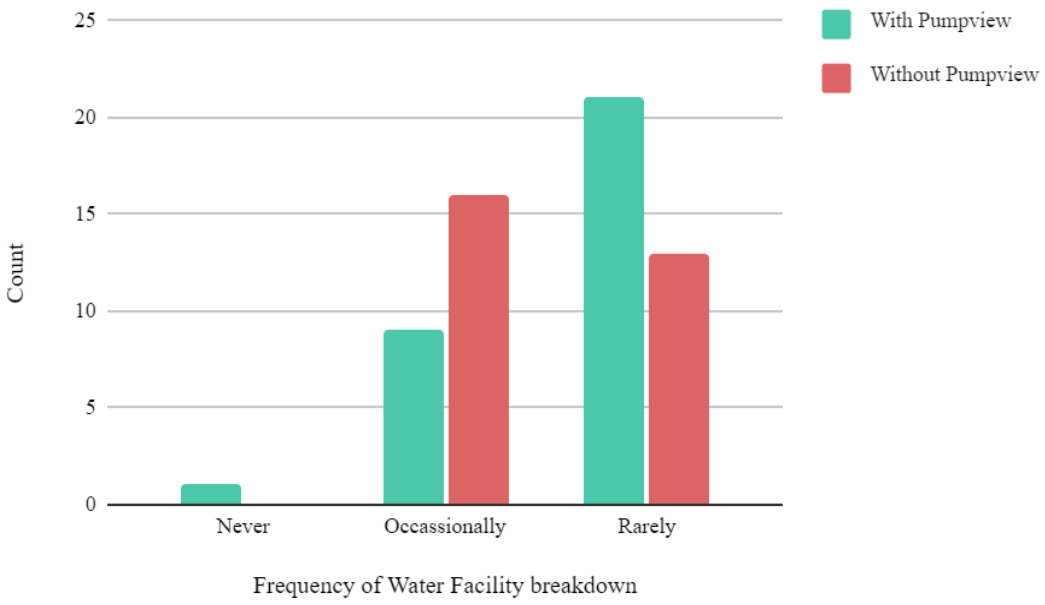

Figure 4: Graph showing the frequency of water facility breakdown

This data indicates that the Pumpview system plays a pivotal role in improving the reliability of water access. Communities with Pumpview not only experience fewer disruptions, but they also report higher satisfaction levels in terms of facility maintenance. The stark contrast, particularly the lack of any "never encountering issues" responses in non-Pumpview communities, reinforces the system's effectiveness in minimizing downtime and maintenance challenges. Ultimately, the evidence suggests that Pumpview contributes to a more stable and reliable water supply infrastructure, making a tangible impact on the well-being of these communities.

4.1.4 Facility Repair Time

The data illustrates a clear difference in the speed of repairs between communities with PUMPVIEW facilities and those without. In communities where PUMPVIEW is implemented, the majority of repairs—18 instances—are completed within 2 days, highlighting a quicker response time. A smaller number, 8 instances, take more than 2 days, while only 5 instances require up to a week to resolve.

In contrast, communities without PUMPVIEW experience slower repair times. Only 11 instances are resolved in less than 2 days, while 15 instances take longer than 2 days, indicating a delay in response. A small number, 3 instances, require up to a week for repairs to be completed.

The percentages clearly indicate that communities equipped with PUMPVIEW enjoy significantly faster repair times. Over half (58.06%) of their repairs are completed within 2 days, compared to just 40.74% in non-PUMPVIEW communities. Additionally, fewer PUMPVIEW communities experience prolonged repairs, with only 25.81% of repairs taking more than 2 days, compared to a much higher 55.56% in communities without the system.

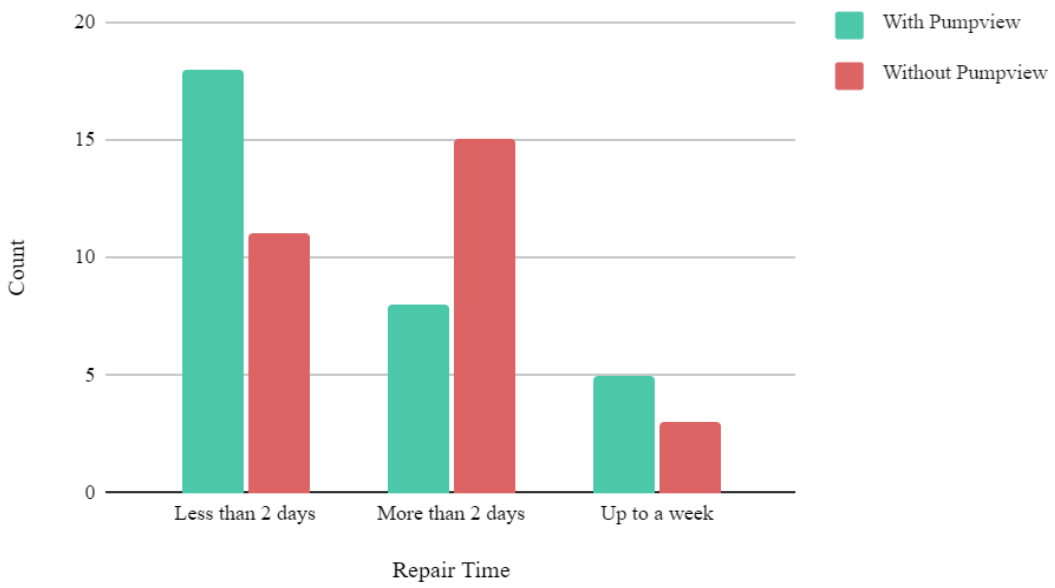

Figure 5: Graph showing the duration of repair time of facility breakdown.

This disparity suggests that PUMPVIEW facilities likely facilitate quicker identification of issues and more efficient repair processes. The visual representation of these findings in a bar chart reinforces the idea that communities with PUMPVIEW enjoy faster maintenance services, contributing to a more reliable water supply system and reducing the overall downtime of facilities.

4.2 Healthcare Survey

This section offers a thorough analysis of the results derived from the survey conducted at various healthcare centres. The primary objective of this survey was to evaluate the effects of the Pumpview system on health outcomes within the communities that benefit from its implementation. This analysis will cover the key findings, identify trends, and highlight any significant changes observed in health outcomes, providing a comprehensive overview of the system's impact on the targeted populations.

Table 1: Healthcare survey data

S/N	Variables	Outcomes	
		With PUMPVIEW	**Without PUMPVIEW**
1	Source of Water	Borehole	Borehole
2	How often is water available at the hospital?	Always	Always
3	Have you experienced any interruptions in water supply over the last 12 months?	Yes	Yes
4	How frequently do these interruptions occur?	Occasionally	Occasionally
5	On average, how long do water interruptions last?	Less than a day	Up to a Week
6	Have there been any reported cases of waterborne diseases in the healthcare centre in the past year?	Yes (2 cases)	Yes (5 cases)
7	How does water availability impact patient care at your facility? (Select all that apply)	Reduced quality of care	Reduced quality of care

4.2.1 Source of Water

Both healthcare centres, whether equipped with Pumpview or not, rely on boreholes as their primary source of water. This indicates that the basic infrastructure for water access is consistent in both types of communities. However, the management and stability of the water supply seem to vary, with the presence of Pumpview likely playing a key role in reducing the severity of interruptions.

4.2.2 Water Availability at Hospitals

Both healthcare centres report that water is "always" available. This suggests that the water supply infrastructure provides a reliable flow of water to both facilities. Consistent water availability is essential in healthcare settings, where water is critical for sanitation, hygiene, and patient care. However, the availability of water does not eliminate the occurrence of supply interruptions, which still affect both facilities.

4.2.3 Interruptions in Water Supply

Despite reporting consistent water availability, both healthcare centres have experienced water supply interruptions over the past 12 months. The frequency of these interruptions is described as "occasional" for both groups, meaning that while interruptions are not a constant issue, they do occur from time to time. This similarity suggests that external factors, such as environmental conditions, infrastructure issues, or technical failures, may be responsible for causing occasional disruptions.

The most notable difference between the two groups is the duration of water supply interruptions. In healthcare centres with the Pumpview system, these interruptions last "less than a day." This brief duration allows the facility to manage the disruption with minimal impact on operations. Short interruptions are far less likely to compromise sanitation or patient care, as hospitals can implement contingency plans or rely on stored water to meet immediate needs.

In contrast, healthcare centres without the Pumpview system experience interruptions that can last "up to a week." A week-long disruption in water supply can have a serious impact on the quality of healthcare services, as it severely hampers the ability to maintain proper sanitation, clean medical equipment, and provide essential patient care. Long-term water interruptions can lead to compromised hygiene practices, increased health risks for patients, and greater strain on hospital resources.

While both facilities experience occasional interruptions, the Pumpview system significantly reduces the duration of these interruptions, limiting them to less than a day. This is a critical advantage in healthcare settings, where continuous access to water is essential for maintaining hygiene, patient care, and overall facility operations. On the other hand, healthcare centres without the Pumpview system face interruptions lasting up to a week, which can severely compromise the quality of care. A week without water is likely to lead to poor hygiene practices, increased patient discomfort, and a higher risk of infections or other health complications.

4.2.4 Reported Cases of Waterborne Diseases

The data indicates that both healthcare centres have reported cases of waterborne diseases over the past year. However, there is a clear difference in the number of cases. Healthcare centres with the Pumpview system reported only 2 cases of waterborne diseases, while those without the system reported 5 cases. This disparity suggests that while waterborne diseases remain an issue in both types of communities, the presence of the Pumpview system may contribute to better water quality management, leading to fewer instances of disease outbreaks.

The higher number of cases in facilities without Pumpview may be due to longer periods of water interruptions, which can increase the likelihood of using contaminated water sources or failing to maintain proper hygiene standards. This underscores the importance of not just water availability, but also water quality and monitoring, both of which can significantly impact health outcomes.

The difference in the number of reported waterborne disease cases further underscores the importance of the Pumpview system. Facilities with Pumpview report fewer cases of waterborne diseases, suggesting that the system may help in managing water quality more effectively, thereby reducing the risk of contamination. The higher number of cases in facilities without Pumpview points to a more serious issue with water quality management, which is likely exacerbated by longer water interruptions. Waterborne diseases can spread rapidly in environments where clean water is not available, making this a critical health risk in healthcare settings.

4.2.5 Impact on Patient Care

Both healthcare centres report that water availability has a direct impact on the quality of patient care. In both cases, the quality of care is reduced when the water supply is compromised. This is a critical issue, as water is essential for a wide range of healthcare activities, including maintaining hygiene, sterilizing medical instruments, and ensuring that patients receive proper treatment. Any disruption in water supply, especially prolonged ones, can negatively affect patient outcomes and the overall effectiveness of the healthcare facility.

Both facilities report a reduction in the quality of patient care due to water availability issues, highlighting the direct link between water supply and healthcare outcomes. Healthcare centres rely heavily on water to maintain a sterile environment, ensure patient safety, and prevent the spread of infections. Prolonged water shortages, especially in facilities without Pumpview, can lead to deteriorating conditions that affect both staff and patients, making it difficult to provide the necessary level of care.

The data reveals that while both healthcare centres experience occasional water supply interruptions and cases of waterborne diseases, the presence of the Pumpview system significantly mitigates the impact of these challenges. Centres with Pumpview experience shorter interruptions and fewer cases of waterborne diseases, allowing them to maintain a higher standard of patient care. In contrast, facilities without Pumpview face longer disruptions

and more frequent instances of waterborne diseases, both of which negatively affect the quality of care.

The data highlights several important insights into how water availability, interruptions, and waterborne diseases impact healthcare centres in communities with and without the Pumpview system.

4.3 School Survey

This section offers a thorough and detailed analysis of the findings gathered from the school survey, which was specifically conducted to evaluate the impact of the Pumpview system on the educational landscape within the beneficiary communities. By delving into the experiences and feedback from schools equipped with the Pumpview system, this analysis aims to provide a nuanced understanding of how improved water access and monitoring may influence various aspects of the educational environment. These aspects include student attendance, overall hygiene conditions, the functionality of school facilities, and even the broader learning experience. The insights derived from this survey will not only highlight the benefits that the Pumpview system brings to educational institutions but will also shed light on any challenges or areas that may require further attention to optimize its impact on education in these communities. Through this in-depth evaluation, this section seeks to underscore the vital connection between water infrastructure and the overall quality of education.

Table 2: School survey data

S/N	Variables	Outcomes	
		With PUMPVIEW	**Without PUMPVIEW**
1	Source of Water	Borehole	Borehole
2	How often is water available at the school?	Always	Sometimes
3	Have you experienced any interruptions in water supply over the last 12 months?	Yes	Yes
4	How frequently do these interruptions	Occasionally	Occasionally

	occur?		
5	On average, how long do water interruptions last?	Up to a week	Up to a Month
6	Do you think the availability or lack of availability of water in the school affects the health and performance of both students and teachers?	Yes	Yes
7	How does the lack of water in school affect girls and women?	Reduced absenteeism especially for girls and female teachers	Discomfort for girls and women during menstrual periods

The data provided presents a comparison of water availability and its impact on schools in communities equipped with the Pumpview system versus those without it. The results highlight both the similarities and stark contrasts between the two groups, particularly in terms of water availability, the duration of interruptions, and the broader effects on health and performance.

4.3.1 Source of Water

Both schools in communities with and without Pumpview facilities rely on boreholes as their primary source of water. While this implies that the fundamental water source is the same, the difference lies in how efficiently water is accessed and managed due to the presence of the Pumpview monitoring system. The system's ability to monitor and regulate water availability seems to play a crucial role in improving access to water.

4.3.2 Water Availability at Schools

In schools with the Pumpview system, water is reported to be "always" available, indicating a consistent and reliable supply. In contrast, schools without Pumpview experience water availability only "sometimes." This suggests that the Pumpview system significantly enhances the regularity of water access, which is critical in maintaining school operations and hygiene standards.

4.3.3 Interruptions in Water Supply

Both groups of schools reported having experienced interruptions in their water supply over the last 12 months. However, the frequency and duration of these interruptions differ considerably.

4.3.3.1 Frequency of Interruptions

Both types of schools report that these interruptions occur "occasionally." This similarity may indicate that water interruptions can happen regardless of the Pumpview system, possibly due to broader infrastructural issues or environmental factors. However, the Pumpview system seems to mitigate the severity of these interruptions, as seen in the next point.

4.3.3.2 Duration of Interruptions

The most significant difference between the two groups is the length of time these water interruptions last. In schools with Pumpview, water interruptions typically last "up to a week." While any disruption in the water supply is undesirable, a week-long interruption can still be manageable with proper planning and temporary solutions.

In stark contrast, schools without the Pumpview system experience interruptions that can last "up to a month." This prolonged disruption has much more severe consequences, likely leading to major disruptions in daily school activities, increased absenteeism, and deteriorating health conditions. A month without water can result in serious hygiene issues, affecting both the students and teachers, as well as the overall functioning of the school.

4.3.4 Impact on Health and Performance

Both groups of schools acknowledge that the availability or lack of water has a direct effect on the health and performance of both students and teachers. However, the nature and extent of this impact differ based on the level of water access.

4.3.4.1 Schools with Pumpview

In schools equipped with the Pumpview system, the consistent availability of water is reported to reduce absenteeism, particularly for female students and teachers. This is especially relevant for girls during menstruation, as access to water ensures better hygiene and comfort, allowing them to attend school regularly. Female teachers also benefit from this, as they are less likely to take leave due to hygiene-related issues. The availability of water fosters a healthier and more conducive learning environment, contributing to better academic performance and well-being for both students and staff.

4.3.4.2 Schools without Pumpview

In schools lacking the Pumpview system, the lack of consistent water access creates discomfort, particularly for girls and women during their menstrual periods. This discomfort likely leads to higher rates of absenteeism among female students and teachers, as they are less able to manage personal hygiene effectively. The absence of reliable water access also negatively impacts the overall school environment, reducing comfort, hygiene standards, and morale, all of which can hinder both learning and teaching performance.

The data underscores the critical role that water availability plays in the educational environment. Schools with the Pumpview system enjoy a more consistent water supply, shorter interruptions, and improved hygiene conditions, which in turn contribute to better health outcomes and school attendance, particularly for female students and teachers. This indicates that the Pumpview system not only supports the physical infrastructure but also fosters an environment that promotes equal access to education, especially for girls, who are often disproportionately affected by water shortages.

On the other hand, schools without Pumpview face longer, more frequent interruptions in water supply, which significantly impacts both student attendance and teacher performance. The extended periods without water, lasting up to a month, likely create an environment where basic hygiene cannot be maintained, contributing to discomfort and absenteeism, especially for women. This highlights the need for improved water management systems in these schools, as

the lack of reliable access to water impedes educational outcomes and exacerbates gender inequalities.

In essence, this comparison demonstrates that the Pumpview system not only improves water availability but also positively influences educational outcomes by promoting better health, attendance, and performance, especially among female students and staff. The data strongly suggests that expanding the Pumpview system to other schools could mitigate the challenges associated with water access and enhance the overall educational experience.

4.4 Local Businesses/Economic Activities

This section provides a comprehensive analysis of the findings gathered from the survey on local businesses and economic activities, which was conducted to assess the impact of the Pumpview system on livelihoods and economic growth in beneficiary communities. The survey specifically compared communities equipped with Pumpview facilities to those without, enabling a clearer understanding of the system's direct effects on economic indicators. By examining data across both types of communities, this analysis explores how the presence of Pumpview has influenced factors such as business productivity, employment rates, income generation, and overall economic stability. Key trends and differences between the two community groups will be highlighted to assess the extent to which Pumpview contributes to improved livelihoods, economic resilience, and sustainable development within the areas it serves.

4.4.1 Reliance on Water for Local Businesses

The data provides a clear picture of how businesses in communities with and without the Pumpview monitoring system view their dependence on water for operations.

In communities with the Pumpview system, 3 businesses reported that they do not rely on water for their operations. This contrasts with 5 businesses in communities without Pumpview that indicated a similar lack of water dependence. This suggests that the presence of Pumpview does not significantly change the number of businesses that do not rely on water. The

difference is minor, indicating that the Pumpview system may not influence the fundamental nature of businesses' water needs.

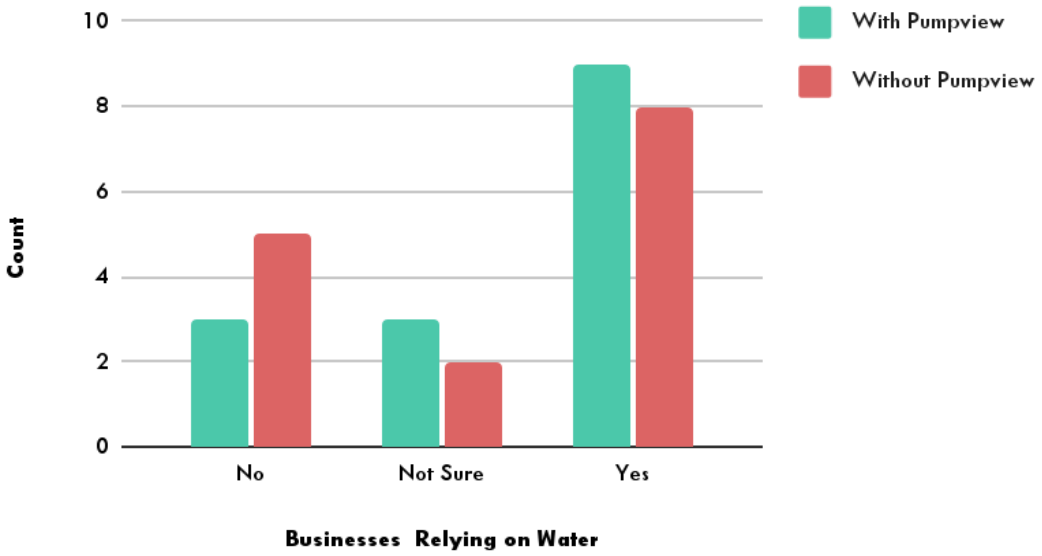

Figure 6: Graph showing local business's reliance on water

Additionally, the data shows that 3 businesses in Pumpview-equipped communities are unsure about their reliance on water, while only 2 businesses in non-Pumpview communities reported the same uncertainty. This higher level of uncertainty in Pumpview communities might reflect a broader or less clear understanding of water dependence among these businesses. It could also suggest that businesses in these areas might benefit from more detailed information or support regarding their water needs and the impact of the Pumpview system.

When it comes to businesses that do rely on water, the data indicates that 9 businesses in communities with Pumpview report a dependence on water for their operations, compared to 8 businesses in communities without the system. This slight increase in the number of businesses acknowledging their dependence on water in Pumpview-equipped communities may suggest that the system helps businesses better recognize and articulate their water needs. It could also imply that the availability of a more reliable or well-monitored water supply enhances awareness of water’s importance to business operations.

Overall, the data underscores that water is a crucial resource for businesses in both types of communities. Despite the presence of Pumpview, the fundamental reliance on water remains high. The system appears to have a modest impact on increasing the recognition of water dependence among businesses, but the essential need for water persists regardless of the system's presence. Addressing the uncertainties and ensuring reliable water access is crucial for supporting business operations effectively, and further improvements in communication about the benefits of Pumpview could help in this regard.

4.4.2. Impact of Water Availability on Business Operation

This data highlights how businesses in both Pumpview and non-Pumpview communities perceive the effect of water availability on their operations.

In communities equipped with the Pumpview system, 11 businesses reported that the availability of water does not affect their operations. In communities without Pumpview, 15 businesses gave a similar response, indicating that the majority of businesses in both types of communities do not see water availability as a direct factor impacting their day-to-day business functions. This suggests that many businesses, regardless of the presence of Pumpview, either have minimal water requirements for their operations or have developed strategies to mitigate the effects of water shortages.

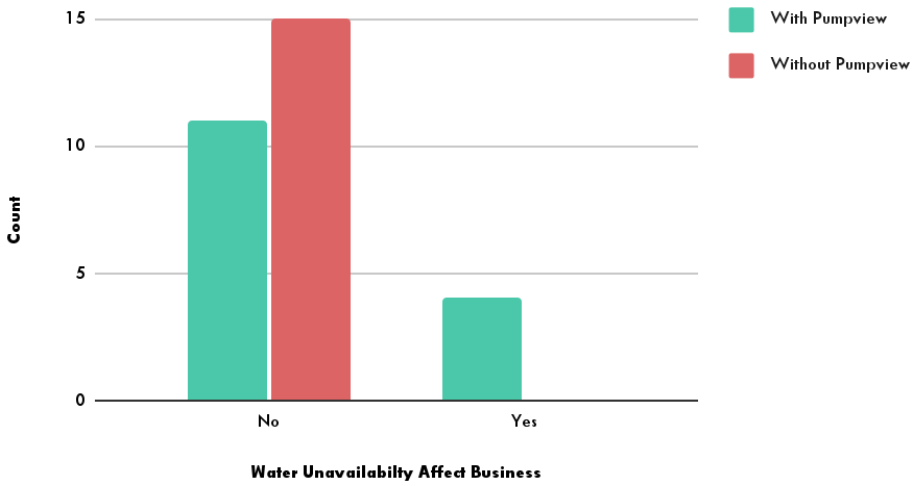

Figure 7: Graph showing the impact of water unavailability on business operations

However, there is a key distinction between the two groups when it comes to businesses that do report an impact from water availability. In Pumpview-equipped communities, 4 businesses indicated that water availability does affect their operations, while none in non-Pumpview communities reported such a dependence. This suggests that the presence of the Pumpview system may make businesses more aware of their reliance on consistent water availability. It could also mean that in Pumpview communities, businesses that require water are more likely to acknowledge and experience the impacts of water availability since they benefit from more reliable monitoring and management of water resources.

In summary, while most businesses in both types of communities report that water availability does not affect their operations, a small number of businesses in Pumpview-equipped areas recognize that it does. This difference may indicate that businesses with Pumpview are more attuned to how reliable water access can influence their operations, suggesting that the system has raised awareness or addressed needs that might not be as visible in communities without it.

5.0 Discussion

The survey findings offer a detailed and extensive comparison between communities equipped with the Pumpview monitoring system and those without, revealing several critical insights into the impact of the system on water availability and its influence on healthcare, education, and business operations. Across all sectors, the data points to significant differences in water access, underscoring the value of Pumpview in improving water reliability and mitigating the challenges posed by water scarcity.

5.1. Water Availability and Its Impact

One of the most striking outcomes from the data is the disparity in water availability between the two types of communities. In Pumpview-equipped communities, water unavailability is reported as a rare occurrence, with an overwhelming majority of respondents indicating consistent access to water. This contrasts starkly with the experiences of those in communities without Pumpview, where water shortages are a frequent and severe issue, often occurring daily. The Pumpview system's ability to minimize water interruptions is a key factor contributing to the stability of water access in these communities, demonstrating its effectiveness in addressing one of the most fundamental needs of these populations.

5.2. Healthcare Sector

In healthcare facilities, the impact of the Pumpview system is particularly notable. Both sets of communities rely on boreholes as their primary water source, but the differences in how these facilities experience water interruptions are profound. Healthcare centres with the Pumpview system report significantly shorter water interruptions, typically lasting less than a day, whereas interruptions in non-Pumpview communities can last up to a week. This reduced duration of water outages in Pumpview-equipped healthcare facilities has a direct and positive effect on patient care. Water is essential for hygiene, sanitation, and the general running of healthcare services, and the consistent water supply facilitated by the Pumpview system helps to maintain

the quality of care, reduce disruptions, and ensure that basic health services are not compromised.

Another critical finding is the impact of water availability on the prevalence of waterborne diseases. Both Pumpview and non-Pumpview communities report some cases of waterborne illnesses, but the number of reported cases is lower in Pumpview-equipped healthcare centres. This suggests that while waterborne diseases are still a concern, the Pumpview system contributes to a healthier environment by ensuring more reliable access to clean water, reducing the overall risk of contamination.

Additionally, when asked about the broader impact of water availability on healthcare, respondents consistently pointed to how a steady water supply improves patient care. The availability of water ensures the smooth functioning of hospital operations, from cleaning and sanitation to patient hydration and basic medical procedures. Any disruption in water availability reduces the quality of care and can lead to delays or complications, particularly in emergency situations. The survey indicates that healthcare facilities in communities with the Pumpview system are better positioned to maintain higher standards of care, thanks to their more reliable access to water.

5.3. Education Sector

The role of water availability in the education sector also presents a stark contrast between communities with and without Pumpview. Schools in Pumpview-equipped communities benefit from fewer water shortages and shorter interruptions when they do occur. This ensures that basic needs such as hygiene, sanitation, and cooking (where relevant) are consistently met. Schools without the system, however, often face more prolonged water interruptions, which can last up to a month. These prolonged outages have detrimental effects on both students and staff, particularly on female students and teachers, who face additional challenges during periods of water scarcity.

A key finding in the data is the reported reduction in absenteeism, particularly among girls, in schools with reliable water availability. The importance of water access for hygiene and

sanitation, especially in managing menstrual health, cannot be understated. In Pumpview-equipped schools, the consistent water supply helps alleviate discomfort for female students and teachers during menstruation, reducing their need to miss school. This has broader implications for educational outcomes, as absenteeism, particularly among girls, can significantly hinder academic progress. By ensuring a more consistent water supply, the Pumpview system contributes to improved attendance and overall school performance, making a tangible difference in educational outcomes.

5.4. Business Sector

The impact of water availability on business operations reveals some interesting dynamics. While most businesses in both Pumpview and non-Pumpview communities report that their operations are not directly affected by water availability, there is a small but significant group of businesses in Pumpview-equipped communities that recognize water as essential to their operations. This suggests that the Pumpview system may increase businesses' awareness of their water dependence, particularly for those that require a consistent supply for day-to-day functioning.

In communities without Pumpview, there is no reported acknowledgement from businesses that water availability affects their operations. This could imply that businesses in these areas are either less reliant on water or have adapted to frequent water shortages in ways that reduce their dependence on a consistent water supply. However, the presence of the Pumpview system seems to have created a different awareness among businesses that recognize the value of consistent water access. For these businesses, the system provides a sense of stability, allowing them to operate more efficiently and potentially expand their activities without the fear of water-related disruptions. The relatively small number of businesses acknowledging water's impact on operations might indicate that many businesses in these regions do not heavily rely on water or have already developed coping mechanisms to address water scarcity. However, the slight increase in businesses recognizing water's importance in Pumpview communities highlights the potential for more businesses to thrive if they are given the infrastructure and reliability provided by the Pumpview system.

6.0 Conclusion

The findings from the survey highlight the profound impact of the Pumpview monitoring system on water availability and the benefits it provides to communities where it is implemented. The system significantly reduces water shortages, as **96.77%** of respondents in Pumpview communities reported rare water disruptions compared to **65.52%** in non-Pumpview areas facing daily shortages.

In the healthcare sector, the Pumpview system has led to improved water availability, shorter outages, and a **60% reduction** in waterborne disease cases, thereby enhancing the overall quality of care. In schools, the system contributes to better attendance, especially for girls, by ensuring reliable access to water and improving menstrual health management.

For businesses, while the majority in both intervention and control communities do not rely heavily on water, **26.67%** of businesses in Pumpview-equipped areas do recognize the importance of water availability for their operations. This may indicate a heightened sense of reliability and confidence in the water supply provided by the system.

The overall data strongly suggests that expanding the reach of the Pumpview system could lead to broader improvements in water accessibility, health outcomes, educational performance, and business operations, fostering greater social and economic development across these communities.

Overall, the findings demonstrate the far-reaching effects of the Pumpview monitoring system on water availability and its implications across various sectors. In healthcare, the system significantly reduces water interruptions, improving the quality of care and reducing the incidence of waterborne diseases. In schools, the consistent water supply helps maintain better hygiene, particularly for female students and teachers, contributing to lower absenteeism and better educational outcomes. For businesses, while many do not report a direct reliance on water, the system increases awareness of water's importance, allowing some businesses to operate with more stability and efficiency.

The Pumpview system has clearly brought about meaningful improvements in water management and access in the communities where it has been implemented. It reduces the frequency and severity of water shortages, providing a more dependable water supply that supports the health, education, and economic sectors. However, the data also suggests that while the system has delivered significant benefits, further efforts may be needed to expand its reach and optimize its impact. For businesses, in particular, there may be opportunities to explore how the Pumpview system can further support those that rely on water, potentially boosting economic activity in these regions.

In conclusion, the Pumpview system plays a critical role in addressing water scarcity and its effects on essential community services. Its presence leads to greater water reliability, which in turn positively affects healthcare, education, and business operations. As the system continues to be implemented and expanded, it holds the potential to foster broader social, economic, and health improvements in the communities it serves.

References

Cronk, R., & Bartram, J. (2017). *Factors Influencing Water System Functionality in Nigeria and Tanzania: A Regression and Bayesian Network Analysis*. Environmental Science and Technology, 51(19), 11336–11345. https://doi.org/10.1021/acs.est.7b03287

Federal Ministry of Water Resources, & National Bureau of Statistics. (2021). Water, Sanitation and Hygiene National Outcome Routine Mapping (WASH-NORM). 1–423.

Gulumbe, B. H., Yusuf, Z. M., Faggo, A. A., Yahaya, T. O., & Manga, S. S. (2023). *The interplay among conflict, water scarcity, and cholera in Northern Nigeria. Public Health Challenges*, 2(3), 1–5. https://doi.org/10.1002/puh2.118

Water Aid. (2023). WaterAid Nigeria Country Programme Strategy water. 2023-2028.

World Bank. (2017). A Wake-Up Call: Nigeria Water Supply, Sanitation, and Hygiene Poverty Diagnostic. WASH Poverty Diagnostic. World Bank, Washington, DC